LOCAL AND REGIONAL VARIATION IN THE VEGETATION OF THE SOUTHERN APPALACHIAN MOUNTAINS

By

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ABSTRACT

CLAIRE LEITH NEWELL: Local and Regional Variation in the Vegetation of the Southern Appalachian Mountains
(Under the direction of Robert K. Peet)

Whereas numerous studies have documented local, landscape-scale variation in vegetation composition, regional-scale vegetation patterns remain largely unstudied. In the absence of a regional synthesis, Whittaker's (1956) classic Smoky Mountains landscape study has been widely employed as a standard model for the Southern Appalachian region. He showed that much variation in vegetation can be explained in terms of elevation and topographic-moisture gradients. However, the climatic, topographic and geologic complexity of this region suggests that environmental processes controlling vegetation and their relative importance may vary significantly within the region.

In this study detailed examinations of community composition and environmental relationships in three Southern Appalachian landscapes (Joyce Kilmer/Slickrock Wilderness, Linville Gorge Wilderness, Shining Rock Wilderness) are presented and then supplemented with data from other landscape-scale studies to develop a regional synthesis of variation in forest composition. Specifically, vegetation data from 1113 stands collected in 9 landscapes (those above, Black and Craggy Mountains, Chattooga River, Grandfather and Roan Mountains, Smoky Mountains, Thompson River) were used to identify and determine the consistency of environmental gradients strongly correlated with vegetation composition and ascertain the consistency of vegetation class composition at landscape- , subregional- and regional-scales.

Cluster analysis grouped stands into six regional vegetation classes used for region-wide vegetation comparisons. Results show more complex vegetation patterns across the Southern Appalachian region than suggested in Whittaker's landscape study. Across all landscapes vegetation was consistently and strongly correlated with soil nutrients and topographic-moisture. The importance of elevation changed between landscapes; correlations between vegetation and elevation were strong in high-elevation

landscapes, but were moderate in mid-elevation landscapes and weak in low-elevation landscapes.

Subregional and regional-scale vegetation patterns were correlated most strongly with elevation, soil fertility, soil texture and topographic-moisture. Subregional vegetation patterns also correlated with precipitation.

Individual vegetation classes exhibited different responses to soil nutrient status, elevation and topographic position, but had comparatively consistent distributions across the four high- and two mid-elevation landscapes. Low-elevation landscapes supported a subset of the six vegetation classes, with one vegetation class dominant across most elevations, topographic positions and soil nutrient regimes.

To my parents
Leith and Jack Newell

their love and knowledge of the mountains
provided the stimulus for this study

In loving memory
of my sister Judy Newell
1960-1979

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CHAPTER 1. INTRODUCTION

Vegetation patterns have long captured the interest of plant ecologists, and considerable effort has been devoted to quantifying community variation at the landscape-scale (1,000-50,000 ha). However, there has been much less effort directed at quantifying regional-scale (200,000-2,000,000) vegetation patterns (but see Chang & Gauch 1986, Gagnon & Bradfield 1987, Allen *et al.* 1991a, Allen *et al.* 1991b), and as a consequence little is known about patterns or the associated underlying processes at this geographic scale. Similarly, our understanding of how a series of landscape-scale studies within a region relate to one another at this broader, regional-scale is mostly unknown (but see Allen *et al.* 1991a). The Southern Appalachian Mountain region, known for its diverse and endemic-rich vegetation assemblages (Braun 1950, Whittaker 1956), is no exception. Since Whittaker's (1956) classic landscape-scale study on the vegetation of the Great Smoky Mountains, studies have documented plant community composition and single species distributions in many individual Southern Appalachian landscapes. Most studies have used Whittaker's study as the model for understanding landscape-scale variation in this region. However, Whittaker's study area represents only a small portion of the Southern Appalachian Mountains. The climatic, topographic and geologic complexity of the region suggests that factors controlling vegetation distribution may vary between locations within this region. Little is known about the patterns of variation in vegetation across the Southern Appalachian Mountains. This limits our ability to fit landscape-scale studies in a regional framework, or to develop an overall understanding of the processes that govern variation in the vegetation of this region.

To date, only Mark (1958), Ramseur (1960), Zobel (1969), Cooper & Hardin (1970), DeLapp (1978), White & Cogbill (1992), Risk (1993), Hedman & Van Lear (1995), Wiser *et al.* (1996) and Newell *et al.* (*in press*) have examined large-scale regional patterns in this area. Apart from Cooper & Hardin and Newell *et al.*, each study focused on a single, narrowly distributed set of communities. Cooper & Hardin (1970) summarized vegetation patterns in the Southern Blue Ridge Escarpment area, but this area represents only the high-precipitation, low-elevation portion of the Southern Appalachians. A five-landscape study by Newell *et al.* (*in press*) represents a preliminary, quantitative examination of variation in vegetation across a broader geographic range within the Southern Appalachian Mountain region.

Considerable effort has been devoted to quantifying the relationships between vegetation composition and environmental factors in order to understand the ecological processes that govern species distribution. Whittaker (1956) suggested that vegetation was primarily distributed along elevation and topographic-moisture gradients, and most subsequent studies of Southern Appalachian vegetation have reiterated the primary importance of elevation and topographic-moisture as factors controlling vegetation composition (e.g., Ramseur 1960, Golden 1981, McLeod 1988, Busing *et al.* 1993, Wiser *et al.* 1996). Some subsequent researchers (e.g., Zobel 1969, DeLapp 1978, Golden 1981, McLeod 1988, Patterson 1994, Wiser *et al.* 1996, Newell *et al. in press*) have identified soil nutrients as the third critical gradient for understanding vegetation patterns of this region. However, studies in lower-elevation landscapes have found that soil characteristics, together with topographic shape and position, were the primary factors controlling vegetation distribution (Patterson 1984, Wentworth & Ulrey *unpub. data*).

The significance of other environmental factors has been documented in only a few studies. Rohrer (1983) and Wiser *et al.* (1996) reported strong correlations between characteristics of the underlying rock type and vegetation composition. The significance of soil texture for species and community distribution has been noted by Mowbray & Oosting (1968).

Despite the fact that vegetation-environment relationships have been described for individual landscapes within the Southern Appalachian region, we have only limited knowledge about how these gradient relationships vary from one landscape to another across the region. Although the elevation and topographic-moisture gradients used by Whittaker and others are of considerable heuristic value, they are complex, composite gradients that do not necessarily vary in a consistent fashion with resource and environmental gradients to which plants correspond (see Austin & Cunningham 1981). Consequently, there is little reason to expect that the patterns observed by Whittaker (1956) are consistent between landscapes within this region. Past emphasis on "complex gradients" (*sensu* Whittaker) has, in part, stemmed from using qualitative measures, or crude quantitative methods for describing complex variables such as topographic moisture. However, recent developments in geographic information systems and the emergence of new quantitative methods of describing topography (e.g., Parker 1982, McNab 1989, McNab 1993, Fels 1994, Newell *et al. in press*) provide an opportunity to overcome many of the problems confronted in past vegetation-environment analyses.

Recent ecological theory suggests that ecological processes associated with vegetation patterns may change with changing spatial scale. The importance of examining vegetation patterns at different spatial scales has been emphasized (e.g., Allen & Starr 1982, Meentemeyer & Box 1987, Wiens 1989, Reed *et al.* 1993), yet few empirical studies have examined this issue (but see Palmer 1990, Martin & Bouchard 1993, Reed *et al.* 1993, Palmer & White 1994, Wiser *et al.* 1996). To date, no one has quantified the vegetation-environment relationships of Southern Appalachian forests across a range of spatial scales. Although we have some understanding of the processes linked with vegetation at the landscape-scale, we can not assume the same set of environmental processes will be strongly associated with smaller-scale community distribution or larger-scale regional vegetation patterns. Lack of understanding of the varying importance of processes associated with vegetation at different spatial scales limits our ability to fully understand vegetation-environment relationships across this region.

My study examines vegetation-environment relationships across a range of spatial scales. I first closely examine landscape-scale community composition and environmental relationships in three individual Southern Appalachian landscapes. Secondly, I examine the consistency of landscape-level vegetation-environment relationships across the Southern Appalachian region using data from 9 landscapes. I quantify regional-scale vegetation-environment relationships and examine how these relationships correspond to patterns observed at the landscape-scale.

The specific objectives of each landscape study were to 1) classify, describe and map contemporary vegetation communities of each landscape, 2) identify the major environmental factors influencing present-day vegetation community composition with an emphasis on landform characteristics and soil attributes, 3) determine the extent to which past disturbances have influenced vegetation community composition and distribution, and 4) compare the vegetation communities and vegetation-environment relationships identified in each landscape with those identified elsewhere in the Southern Appalachian Mountains.

The overall objective of the regional synthesis was to quantify geographic variation in forest vegetation across the Southern Appalachians and determine which factors are most likely responsible for the geographic variation across this region. Specifically, I ask (1) whether the environmental gradients most strongly correlated with vegetation patterns within individual landscapes are consistent across the region, (2) whether vegetation classes have a consistent position with respect to the major environmental gradients across the region, (3) to what extent is the composition of individual vegetation classes consistent across the region, and finally, (4) whether the environmental factors most strongly correlated with vegetation patterns change between landscape-, subregional- and regional-scales.

1.1 Study Areas

1.1.2 Landscape studies

The three Wilderness areas examined in this detailed study of landscape vegetation patterns each characterizes different features of the Southern Appalachians. Each contains features or vegetation communities that have previously received little study, but are necessary to fully understand the vegetation patterns of the region. Linville Gorge Wilderness (hereafter Linville Gorge) is situated on the eastern edge of the Southern Appalachian Mountains (Figure 1.1). The uniquely rugged topography of this portion of the Southern Appalachians provides habitat and refuge for a significant number of regionally rare or spatially restricted species and ecosystems. Linville Gorge also contains one of three remaining large, intact old-growth forest in the Southern Appalachians. Joyce Kilmer/Slickrock Wilderness (Joyce Kilmer), located in the southwest corner of the Southern Appalachian Mountains, is famous for the old-growth forests in Poplar Cove. These forests represent a portion of the second extensive area of old-growth forest in this region (Lorimer 1980). Shining Rock Wilderness (Shining Rock), centrally located in the Southern Appalachian Mountains in the Balsam Mountains, represents one of the few high-mountain areas in the Southern Appalachians (Ramseur 1960). The results of the three landscape studies presented here were originally documented as challenge cost-share contract reports for the US Forest Service.

Like many landscapes in the Southern Appalachian region, forests in Shining Rock and in one of the two major watersheds of Joyce Kilmer were heavily logged and subsequently burned in the early twentieth century (USFS *unpub. data*). Although such intense, broad-scale disturbances conspicuously alter community composition and spatial distribution (Ramseur 1960, Pyle 1988), few studies have quantified their impacts. Moreover, little is known about whether such disturbances change vegetation relationships with major environmental factors.

Chestnut blight also had a widespread impact on Southern Appalachian forests. However, because chestnut death coincided with the major logging period, it has been difficult to fully assess the impact of the loss of this species. The old-growth forests in the Little Santeetlah watershed of Joyce Kilmer provide an opportunity to examine the impacts of chestnut death in the absence of logging. Of the limited research undertaken to assess the impacts of chestnut death, most has centered on forests in the Great Smoky Mountains, which represent only a small section of the Southern Appalachian region. In this study I attempt to quantify the impacts of past widespread disturbance by both logging and chestnut blight on the present composition and distribution of vegetation communities across several landscapes.

Although the stand dynamics of the old-growth forests at Poplar Cove in Joyce Kilmer and the western Smoky Mountains have been well-documented (Lorimer 1976, Lorimer 1980, Runkle 1982, Runkle & Yetter 1987), old-growth forests in other areas of the Southern Appalachian Mountains remain relatively undescribed. Climatic and elevation differences between Linville Gorge and the latter two landscapes with old-growth forests suggest that the composition of old-growth forests in the dry, low-elevation Linville Gorge landscape will be different from those in the high-precipitation, higher-elevation landscapes of the western Smoky Mountains and Joyce Kilmer.

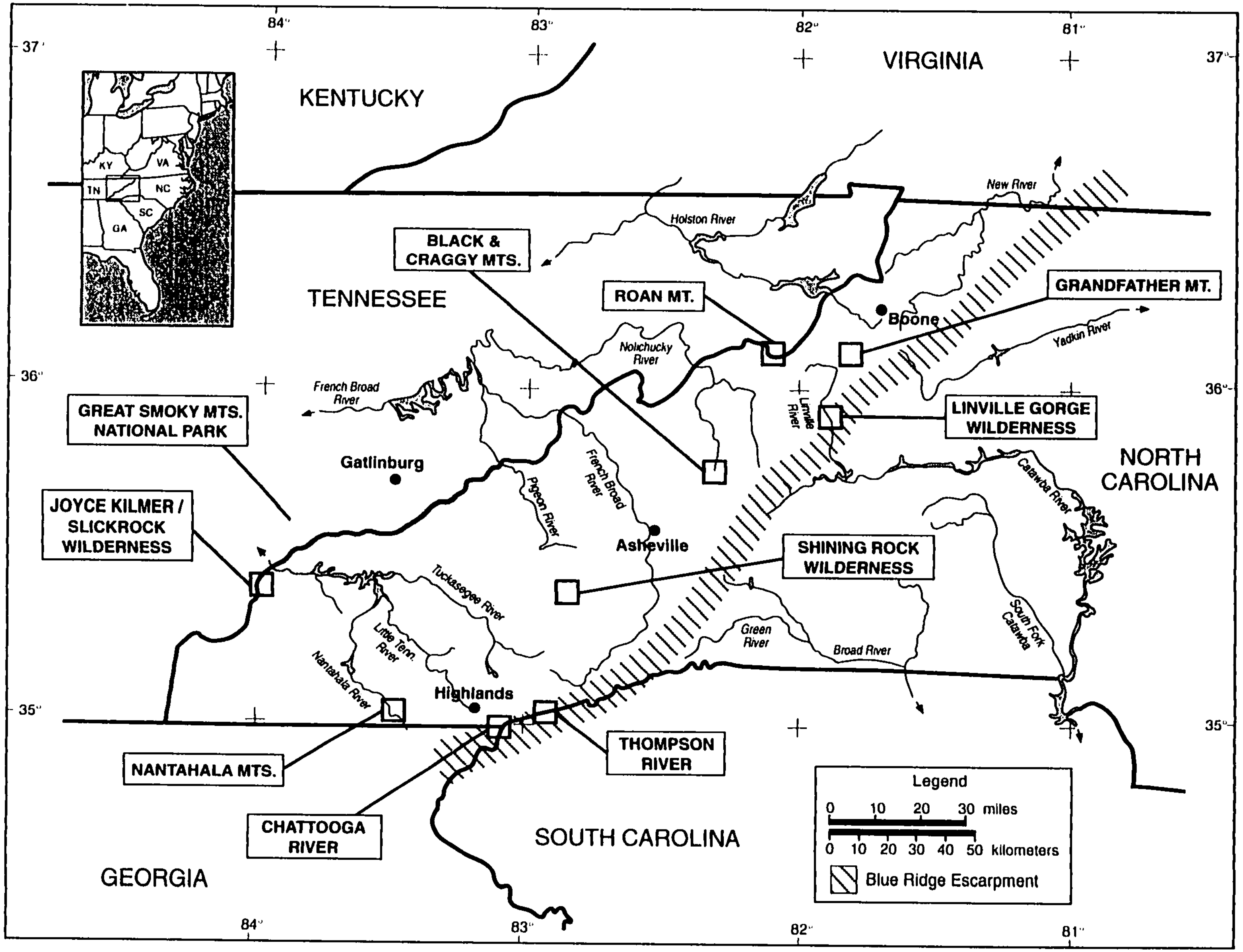
1.1.2 Comparative studies

Data from 9 landscapes between 3,500 and 35,000 hectares in size, are used in this study (Figure 1.1). Linville Gorge, Joyce Kilmer and Shining Rock have been discussed in detail in the previous section. These landscapes were sampled by the author between 1992 and 1995. Datasets from 6 comparative landscapes were used; the Black and Craggy Mountains (hereafter Black Mountains; McLeod 1988), the Chattooga River Gorge (Chattooga River; Patterson 1994, USFS *unpub. data*), Grandfather and Roan Mountains (Grandfather and Roan; NCVS *unpub. data*), the Nantahala Mountains (Nantahalas; NCVS *unpub. data*, Roberts 1996), the Thompson River Gorge (Thompson River; Wentworth 1980) and the western Great Smoky Mountains (Smoky Mountains; Callaway *et al.* 1987, Dellinger *unpub. data*, White *unpub. data*).

The Black Mountains, Grandfather and Roan Mountains and Shining Rock represent four of the eight high-mountain landscapes within the Southern Appalachian Mountains (Ramseur 1960). Shining Rock, ranging in elevation from 970 to 1800 m, is centrally located in the Balsam Mountains of Haywood County, North Carolina (NC). Further north in Yancey and Buncombe Counties, the Black and Craggy Mountains span an elevational range from 730 m to the top of Mount Mitchell at 2040 m (the highest point in eastern North America; McLeod 1988). Grandfather Mountain and Roan Mountain are located to the northwest of Linville Gorge. Grandfather Mountain, located in Avery County, NC, ranges in elevation from 515 to 1620 m. Roan Mountain is situated astride the junction of North Carolina and Tennessee and has an elevational range of 1340 to 1820 m (Figure 1.1).

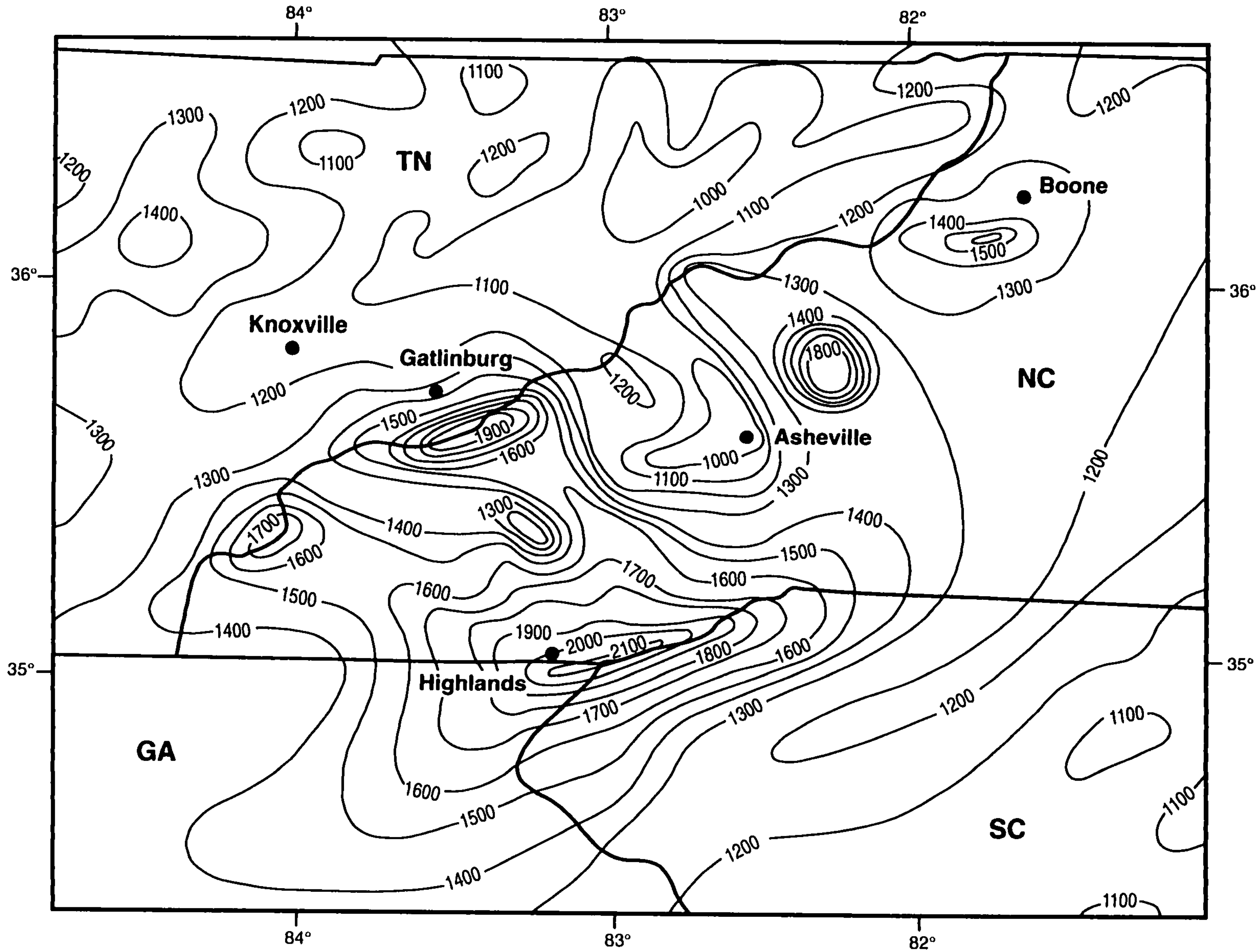
Joyce Kilmer and the Nantahalas represent mid- to high-rainfall, mid-elevation

Figure 1.1 Map of the Southern Appalachian Mountains of North Carolina, South Carolina, Georgia and Tennessee, showing the distribution of the 9 landscapes used in this dissertation. The stippled line represents the Brevard Fault, which represents the eastern border of the Southern Appalachian Mountains.



84°
83°
82°
81°
37°
36°
35°
VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
KY
VA
TN
NC
SC
GA
New River
Holston River
BLACK & CRAGGY MTS.
ROAN MT.
GRANDFATHER MT.
Boone
Yadkin River
Nolichucky River
Linville River
LINVILLE GORGE WILDERNESS
French Broad River
GREAT SMOKY MTS. NATIONAL PARK
Gatlinburg
Pigeon River
French Broad River
Catawba River
Asheville
JOYCE KILMER / SLICKROCK WILDERNESS
SHINING ROCK WILDERNESS
Tuckasegee River
Little Tenn. River
Green River
Broad River
South Fork Catawba
Nantahala River
Highlands
NANTAHALA MTS.
THOMPSON RIVER
CHATTOOGA RIVER
Legend
0 10 20 30 miles
0 10 20 30 40 50 kilometers
Blue Ridge Escarpment

Figure 1.2 The distribution of annual precipitation across the Southern Appalachian Mountains region. Precipitation is measured in millimeters. Contour lines were redrawn from state precipitation maps for Georgia, North and South Carolina and Tennessee (Ruffner 1978a, Ruffner 1978b).



84°
83°
82°
36°
35°
TN
NC
GA
SC
Boone
Knoxville
Gatlinburg
Asheville
Highlands
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1900
2000
2100

landscapes in the moister, southwest and southern section of the Southern Appalachian Mountains (Figure 1.2). Joyce Kilmer, is situated south of the Smoky Mountains in the Unicoi Mountains of Graham County, NC and Monroe County, eastern Tennessee. This landscape ranges in elevation from 330 m to 1620 m. The Nantahalas, located in Jackson County, NC, span an elevational range from 540 to 1640 m. The western Smoky Mountains span the border between North Carolina and Tennessee. This area represents another high-elevation landscape (elevational range from 300 to 2025 m; Ramseur 1960). However, the dataset used in this study was sampled in a mid-elevation area at the southern-end of this region, and represents the third mid-elevation landscape in this study.

Further south astride the junction of North and South Carolina and Georgia, the Chattooga and Thompson Rivers represent two of the six deep gorge systems in the low-elevation, high-rainfall Southern Escarpment Region of the Southern Appalachian Mountains (DuMond 1970; Figure 1.2). Elevations range from 500 to 1500 m in the Chattooga River and from 335 to 1340 m at Thompson River. Both areas are complex landscapes of steep gorges, broad ridges, sideslopes and coves (DuMond 1970, Wentworth 1980, Patterson 1994). Linville Gorge is a more northern Escarpment gorge system, located in Burke County, NC. This landscape represents the drier, lower-elevation regions on the eastern-edge of the Mountains (Figure 1.2). Linville Gorge consists of a long, narrow, rugged valley dominated by highly dissected slopes and spans an elevation range from 400 to 1250 m.

The Chattooga River, Nantahalas, Roan Mountain, Shining Rock and Thompson River, and areas within the Black Mountains, Smoky Mountains and Grandfather Mountain were extensively logged in the early twentieth century and were subsequently impacted by intense fire. In contrast, Linville Gorge, and certain areas within the Black Mountains, Joyce Kilmer and the Smoky Mountains contain primarily old-growth forests.

1.2 Geologic setting

Correlations between underlying geology and variation in vegetation patterns have been suggested in a few Southern Appalachian studies (e.g., Graves & Monk 1985, Schafale & Weakley 1990, Wiser *et al.* 1996). However, our understanding of this association is limited.

The study areas lie within the Blue Ridge Geologic Province which is delimited by the Brevard Fault on the east and by the Blue Ridge Fault on the northwest. The Blue Ridge Province was formed during a long period of continental collision when a series of resistant, Precambrian thrust sheets were pushed westwards over older basement rocks. In places thrust sheet domes were formed, created when resistant underlying sedimentary rock folded as the thrust sheets moved across (Hatcher & Goldberg 1991). The Southern Appalachian Mountains of today represent a remnant of a more extensive and higher-elevation mountain chain (Hatcher 1988). Erosion took place after the mountain building period, aided by faulting and fluvial down cutting. In some areas thrust fault dome crests eroded away, exposing a "window" of younger rocks beneath the thrust sheets. The most prominent of these is the Grandfather Mountain Window in the Blue Ridge thrust sheet (Hatcher & Goldberg 1991).

The Blue Ridge Geologic Province can be separated into two sections by the Hayesville thrust fault, that runs southwest-northeast. Rocks in the western Blue Ridge consist of late Precambrian sedimentary sandstones and shales in the Ocoee Series which were deposited on Grenville continental basement rocks in a series of rift basins located along the eastern edge of North America. Material eroding from the Grenville Mountains infilled these basins. Rocks in the eastern Blue Ridge were originally deposited as off-shore sediments. In the eastern Blue Ridge mafic, ultramafic and granitic rocks are common and basement rocks are only known to occur with certainty in two places. The reverse is true for the western Blue Ridge with basement rocks common and ultramafic unknown (Hatcher 1988, Hatcher & Goldberg 1991).

Rock types of the 9 study areas broadly divide into 2 groups. Mafic rocks represent those high in iron and magnesium; these typically produce more fertile soils than felsic rocks. Mafic rocks are most prominent in the northern study areas (Black Mountains, Grandfather and Roan), although veins or pockets of mafic rocks are present in some southern study areas (Chattooga River, Nantahalas, Thompson River). Broad-scale differences in geology may correspond with regional and between-landscape differences in vegetation composition. However, compositional differences and the distribution of specific vegetation groups within a single landscape, may be influenced by subtle chemical and textural differences between specific parent material types. This theme is examined in Chapters 3, 4 and 5. Figures 1.3-1.5 show the distribution the major parent material types in Linville Gorge, Joyce Kilmer and Shining Rock.

In the southern section of the eastern Blue Ridge, the Chattooga River and Thompson River have similar geology, with sedimentary rocks mostly in the Tallulah Falls Formation metamorphosed into gneiss, schist and quartzite (Hatcher 1988). To the east and north of the Chattooga River, the gneiss Toxaway Dome and Whiteside and Rabun granitic plutons represent the extent of exposed older basement rock in the eastern Blue Ridge (Hatcher & Goldberg 1991). The Chattooga River is underlain by granitic metagraywacke, biotite muscovite schist, aluminous garnet schist, and gneiss, with small areas of more base-rich amphibolite present (Bell & Luce 1983, Luce *et al.* 1983). The Thompson River region consists of a mix of Precambrian and lower Paleozoic igneous and metamorphosed rocks (Stuckey 1965). To the east of these watersheds the Brevard Fault zone marks the boundary of the Tallulah Falls Formation. This zone contains several narrow belts of base-rich marble.

Further north in the eastern section of the Blue Ridge, the Nantahalas are underlain by coarse-grained diorite gneiss, quartoze metasandstone and muscovite-biotite schist. There are also small pockets of olivine and base-rich marble (Hatcher 1988). Felsic, highly metamorphosed sedimentary rocks dominate Shining Rock (Hadley & Nelson 1971, Butler 1973; Figure 1.4). These are predominantly Precambrian mica gneiss and garnet-mica schist, with Paleozoic migmatite also present (Lesure 1981).

Mafic amphibolite is a feature of both Roan Mountain and the Black Mountains. These two high-mountain landscapes are part of the Ashe Formation (Hatcher & Goldberg 1991). The Black Mountains are mainly underlain by mica-garnet schist, with layers of quartz-biotite gneiss and meta-arkose. Lenses of base-rich hornblende-gneiss or amphibolite are also present (Howell 1974, Lesure *et al.* 1982). Roan Mountain is underlain by amphibolite, gneiss and schist (Hatcher & Goldberg 1991).

In the western section of the Blue Ridge, both Joyce Kilmer and the Smoky Mountains contain predominantly felsic Precambrian-aged metasedimentary rocks of the Great Smoky Group in the Ocoee Series. The Great Smoky Group consists of a sequence of deep marine sediments of conglomerate, arkosic sandstone, shale and graywacke (Lesure *et al.* 1977; Figure 1.5) which are between 4 and 6 km thick (Hatcher & Goldberg 1991). This group is covered by unconsolidated Quaternary-aged colluvial and alluvial deposits in some lower-slopes and valley floors of Joyce Kilmer. Most of the western Smoky Mountains are underlain by basement gneisses and schists, with Precambrian metamorphosed sedimentary sandstones predominantly in the Great Smoky Group and quartzites and sandstones in the Paleozoic Chilhowee Group (King *et al.* 1968).

Grandfather Mountain and Linville Gorge are situated further north in the western section of the Blue Ridge. These two study areas lie within the Grandfather Mountain Window where relatively younger, but still Precambrian rock shows through the ancient overthrust rocks of the Blue Ridge (Hatcher & Goldberg 1991). Linville Gorge is underlain by a combination of felsic quartzite, meta-arkose, phyllite and gneiss (D'Agostino *et al.* 1986; Figure 1.3). The area of Grandfather Mountain is also underlain by mafic volcanic rocks, containing epidote, albite, chlorite and actinolite and Linville metadiabase (Hatcher & Goldberg 1991).

1.3 Climate

Local climate within the Southern Appalachian Mountains varies significantly with latitude, elevation, and topographic characteristics such as slope orientation and abrupt topographic changes in elevation (Shanks 1954, Dickson 1959, Kopec & Clay 1975, Swift *et al.* 1988, Konrad 1996). Moisture-laden winds from the southwest produce high rainfall throughout much of the area (Dickson 1959, Kopec & Clay 1975). In the Southern Escarpment region, air from north-to-northwest moving storms hits the Escarpment front and is forced up over this sharp topographic rise (Figure 1.2). The rising air cools, resulting

Figure 1.3. Map of the Linville Gorge Wilderness study area showing topography and parent material units. The following abbreviations were used; parent material type (**AL**=alluvium, **C**=Cranberry gneiss, **CL**=lower quartzite, **CP**=phyllite, **CU**=upper quartzite, **G**=Grandfather Mountain Formation meta-arkose, **W**=Wilson Creek gneiss) and prominent high points (**H**=Hawksbill Mountain, **I**=Gingercake Mountain, **L**=Laurel Knob, **S**=Shortoff Mountain, **T**=Tablerock Mountain, **W**=Wiseman's View). The Wilderness boundary is indicated by the dashed line. Geology boundaries follow D'Agostino *et al.* (1986). Contour lines are given in meters.

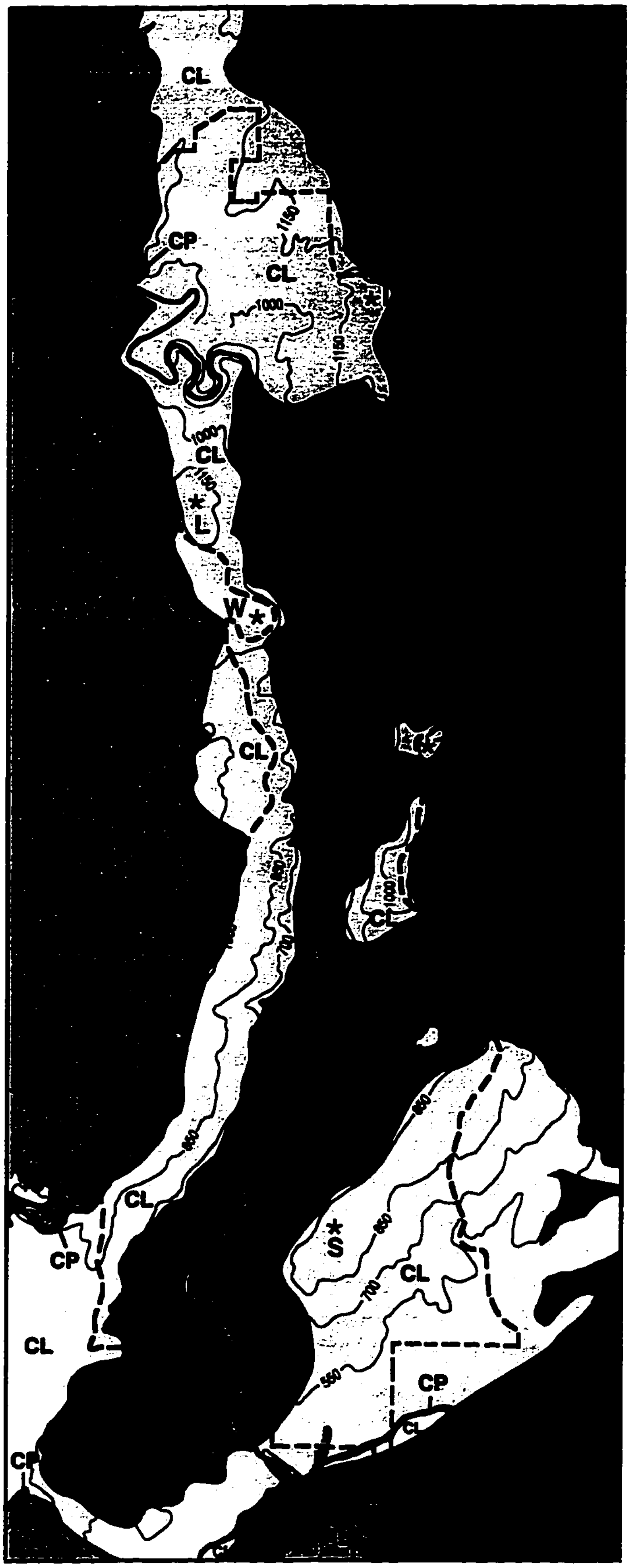
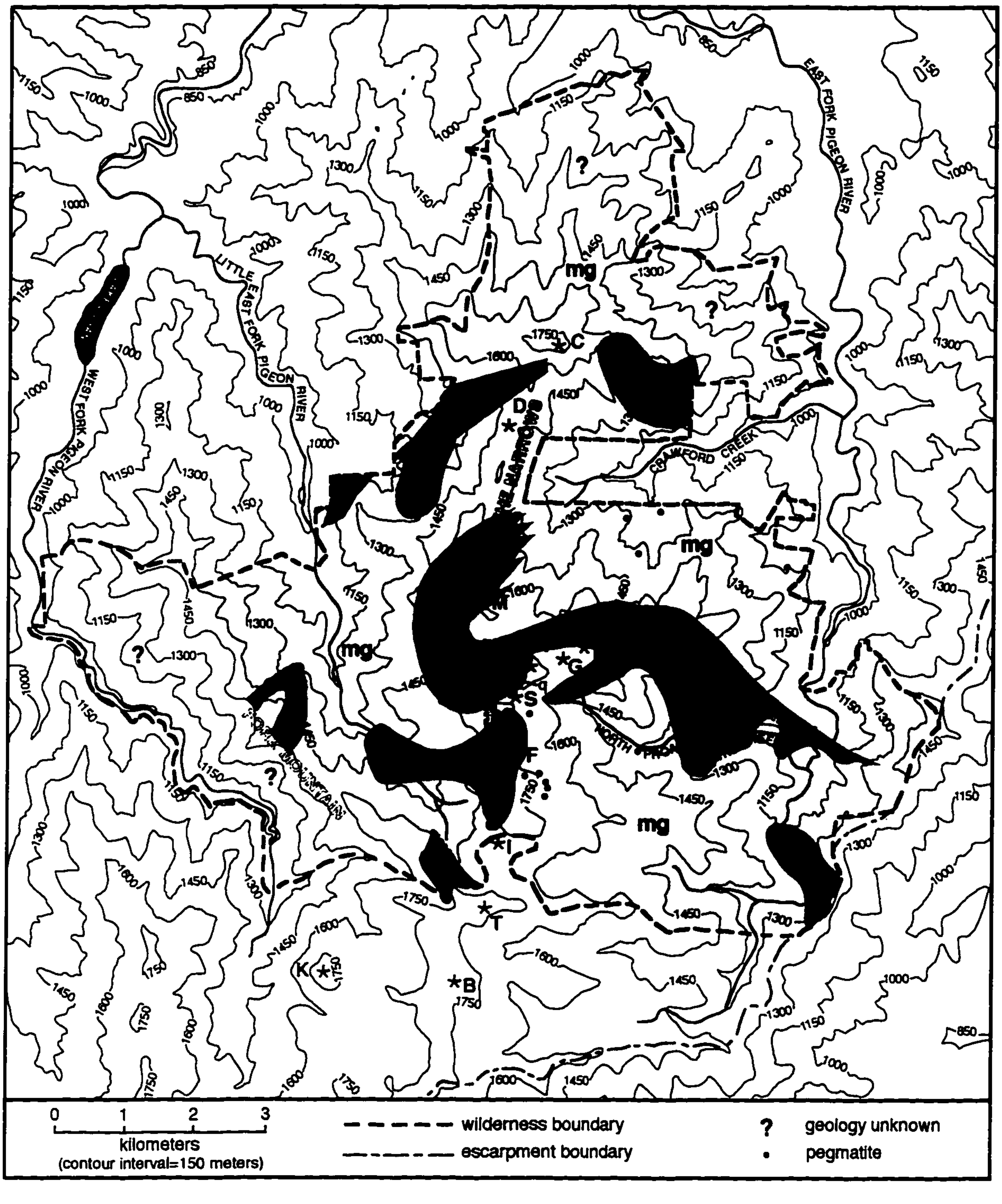
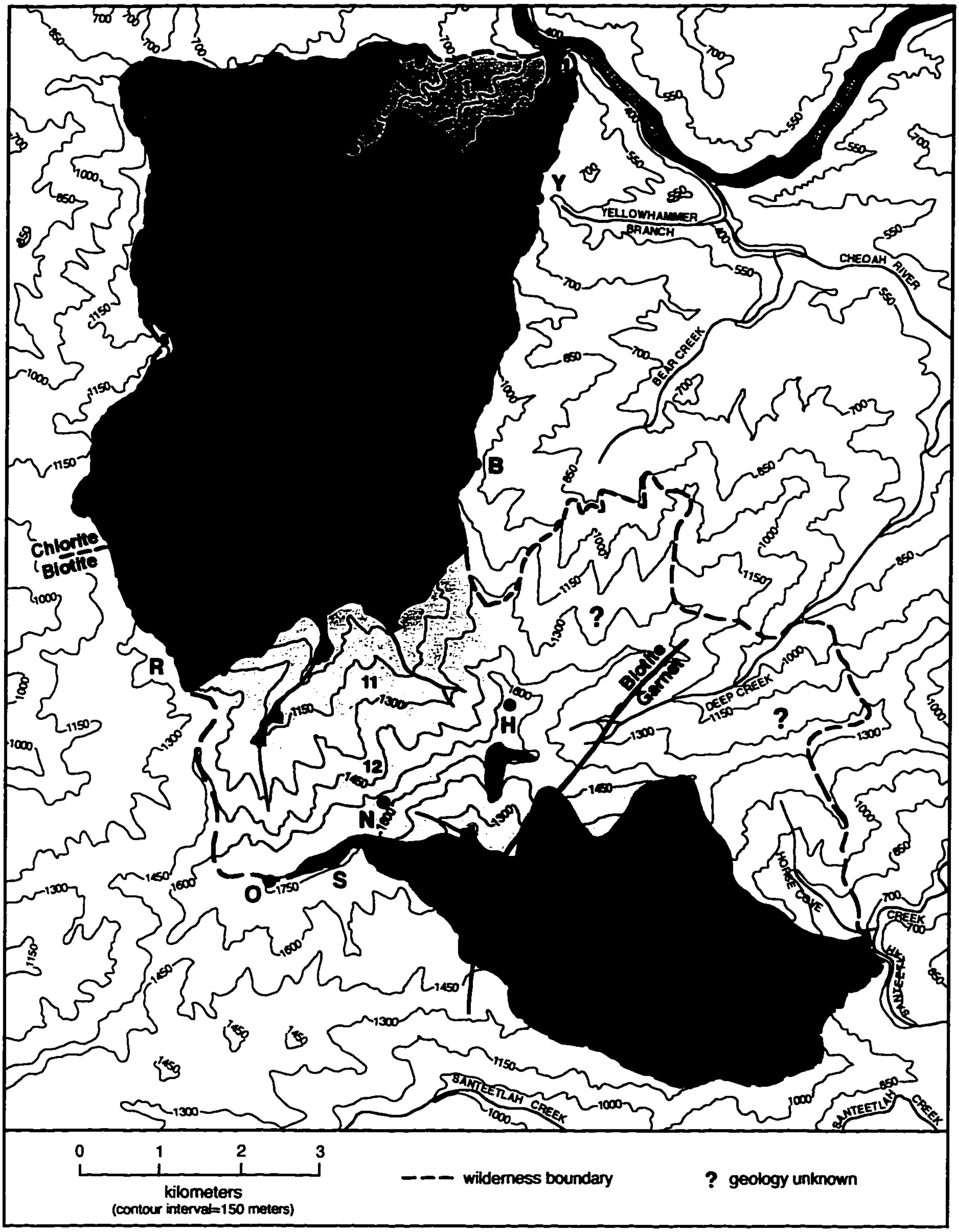

CL
1150
CP
CL
1000
1150
1000
CL
1150
L
W
CL
850
700
1000
850
CL
CP
CL
CP
850
S
850
CL
700
550
CP
CL

Figure 1.4. Map of the Shining Rock Wilderness study area showing topography and parent material units. The following abbreviations are used: parent material type (**gms**=Garnet-mica schist; **m**=Migmatite; **mg**=Mica gneiss; **q**=massive Quartz; unfilled areas (represented by **?**) represent unmapped areas which were added to the Wilderness in 1984 after the geologic map had been completed. Prominent high points and other topographic features are represented by the following; **B**=Black Balsam Knob, **C**=Cold Mountain, **D**=Deep Gap, **F**=Flower Gap, **G**=Beech Spring Gap, **I**=Ivestor Gap, **K**=Sam Knob, **L**=Dog Loser Knob, **M**=Stairs Mountain, **O**=Old Butt Knob, **S**=Shining Rock Gap, **SR**=the Shining Rock prominentory, **T**=Tennent Mountain. Geology boundaries follow Lesure (1981). Contour lines are given in meters.



WEST FORK PIGEON RIVER
LITTLE EAST FORK PIGEON RIVER
EAST FORK PIGEON RIVER
CRAWFORD CREEK
mg
?
C
D
G
S
F
I
T
B
K
0 1 2 3
kilometers
(contour interval=150 meters)
wilderness boundary
escarpment boundary
? geology unknown
pegmatite

Figure 1.5. Map of the Joyce Kilmer Slickrock Wilderness study area showing topography and parent material units. The following abbreviations are used: parent material type **Q**: colluvium and alluvium, **1**: cobble arkosic metasandstone, **2**: pyritic slate, **3**: metasandstone-metaconglomerate, **4**: slate- metasandstone, **5**: metaconglomerate- metasandstone, **6**: arkosic metasandstone, **7**: arkosic metasandstone-metaconglomerate-slate, **8**: slate **9**: graphitic metagraywacke, **10**: arkosic metasandstone-slate, **11**: arkosic metasandstone-metaconglomerate-metasiltstone, **12**: metagraywacke, **13**: arkosic metasandstone-metaconglomerate, **14**: phyllite-mica schist, **15**: arkosic metasandstone-phyllite; unfilled areas (represented by **?**) represent unmapped areas which were added to the Wilderness in 1984 after the geologic map had been completed. Prominent high points and other topographic features are represented by the following; **B**=Big Fat Gap, **H**=Hangover, N=Naked Ground, **O**=Bob Bald, **R**=Rockstack, **S**=Stratton Bald, **Y**=Yellowhammer Gap. Geology boundaries follow Lesure *et al.* (1977). Contour lines are given in meters.


Chlorite
Biotite
Biotite
Garnet
YELLOWHAMMER
BRANCH
CHEOAH RIVER
BEAR CREEK
DEEP CREEK
HORSE COVE
SANTEETLAH CREEK
Y
B
R
H
N
O
S
11
12
?
0 1 2 3
kilometers
(contour interval=150 meters)
wilderness boundary
? geology unknown

in heavy rainfalls exceeding 2000 mm per year. Moisture is progressively lost as winds move northeastwards across the region (Dickson 1959). There is a rainfall gradient across the Southern Appalachians from a low of about 950 mm per year in the Asheville Basin to approximately 2500 mm along the Southern Escarpment (NOAA 1990). Precipitation is highest between June to August and January to March, with September and October having lowest levels (Kopec & Clay 1975, Earthinfo Inc. 1989).

Additional precipitation is generated as the air moves northwards across high-elevation peaks (Figure 1.2). On the high peaks, precipitation ranges from 1270 to approximately 2300 mm per year (Shanks 1954, Stephens 1969, Earthinfo Inc. 1989), with highest levels recorded in the Great Smoky Mountains (Clingmans Dome; Stephens 1969). High-elevation precipitation levels are elevated by moisture in the form of fog condensing on intercepted vegetation (Smathers 1982). Precipitation in low-elevation areas in the vicinity of Linville Gorge, Grandfather and Roan ranges from 1250 mm at Banner Elk to 1625 mm at Blowing Rock (Figure 1.2). High-elevation areas of Grandfather Mountain average at least 1550 mm per year (Earthinfo Inc. 1989). There is a rainfall gradient across the Shining Rock region from 1825 mm at the low-elevation Pink Beds station, 7 km to the south-east on the front-face of the high-rainfall escarpment, to 1025 mm 19 km north at Canton, in the rain-shadow area associated with the Asheville Basin. High-elevation areas within Shining Rock may experience similar precipitation levels to nearby Mount Pisgah and Richland Balsam which average 1500 mm and 2195 mm respectively per year (Smathers 1982, Earthinfo Inc. 1989). Rainfall in the Black Mountains area ranges from 1170 mm in low-elevation areas to 2000 mm on the high peaks (Smathers 1982, McLeod 1988). The Smoky Mountains averages approximately 1400 mm of rain per year at low-elevations to 2300 mm near Clingmans Dome (Shanks 1954, Stephens 1969). Annual rainfall levels at a low-elevation site immediately east of Joyce Kilmer averages approximately 1500 mm per year (NOAA 1990). However, the high-elevation areas of Joyce Kilmer experience substantially higher precipitation levels. Sites in the Smoky Mountains with similar elevation to the high-elevation (1500 m) Joyce Kilmer area, average 2200 mm rain per year (Shanks 1954). The southern Little Santeetlah valley of Joyce Kilmer also receives higher precipitation than the northern Slickrock valley which is in a modest rain shadow. Mean annual precipitation in the Nantahala area ranges from 1780 mm at the low-elevations to 2500 mm at the high-elevations (Swift *et al.* 1988). The Chattooga River averages between 1625 and 2150 mm of rain per year (DuMond 1970, NOAA 1990), while records from gorges adjacent to Thompson River suggest a mean annual rainfall of between 2300 and 2500 mm for the wetter, upper-gorge region (Wentworth 1980).

January and February are typically the coldest months, and July and August are the warmest months in the Southern Appalachian Mountains (Stephens 1969, Swift *et al.* 1988, Earthinfo Inc. 1989). In the Smoky Mountains, Dickson (1959) found a greater elevational temperature gradient in the summer than the winter, which Hicks (1979) attributes to higher summer solar radiation intensity. During the summer, higher-elevation areas in the Smoky Mountains are typically 5.6-8.4° C cooler than low-elevation areas (Shanks 1954). Shanks (1954) suggests a decrease in average annual temperature of 1.24° C per 305 m of elevation for the Smoky Mountains. In the Smoky Mountains, Stephens (1969) recorded July temperature averages of 22° C at 445 m and 13° C at 1920 m. Similar low-elevation areas have winter temperatures of 6 - 8° C (Shanks 1954). Further north, Mount Mitchell (2022 m elevation) and Grandfather Mountain (1605 m) have summer temperatures of, respectively 17° C and between 13° and 21° C (McLeod 1988, Earthinfo Inc. 1989). Winter temperatures at Grandfather Mountain range between -8° and 2° C (Earthinfo Inc. 1989).

Low-elevation areas in the Southern Appalachian Mountains have winter temperatures which range between -4° and 12° C. Summer temperatures for low-elevation areas throughout the Southern Appalachian region range between 11° and 30° C (Swift *et al.* 1988, Earthinfo Inc. 1989, NOAA 1990).

Wind and snow are important climatic features of Southern Appalachian Mountain high-elevation areas. Grandfather Mountain averages 1300 mm of snow per year (Earthinfo Inc. 1989), although, snow depths vary across the region and from year to year. High-elevations experience winds of up to 100 km/hour for 20 to 25 days per year. Winds on high summits can reach over 200 km/hour at times (Saunders 1979).

1.4 Soils

Availability of soil information varies between landscapes in this study. The following descriptions are based on comprehensive soil surveys undertaken in 5 of the study areas.

Soil depth and characterization varies with underlying geology and geomorphology. The soils of slopes and ridges typically form in residuum from soil creep and weathering rock. High-elevation ridges and side slopes typically have thin soils. These sites are dominated by coarse-loamy, mixed frigid and mesic Lithic or Typic Haplumbrepts and coarse-loamy, mixed, mesic or micaceous Typic and Umbric Dystrochrepts. High-elevation areas underlain by felsic to mafic high-grade metamorphic and igneous rocks, have Burton, Craggey and Wayah soils on ridges and sideslopes, with coves and drainage systems underlain by Tanasee and Balsam. Areas with low-grade metasedimentary rocks have Cheoah and Oconoluftee soils (McLeod 1988, Soil Conservation Service 1994, Soil Conservation Service *unpub. data*).

Mid- and low-elevation slopes and mesic ridgelines have moderately deep soils. Such sites are dominated by loamy-skeletal or coarse-loamy, mixed, mesic Lithic, Typic and Umbric Dystrochrepts; coarse-loamy, mixed mesic Typic Haplumbrepts, loamy and fine-loamy, mixed mesic Typic and Humic Hapludults (McLeod 1988, Velbel 1988, Soil Conservation Service 1994, Soil Conservation Service *unpub. data*). Soils sort by geology and site orientation on this portion of the landscape. Warm slopes underlain by felsic to mafic high-grade metamorphic and igneous rock, are dominated by a different and broader range of soils (Ashe, Chestnut, Cleveland, Clifton, Cowee, Deneyville, Evard, Fannin and Hayesville) than cool slopes (Plott, Trimont). Ditney, Soco, Stecoah and Unicoi soils dominate warm slopes and mesic ridges underlain by low-grade metasedimentary rocks, whereas Cheoah and Jeffrey soils are prominent on cool aspects. Brasstown, Cataska, Junaluska and Sylco soils are present on sites of any aspect (McLeod 1988, Soil Conservation Service 1994, Soil Conservation Service *unpub. data*).

The soils of dry, lower-elevation sideslopes and ridges are thin and often stony. These are mapped as fine to coarse-loamy, mixed or micaceous, mesic Typic, Lithic or

Umbric Dystrochrepts and Typic Hapludults. These sites separate by geology, with Cowee, Evard, Fannin and Hayesville soils on more base-rich rock and soils in the Brasstown, Cataska, Ditney, Junaluska, Sylco and Unicoi series associated with less-fertile rock types (Soil Conservation Service 1993, Patterson 1994, Soil Conservation Service 1994).

Lower-slopes and riverflats have soils that developed on alluvium and colluvium. These sites are mapped as Typic Udifluvents, coarse-loamy, mixed mesic Umbric Dystrochrepts, and Typic and Fluventic Haplumbrepts (McLeod 1988, Soil Conservation Service 1993, Soil Conservation Service *unpub. data*). Coves and lower-slopes tend to have deep, moist soils in the Braddock, Cullasaja, Dillsboro, Saunook and Tuckasegee series on felsic to mafic high-grade metamorphic and igneous rocks, and Brevard, Soco, Spivey and Whiteoak series on low-grade metasedimentary rocks. Riverflats have soils in the Biltmore, Colvard, Dellwood, French, Hosting, Rosman, Spivey, Toxaway and Whiteoak series (McLeod 1988, Soil Conservation Service 1993, Soil Conservation Service *unpub. data*).

Rock outcrops are often associated with coarse, but thin, Typic and Lithic Dystrochrepts (Chestnut, Cleveland, Ditney and Unicoi series; Soil Conservation Service 1993, Patterson 1994). On such sites soils are thin and poorly developed.

1.5 Past disturbances

1.5.1 Human settlement, Logging

During the eighteenth and early nineteenth centuries, European settlements were diffusely scattered across mid- and low-elevation coves and toeslopes of landscapes throughout the Southern Appalachians (see Pyle 1988). Human impact was limited to some small-scale land clearance for cultivation, grazing and homesteads. Some broad, high-elevation ridges were cleared for pasture (Barden 1978a, Pyle 1988, USFS *unpub. data*).

Human presence and impact in forested landscapes dramatically increased in the late 1800's and early 1900's when widespread logging operations began. Logging has had a lasting impact on the current distribution of vegetation across much of the Southern Appalachians. Early logging was small-scale, selective and limited in its impact (McCracken 1978). Extensive, broad-scale logging activities occurred for 30 to 50 years in some landscapes. Logging type and intensity varied between localities, with extractions ranging from high-grade timber only, to near removal of the full overstory. Spruce and fir were the dominant species cut from high-elevation forests (Saunders 1979), while chestnut, oak, hickory, hemlock and a variety of other hardwoods were extracted from the mid- and lower-elevations. As an example, from 1895 to 1940 at Shining Rock, between 110,000 and 142,000 m^3 of timber (80% chestnut) was extracted for an area roughly 4500 ha in size (USFS *unpub. data*). The logs were typically hauled by animals and steam-powered skidders (McCracken 1978, USFS *unpub. data*), with the severe ground damage caused by the latter still visible in places today. The majority of logging halted between 1935 and the mid 1940's, enforced in some areas by the establishment of the Great Smoky Mountains National Park and National Forests and in other areas by the exhaustion of harvestable timber.

Some high-elevation areas, remote regions (J. Alger *pers. comm.*, USFS *unpub. data*) and less productive ridgelines escaped logging. These typically were small in size and scattered throughout the logged forest matrix. However, three large, intact areas of old-growth forest remain in the Southern Appalachian Mountains. This present study includes all two of these (the Little Santeetlah watershed in Joyce Kilmer, Linville Gorge) and part of the third (western Great Smoky Mountains).

1.5.2 Fire

Historically, fire had a major influence on the distribution of vegetation in the Southern Appalachians. The pre-European fire frequency and severity varied with respect to vegetation type, moisture and elevation (Harmon 1982). Low-elevations generally had higher fire potential due to lower precipitation levels and higher fuel loading. Fires were most frequent in pine forests (Barden & Woods 1973, Harmon 1982). Lightning and aboriginal Americans were the two major causes of fire in the Southern Appalachian Mountains (Harmon 1982). Aboriginals used fire to clear land for settlements and cultivation and to improve habitats for game (Delcourt & Delcourt 1996). Lightning strikes typically initiate small (mean size 3.4 ha) ground fires. The year-to-year frequency of lightning ignitions varies greatly, but is mostly concentrated between April and August. Ignitions are most frequent on xeric slopes and ridges at lower-elevations (Barden & Woods 1973).

European-set fires are typically somewhat larger (mean size 5.4 ha), more intense and spread faster than lightning fires (Barden and Woods 1973). Humans have been an important source of ignition in the Southern Appalachians over the past few centuries. Fire was used to clear land for food gathering, cultivation and maintaining pastures (Barden 1978a, Harmon 1982). Large, severe fires, often fueled by logging slash and enhanced by preceding droughts (see Hursh & Haasis 1931) occurred during the 1920's and 1930's throughout the Southern Appalachians (Saunders 1979, Harmon *et al.* 1983, Pyle 1988). The combination of drought, high fuel loadings from logging slash, and high winds which fueled the two fires that swept through Shining Rock Wilderness in 1925 and 1942, serves to illustrate how compounding factors can cause intense, widespread burning. Fires were deliberately lit in some cases. In some instances these fires caused deep soil loss (USFS *unpub. data*). The frequency of human-set fires declined as lands were incorporated into National Forests and Parks and fire suppression policies were enforced, but at least some fires today are initiated by humans (Barden & Woods 1973).

Research suggests that post-European, presettlement upland oak, pine and chestnut communities were subjected to frequent fires with a mean interval between fires of 7 to 12 years (Harmon 1982, France & Sutter 1987, Frost 1995). For the Smoky Mountains as a whole, Harmon (1982) estimated a mean fire return interval of 10-40 years. However, fire suppression of the last 50 or so years has reduced the flammability of xeric communities and the fire interval has increased (Harmon 1982). Post-suppression fires are typically less frequent, but more intense than pre-suppression fires (Barden & Woods 1973).

Historically, fires appear to have played an important role in the maintenance of xeric *Pinus* communities. Characteristics such as the epicormic sprouting and thick, fire-resistant bark of *Pinus rigida* and the serotinous cones of *Pinus pungens* (Zobel 1969, Barden 1978b, Harmon *et al.* 1983, Harmon 1984) suggest the importance of fire in the evolution and maintenance of these species. Fire burns litter, exposes mineral soil and eliminates competing vegetation (Zobel 1969). Intense crown fires provided suitable conditions for *Pinus* regeneration (Barden & Woods 1976), whereas less intense fires probably stalled replacement by young hardwoods and thus helped maintain pine dominance. However, 50 years of fire suppression have lead to a general decline in the cover of pine species and an invasion of hardwood species. Suppression may have allowed hardwoods invading xeric *Pinus* communities to grow into fire-resistant size classes (Harmon 1984).

Fire appears to be necessary for the maintenance of some oak forests (Lorimer 1989, Abrams 1992). Poor regeneration by _Quercus_ species has been noted throughout eastern North American forests and its thought to result from fire suppression. Low-intensity surface fires appear to stimulate oak regeneration and reduce the abundance of shade-tolerant but fire-sensitive competitors.

Other, less abundant plant communities and species are also maintained by fire. The recovery of rock outcrop vegetation after recent controlled burns in Linville Gorge suggests that fire was and remains important for sustaining specific vascular species associated with the outcrops, particularly the rare prostrate shrub *Hudsonia montana*, which is endemic to exposed rock ledges in the Linville vicinity. Fire reduces the competition of aggressive woody shrubs and lichens which hinder the establishment and growth of *Hudsonia* and other rock outcrop plants (Frost 1990, 1993).

1.5.3 Tree diseases

Chestnut was once a major canopy species throughout the Southern Appalachian Mountains (Reed 1905, Braun 1950, Whittaker 1956) but was severely attacked by the introduced chestnut blight (*Cryphonectria parasitica*) during late 1920's and 1930's (Keever 1953, Arends 1981). Today chestnut persists only in sprout form as a minor component of the understory.

Research from Joyce Kilmer provides some insight into the impact of loss of chestnut on the surrounding forests. Peak establishment of *Liriodendron*, *Betula lenta* and *Acer rubrum* in Poplar Cove suggests that in Joyce Kilmer chestnut was severely infected by about 1935 (Lorimer 1976). The death of this species, which represented 20 to at least

50% of the canopy (Braun 1950, Lorimer 1976), has had a major impact on these low-elevation forests. Lorimer (1976) suggests that stand structure and composition of some stands in this area were affected more by chestnut death than any other disturbance in the preceding 200 years or so. A period of high windthrow frequencies followed the blight, producing 50 to 60 overstory treefalls/hectare in this area (Lorimer 1976). The impact on the surrounding forests was potentially immense; chestnut trees were generally large, resistant to decay and typically fell with root crown, stem and bole still intact (Lorimer 1976, *per. obs.*), which illustrates the potential size of the gaps created by a falling chestnut tree.

Loss of chestnut, like other disturbances, lead to a release of trees from suppression and high seedling (particularly *Acer rubrum*, *Betula lenta*, *Halesia tetraptera*) establishment (Lorimer 1976). In some instances canopy composition was drastically altered. Alteration of understory site conditions, resulting from canopy opening lead to changes in understory species composition (Woods & Shanks 1959).

The impact of the balsam woolly adelgid (*Adelges piceae*) in spruce-fir forests has been widespread throughout the high peaks of the Southern Appalachians. The adelgid attacks fraser fir (*Abies fraseri*) that is a major canopy species of high-elevation forests. *Abies* can persist in sapling form, but is attacked through bark fissures once trees are >4 cm in diameter (Eagar 1984, Busing & Clebsch 1988).

The impact of other introduced tree pathogens and pests has been less widespread and/or has initiated more subtle changes to vegetation composition and structure. Dogwood and butternut populations have both been infected (Britton & Pepper 1994). Hemlock and oak species are predicted to be attacked by the hemlock adelgid and gypsy moth that are moving south towards the Southern Appalachian region. The potential impact of these two insects is high. They have the potential to dramatically alter the vegetation composition of this region, with the level of change comparable to the impact of chestnut blight.

1.6 Vegetation

Broad-based vegetation patterns of the Southern Appalachian Mountain region have been described by Braun (1950). She documented three general groups within the Southern Appalachian Mountain section of Oak-Chestnut Forest region. Braun's Moderate Elevation forests subdivide into Oak-Chestnut forests, Mixed Mesophytic or Cove Hardwood forests and Oak-Pine forests and these are present over much of the mid- and low-elevation areas of the Southern Appalachians. Some higher-elevation landscapes include both of Braun's Higher Elevation forest types; the Northern Hardwood forests and Spruce-Fir forests, with the latter more restricted in distribution. Braun's Balds forms (grassy and heath) have scattered distribution throughout the mid- and high-elevations of this region.

More detailed vegetation descriptions were documented by Whittaker (1956) for a small subsection of the Southern Appalachian region. He also examined vegetation distribution patterns and identified elevation and topographic-moisture as the major gradients with which vegetation is associated. Both Braun (1950) and Whittaker (1956) provide a starting point for understanding vegetation patterns across the Southern Appalachian Mountains. However, more recent vegetation studies in this region have suggested that biophysical factors such as climate, underlying geology and soils may have significant associations with regional vegetation patterns. In this present study I examine how soil and topographic characteristics, geology and climate relate to variation in the distribution and composition of vegetation across the Southern Appalachian region.

CHAPTER 2. METHODS

2.1 Field Sampling

Samples from 1199 stands in 9 landscapes were included in this study (Table 2.1). Plots were located over the range of available elevations, and topographic and geologic conditions so as to capture the topographic and edaphic diversity present in each landscape. Each plot was located in an area of comparatively homogeneous vegetation and topography.

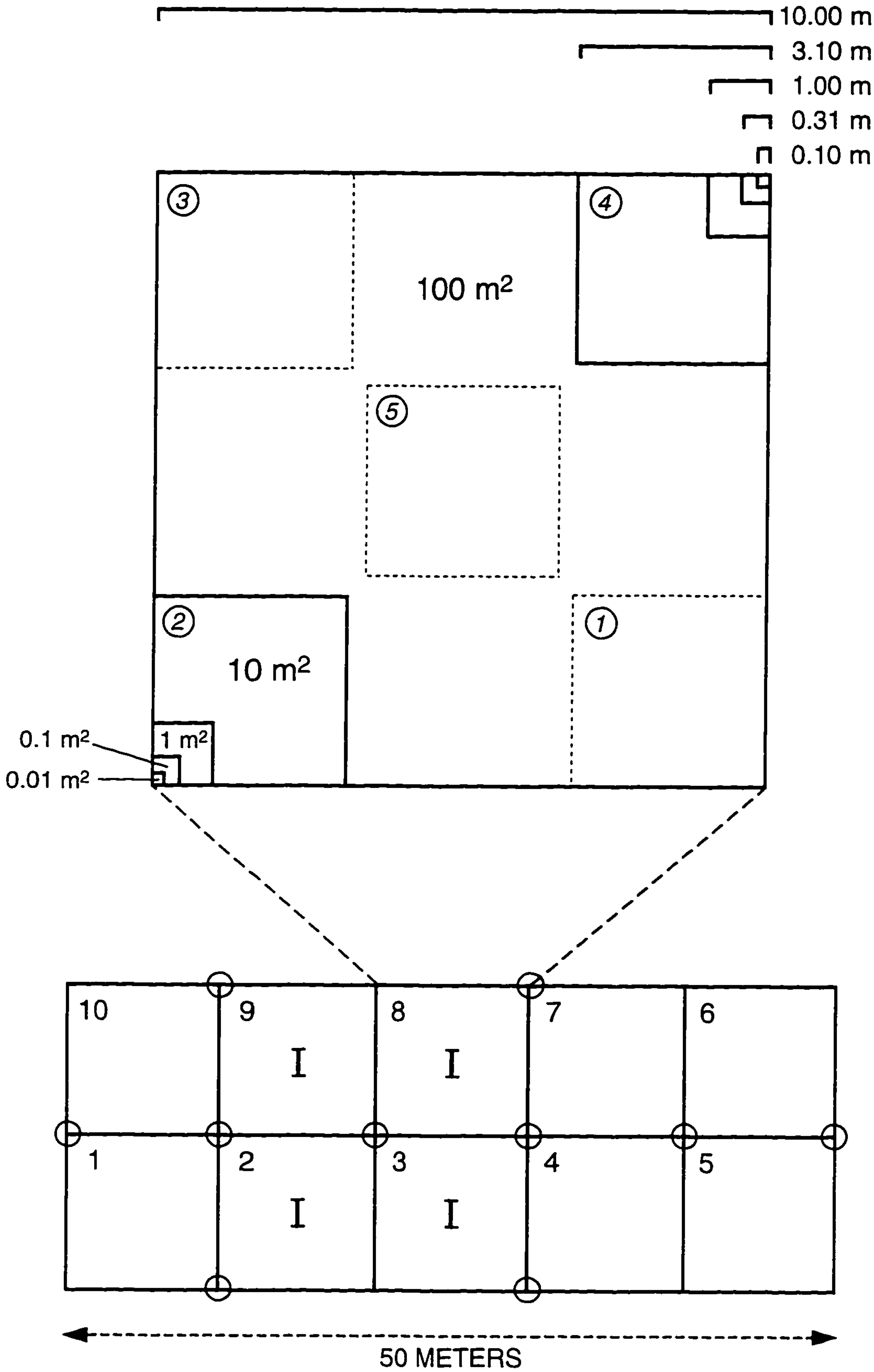
For the Chattooga River, Grandfather Mountain, Joyce Kilmer, Linville Gorge, the Nantahalas, Shining Rock and the 1996 Smoky Mountain stands, vegetation was sampled using the methodology developed for the North Carolina Vegetation Survey (NCVS; see Peet *et al.* 1996; Table 2.1). The standard sample unit consisted of contiguous 0.01 ha (10 x 10 m) modules, which were typically aggregated to form a standard sample aggregate or plot of 20 x 50 m (ten modules; Figure 2.1). A smaller number of 10 x 10 modules were used where the spatial extent of homogeneous vegetation or topography could not accommodate a 0.1 ha plot. Half-inch, thin-wall steel conduit stakes were used to permanently mark the plot center line and module corners in all of these localities (Figure 2.1).

Each aggregate plot contained one to four (typically four) intensively sampled modules (Figure 2.1). Presence and cover of all plant species were recorded in each intensive module and all tree stem diameters were recorded by diameter. The presence of all vascular species rooted within the module was recorded in two to four sets of nested sub-modules with the following nesting classes: **5** = 10 x 10 cm sub-module, **4** = 31 x 31 cm, **3** = 1 x 1 m, **2** = 3.1 x 3.1 m, and **1** = 10 x 10 m (i.e. the entire module). Species cover was estimated as a vertical projection onto the module and was assigned using a ten-class system: **1** = trace, **2** = 0-1% cover, **3** = 1-2%, **4** = 2-5%, **5** = 5-10%, **6** = 10-25%, **7** = 25-50%, **8** = 50-75%, **9** = 75-95%, and **10** = 95-100%. Diameters of all woody stems (trees,

Table 2.1. Plot information for the 9 landscapes used in this dissertation. Vegetation was mostly sampled using the standard North Carolina Vegetation Survey (NCVS) sampling scheme (normal plot size = 0.1 ha; Peet *et al.* 1996), or was collected using methods similar to those of Whittaker (1960; 0.1 ha plot size). Data from Whittaker plots were subsequently adjusted to be compatible with the NCVS scheme (see text). Number of forest plots used in the regional analysis and total number of plots in the datasets are shown for each landscape.

Study Area	**sampling method**	**years sampled**	**number of samples**	**number of forested plots**
Black and Craggy Mountains (McLeod 1988)	Whittaker	1970-1986	156	137
Chattooga River Gorge: Chattooga River (USFS *unpub. data*)	NCVS	1993	20	20
Ellicott Rock Wilderness (Patterson 1994)	NCVS	1990, 1991	57	54
Grandfather and Roan Mountain (NCVS 1995, *unpub. data*)	NCVS	1995	75	70
Great Smoky Mountains: 1996 plots (Dellinger, *unpub. data*)	NCVS	1996	32	32
1977-1981 plots (White, described in Callaway *et al.* 1986)	Whittaker	1977-1981	75	75
Joyce Kilmer/Slickrock Wilderness (Chapter 5)	NCVS	1994, 1995	183	177
Linville Gorge Wilderness (Chapter 3)	NCVS	1992	181	162
Nantahala Mountains: (NCVS 1995 & 1996, *unpub. data*)	NCVS	1996	89	85
(Roberts 1996)	NCVS	1994	18	18
Shining Rock Wilderness (Chapter 4)	NCVS	1993	160	140
Thompson River Gorge (Wentworth 1980)	Whittaker	1976-1978	150	150
TOTAL NUMBER OF SAMPLES:			**1199**	**1120**

Figure 2.1. Diagram of standard 0.1 ha sample plot with ten, 10 x 10 meter modules. Typical module numbering is given, 'o' = permanent metal stake positions and 'I' = intensively sampled modules. Intensive modules were typically sub-sampled at five nested sizes in two corners. Additional sub-modules were sometimes sampled in plots less than 400 m^2 in size. The dashed line indicates the positions of additional nested sub-modules.



10.00 m
3.10 m
1.00 m
0.31 m
0.10 m
3
4
100 m2
5
2
1
10 m2
1 m2
0.1 m2
0.01 m2
10
9
8
7
6
I
I
1
2
3
4
5
I
I
50 METERS

shrubs and lianas) taller than 1.4 m in height were recorded at 1.4 m (breast height) by the following diameter classes: (0-1 cm, 1-2.5 cm, 2.5-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, 20-25 cm, 25-30 cm, 30-35 cm, 35-40 cm; stems ≥ 40 cm diameter were recorded separately to the nearest centimeter). If the full sample contained fewer than 4 modules, all modules were sampled intensively. Presence and cover were estimated for any additional vascular plant species rooted in the remaining (residual) modules (usually 6). Woody stems were tallied collectively, by species and diameter, for all the residual modules. For stands from Grandfather and Roan, Joyce Kilmer, Linville Gorge, the Nantahalas and Shining Rock, the vertical structure of the entire intensively sampled module area was recorded by assigning cover abundance scores to individual woody species for each of the following height classes: 0-0.5 m, 0.5-6 m, 6-15 m, 15-35m and >35 m.

For the Black Mountains, the Smoky Mountains and Thompson River datasets, vegetation was sampled with 0.1 hectare plots similar to those used by Whittaker (1960) and Peet (1981). At the Black Mountains leaf cover of all species was estimated using a modified seven-class Braun Blanquet scale, where 1 = solitary with small cover, 2 = few with small cover, 3 = numerous up to 5% cover, 4 = 5-25%, 5 = 25-50%, 6 = 50-75%, 7 > 75% (McLeod 1988). McLeod's cover values were converted to the standard NCVS ten-class system described above. Braun Blanquet cover values 1 and 2 were converted to NCVS class 1, whereas Braun Blanquet classes 5 and 6 were converted to NCVS cover classes 7 and 8. Class 7 in McLeod's Braun Blanquet system was converted to NCVS class 9 as it is rare to have a NCVS class value of 10. The Braun Blanquet classes 3 and 4 had to be converted to NCVS classes 2,3,4 and 5,6, respectively. To achieve this, the relative frequencies of these five NCVS classes were calculated in a NCVS dataset of roughly 180 plots. Braun Blanquet classes in the Black Mountain dataset were then randomly assigned to their corresponding NCVS cover classes, constrained by the frequency of the respective NCVS classes in the NCVS dataset (Wentworth & Ulrey 1996).

Absolute percentage cover values for leaf area of species <1.4 m tall at Thompson River and the Smoky Mountains were assigned to a NCVS cover class based on their percentage cover. For these two study areas, woody species were recorded by stem diameter at breast height (1.4 m). Diameters were converted to the ten-class cover scale using regression methods developed by Wentworth & Ulrey (1996). Firstly, tree stem diameter and crown diameter information of individual species collected at Wine Springs, NC (USFS *unpub. data*), was used to develop a model to predict tree crown area from stem diameter information. This model was then applied to the Ellicott Rock Wilderness dataset (Patterson 1994), where stem diameter tallies and NCVS cover class values had both been recorded. For individual tree species, total crown area of all stems was calculated for the combined four intensively sampled modules. Crown area measurements were rescaled to 0.1 ha to be compatible with the scale of NCVS cover class estimates. NCVS cover class scores from the Ellicott Rock Wilderness dataset were linearly regressed against estimated log transformed tree crown area to develop a model to predict species cover class values (Wentworth & Ulrey 1996).

Botanical nomenclature follows Weakley (1997) where completed, and otherwise Kartesz (1994). For example, *Quercus montana*, as recognized by Weakley (1997), was accepted as the preferred name over *Q. prinus* recognized by Kartesz (1994). Standardization of the datasets used in the regional analysis are discussed in Chapter 6.

Characterization of the surface substrate provides an additional method of quantifying the environmental conditions of a plot site. For stands at Grandfather Mountain, Joyce Kilmer, Linville Gorge and Shining Rock, surface substrate composition of the total intensively sampled area was estimated using percentage cover of seven surface classes: bryophytes and lichens, decaying wood, bedrock and boulders, gravel and cobbles, sand and mineral soil, litter and organic matter, and water.

Documentation of the disturbance history provides important information for interpretation of compositional data. For Joyce Kilmer, Linville Gorge and Shining Rock, evidence of past disturbances in the plot and surrounding area were recorded. The presence of fire scars, charred stems and pieces of charcoal (>5 mm) in the soil profile was noted as evidence for past fire. Proximity to human disturbances, such as camp sites and walking trails and evidence for past logging were also noted for all plots. The presence of chestnut logs and sprouts was recorded. Estimates of stand canopy age were made by coring at least four medium-sized canopy trees of the dominant species within a plot. For Shining Rock, disturbance history was supplemented with detailed fire and logging disturbance maps, derived by the US Forest Service from historic records (USFS *unpub. data*).

For the Grandfather and Roan, Joyce Kilmer, Linville Gorge, Nantahalas and Shining Rock, detailed directions for plot relocation were recorded on the original plot sheets now archived in the Biology Department, University of North Carolina at Chapel Hill. Site position for plots from Linville Gorge, Joyce Kilmer and Shining Rock were permanently marked by a pin prick on 1:24,000 color, winter-flown aerial photograph transparencies and prints, and 1:12,000 color, winter-flown aerial photograph enlargements and are archived at the office of the National Forests of North Carolina, Asheville. A digital copy of all 9 datasets used in this study are archived in the Biology Department, University of North Carolina at Chapel Hill. Plant collections (between 300 and 2000 specimens per study area) for the Grandfather and Roan, Joyce Kilmer, Linville Gorge, Nantahalas and Shining Rock datasets are housed at the Herbarium of the University of North Carolina at Chapel Hill.

2.2 Site environmental characterization

Quantification of specific environmental information is necessary to understand compositional variation both within individual landscapes and between landscapes across the Southern Appalachian Mountain region. Past Southern Appalachian studies have documented or suggested strong links between vegetation composition and elevation, topographic characteristics, soil nutrients and underlying geology (e.g., Whittaker 1956, McLeod 1988, Patterson 1994, Wiser *et al.* 1996, Newell *et al. in press*). A wide range of specific environmental information was used in the present study in an attempt to quantify all potentially important factors that might correspond with variation in vegetation composition.

2.2.1 <u>Soil characteristics</u>

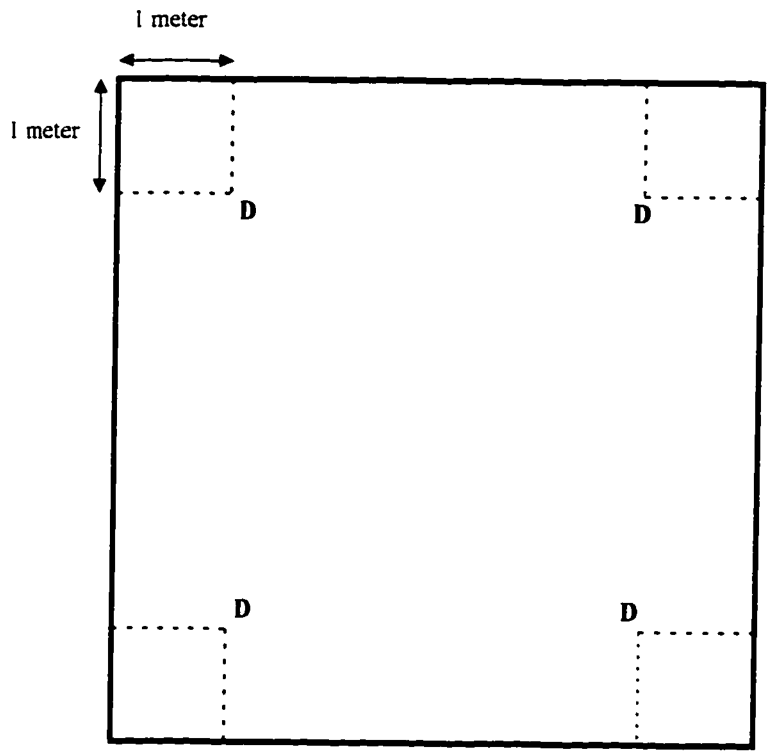
For study areas sampled using the NCVS methodology (see Table 2.1), soil samples were collected from the top 10 cm of mineral soil (below the litter layer) in the center of each intensively sampled module (Figure 2.1). Four subsamples were also collected in plots from the Black Mountains (McLeod 1988). In the Thompson River, one composite sample was used, pooled from 5 subsamples, collected at 10 m intervals along the plot 50 m centerline (T. Wentworth *pers. comm.*).

Total exchange capacity (m.e.q./100g), pH, percent humic matter, estimated nitrogen release, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Ca, Mg, K, Na, other bases, H), extractable micro-nutrients (B, Fe, Mn, Cu, Zn, Al (p.p.m)), soluble sulphur and bulk density values were determined for each subsample. Extractions were carried out using the Mehlich III method (Mehlich 1984) and percent humic matter was determined by loss on ignition. Textural analysis was determined using the Bouyoucos hydrometer method (Patrick 1958) for a composite sample of the four subsamples from each plot (for Grandfather Mountain, Joyce Kilmer, Linville Gorge, the Nantahalas, Shining Rock, the 1996 Smoky Mountain plots) and one subsample per plot from the 1977-1981 Smoky Mountains plots. Chemical and textural analyses were conducted by Brookside Laboratories, Inc., New Knoxville, Ohio (for the Chattooga River, Grandfather Mountain, Joyce Kilmer, Linville Gorge, the Nantahalas, Shining Rock, the 1996 Smoky Mountain plots) or the North Carolina State Testing Laboratory, Raleigh, North Carolina (for Black Mountains, Thompson River). Texture and pH readings for the 1977-1981 Smoky Mountain data were calculated by R. Callaway (Callaway 1983).

All soil values for a plot (typically four) were averaged to obtain a single soil plot value. Compatible soil information was not available for 59 plots at Thompson River and 32 at the Black Mountains. Texture values were not calculated for soils from the Black Mountains, Chattooga River, Thompson River and 18 of the Nantahala plots (Roberts 1996).

For plots sampled at Shining Rock and Joyce Kilmer, soil depth to bedrock was measured as a surrogate for soil moisture storage capacity. Depths were measured in centimeter increments up to 90 cm in depth using a metal probe. Measurements greater than 90 cm were assumed to have uniform influence on moisture storage. Soil depths were obtained from the four corners of each intensively sampled module at a 1.4 m diagonal distance inside the module corner for a typical total of 16 measurements per plot (Figure 2.2). Depths were averaged to obtain mean module and plot values.

Figure 2.2. Position of soil depth measurements, represented by 'D', in an intensively sampled module. Similar measurements were made in all intensively sampled modules within a plot. See Figure 2.1 for the full 0.1 ha plot layout. Measurements are not to scale.



2.2.2 Topographic characteristics

The influence of topography on vegetation distribution has been quantified in a number of studies conducted in the Southern Appalachian region (e.g., Callaway *et al.* 1987, McLeod 1988, Fels 1994, Patterson 1994, Newell *et al. in press*). However, no single characteristic has been found to adequately characterize the influence of the complexities of topography on vegetation. Moreover, correlations between vegetation and specific components within this complex variable may vary between landscapes. I measured a broad range of variables in an attempt to characterize all potentially important topographic characteristics. Elevation, slope and aspect were measured at the center of the combined intensively sampled module area (Figure 2.1). Meso-scale landform characteristics, or plot location within the surrounding landscape, was quantified using the McNab (1993) Landform Index (LFI). LFI was calculated by measuring the slope percentage to the horizon in the eight cardinal and subcardinal directions (45° increments) using the plot aspect as the first cardinal vector. The same 45° increments were used to measure microtopographic shape or terrain shape, calculated as the McNab (1989) Terrain Shape Index (TSI). TSI was obtained by measuring the plot ground surface slope angle of 20 meter vectors. Slope angles were recorded in degrees in the field and converted to percentages to calculate these indices. For Linville Gorge, Joyce Kilmer and Shining Rock, map distance in millimeters downslope to the nearest stream and distance upslope to the nearest ridge were recorded from a 1:24,000 scale map with measurements made perpendicular to the contour lines. To eliminate potential problems associated with variable stream-to-ridgeline slope lengths, the preceding two distances were used to calculate relative slope position where relative slope position = distance to nearest stream divided by distance to nearest ridge plus distance to nearest stream, with increasing relative slope position values corresponding to higher slope position. Subjective multi-point indices (Table 2.2) were used to characterize topographic position (nine category index) and landform type (seven-point index).

Sample site locations from each study were digitized and entered into a geographic information system (GIS) database. After error checking, site latitude, longitude and UTM (North American Datum 1927) co-ordinates were extracted. Site locations were used to extract landform characteristics from a USGS 30m-resolution digital elevation model

Table 2.2. Topographic environmental indices recorded at each sample plot in the three Wilderness areas.

Topographic position:

A - plain/level
B - toe
C - lower-slope
D - mid-slope
E - upper-slope
F - escarpment/face
G - ledge/terrace
H - crest
I - basin/depression

Landform type:

A - cove
B - ridge
C - side-slope
D - ravine
E - gully
F - river flat
G - river margin

(DEM). Digital LFI and TSI were calculated for the three landscape analyses, with the latter derived using a 3 X 3 pixel window (i.e. 90 X 90 m area) using software written by J.E. Fels. Characteristics of site shape were defined by calculating site profile curvature, which measures microtopographic curvature parallel to slope aspect, and site section curvature, measuring shape perpendicular to aspect. Digital relative slope position (RSP; Wilds 1996) was calculated for the 9 landscapes in the regional analysis using methods developed by Wilds (1996). For digital relative slope position increasing values correspond to sites with higher slope position. These were calculated in ARCINFO (Environmental Systems Research Institute, Inc. 1995).

Aspect was transformed into a linear variable ranging from 0.00 to 2.00 using the method of Wiser *et al.* (1996), as modified from Beers *et al.* (1966): $A' = \cos(A_{max} - A) + 1$, where A = aspect measured in degrees and A' = the transformed aspect code. Transformed values between 1° and 75° with increments of 5° were used to identify A_{max}. A_{max}, the aspect with the most mesic vegetation was derived as the value that maximized the variance in vegetation accounted for using Canonical Correspondence Analysis (CCA; ter Braak 1987) with transformed aspect as the sole environmental determinant. For Joyce Kilmer, $A_{max} = 01°$, whereas $A_{max} = 50°$ at both Linville Gorge and Shining Rock. For the collective 9-landscape region used in the regional analysis $A_{max} = 40°$.

Solar radiation has been shown to correlate with vegetation composition (Hutchison & Matt 1977). Potential solar radiation was calculated digitally in ARCINFO using the program SOLARFLUX (Hetrick *et al.* 1993a, 1993b). SOLARFLUX uses an elevation surface and latitude with the user able to specify time of year, time-length per day and time-interval per day for solar radiation calculations. In each study solar radiation was based on hourly calculations for five hours (between 10:00 and 15:00 hours) per day for March 23. This date was chosen based on the findings of a study by Hutchison & Matt (1977) and my own analyses. In a detailed study of solar radiation penetration into deciduous forest, Hutchison & Matt (1977) showed that for forest strata beneath the canopy, daily solar radiation totals were highest in late spring prior to canopy tree leaf expansion. This suggests that solar radiation has greatest impact on the broadest range of species during late spring. To verify this conclusion, I correlated vegetation plot scores on ordination axes 1 and 2 with solar radiation values calculated for December 23, March 23, June 23 and September 23, and also the average of these four values. For each dataset (Joyce Kilmer, Linville Gorge and Shining Rock), I found highest correlations between spring solar radiation values and vegetation stand scores.

Topographic-moisture has been suggested to control Southern Appalachian Mountain vegetation patterns (e.g., Whittaker 1956, Day *et al.* 1988, McLeod 1988). Subjective attempts at quantifying such a complex gradient (e.g., Wentworth 1980, Peet 1981) have been refined in more recent studies with the use of quantitative methods of characterizing topography (e.g., Fels 1994, Patterson 1994, Newell *et al. in press*). To quantify site moisture potential I used digital topographic information to develop the Topographic Moisture Index (TMI; also see Newell *et al. in press*), using a modified version of Parker's (1982) topographic relative moisture index. Following Parker (1982), TMI values range from 0 to 60, with higher values corresponding to greater site moisture. TMI is an additive scalar based on the influence of three topographic characteristics; topographic position (relative slope position), curvature and solar radiation. Topographic position, orientation (slope and aspect) and potential solar radiation are known to have a strong influence on vegetation patterns through evapotranspiration and water runoff (Selby 1985). Digital relative slope position was computed using methods developed by Wilds (1996) and was rescaled to have values of between 0 and 20. A measure of overall site curvature was calculated using profile and section curvature (see Wilds 1996) and this was rescaled to have values between 0 to 10. Spring solar radiation (March 23) values, calculated using SOLARFLUX, were rescaled to have values between 0 and 30. Rescaled curvature, solar radiation and relative slope position values were added to produce a measure of site potential moisture, the TMI index. All variables and final TMI values were calculated in ARCINFO.

2.2.3 Local climatic variation

Topographic characteristics, such as the sharp topographic rise associated with the Blue Ridge Escarpment front, site orientation and changes in elevation influence the local distribution and intensity of rain (Dickson 1959, Moore *et al.* 1991, Basist *et al.* 1994, Konrad 1996, Chapter 1). The location of Shining Rock along a steep precipitation gradient between the high-rainfall Escarpment front and the Asheville Basin rain-shadow area suggests the existence of a precipitation gradient across this study area. Restriction of daily summer rainstorms to the southern-most and high-elevation portions of Shining Rock (*pers. obs.*) reinforce such a suggestion. Variation in localized precipitation patterns may influence the vegetation patterns and the following methods were used to examine this hypothesis.

Limited weather station numbers and their high concentration in low-elevation areas of the Southern Appalachians have lead climatologists to search for alternative methods to accurately model rainfall patterns. Studies have shown high correlations between distance to moisture source regions and precipitation patterns (e.g., Doll 1992, Konrad 1996). I attempted to describe the spatial variation of rainfall across Shining Rock by using distance to moisture source as a surrogate for quantified rainfall measurements. All distances were measured in millimeters from 1:24,000 scale topographic maps. I identified two potential moisture source areas in Shining Rock; the Escarpment and high-elevation region. The Escarpment roughly bounds the southern section of Shining Rock. The middle Escarpment section faces due south with the adjacent two sides oriented at 45°, facing to the southeast and southwest of this section. To account for possible influence of rain from each escarpment section on a sample site, I measured the shortest distance from a plot to each section and averaged the three measurements to determine the mean plot-to-Escarpment distance, representing the mean effect of rainfall produced by Escarpment orographic storms on a plot site. The high-elevation region within Shining Rock was defined as the area ≥1700 m (5600 ft). Distance from each plot to the nearest high-elevation area quantified the influence of rain from this moisture source. The effect of rain from both moisture sources on a plot was quantified by multiplying average escarpment distance and shortest distance to the high-elevation zone.

Rainfall gradients exist within most landscapes in the Southern Appalachians. However, the position of Shining Rock between the high-rainfall Escarpment front and the Asheville Basin rain shadow, which together almost represent the two extremes of the rainfall gradient in the Southern Appalachians, points to a higher rate of change in rainfall levels across the Shining Rock landscape than experienced in most landscapes. There is a strong rainfall gradient across the Southern Appalachian region (see Chapter 1). However, lack of quantitative information prevents me from quantifying the influence of this environmental process on regional-scale vegetation patterns.

2.3 Classification and characterization

To quantify compositional variation within individual landscapes and across the region, stands were clustered into groups with compositionally similar vegetation. The vegetation and site characteristics of each was quantified to help differentiate between groups.

Prior to analysis, data was summarized across each plot. For each species in each plot in all localities, an overall plot mean cover was calculated by converting cover scores to their respective mid-point percentage value, averaging these across the entire 0.1 ha plot aggregate, and then converting percentages back to cover score classes. All soil nutrient values were log-transformed before ordination analyses to make values biologically more interpretable (Palmer 1993).

Stem diameter information was used to calculate total stem densities and basal area for each species per hectare. Relative density and relative basal area were averaged to form an importance value for individual woody species. For Joyce Kilmer, Linville Gorge and Shining Rock site chemical and textural information were classified by geologic type and a multiple analysis of variance was performed to determine whether the soil chemistry and texture of each geologic type were statistically different.

2.3.1 Numerical methods

A community classification was generated for each of the three individual landscapes (Joyce Kilmer, Linville Gorge and Shining Rock) and for the entire 9-landscape dataset by clustering the sample plots into groups containing compositionally similar vegetation. The regional classification only included mature forest stands (see Table 2.1). Preliminary analyses were undertaken using three different polythetic, hierarchical clustering techniques. Two-Way Indicator Species Analysis (TWINSPAN; Hill 1979b) as implemented in Hall (1992) was chosen because it is considered as the standard clustering method by many ecologists (e.g. Rodwell 1991). The results of this method were compared with two distance-based, agglomerative clustering techniques, Unweighted Pair-Group Method using arithmetic Averages method (UPGMA; Sneath & Sokal 1973) and Ward's minimum variance method (Ward 1963). Both agglomerative methods are robust, widely-used clustering algorithms (Sneath & Sokal 1973, Orloci 1975, Feoli & Gerdol 1982, Pielou 1984, Belbin & McDonald 1993). Ward's method identifies clusters using minimized within-cluster variance which is defined as the sum of squares of the distances between every point and the centroid of the cluster. In contrast, UPGMA uses average dissimilarity to determine group membership (Gauch 1982, Pielou 1984). These two techniques were implemented in SAS (SAS Institute Inc., 1996) using PROC CLUSTER. The TRIM function in PROC CLUSTER was used to remove outliers from a cluster analysis. TRIM omits samples with low estimated probability densities from the analysis (SAS Institute Inc., 1990). Two dissimilarity measures were used to calculate a dissimilarity matrix that calculates distances between stands, based on (1) species cover, using the coefficient of community value (Bray & Curtis 1957) with average cover per 0.1 ha plot used and (2) species presence or absence, based on Jaccard's similarity coefficient (Sneath 1957).

A weakness of the Ward's method is the formation of similar-sized clusters (Pielou 1984). The generation of equal-sized groups can spuriously place outlying plots or groups throughout the classification. These were removed using the TRIM function. UPGMA is subject to chaining. Moreover, in this method distances between clusters are undefined because clusters can not be identified with a precise representative point (Pielou 1984). However, one strength of UPGMA is its ability to separate rare, peripheral samples into groups (Sneath & Sokal 1973, Gauch 1982).

In the past TWINSPAN has been one of the most widely used clustering methods, however recent research has identified several short comings of this method. TWINSPAN dichotomizes stands on the basis of one compositional gradient, which does not adequately represent the multiplicity of compositional gradients present in these complex datasets. This method divides a dataset dichotomously into more or less two halves (Gauch 1982, van Groenevoud 1992), which results in the placement of compositionally similar stands on both sides of the primary dichotomy in each of the three landscape classifications. Similar results have been observed by others (e.g., van Groenevoud 1992, Belbin & McDonald 1993). Subsequent subdivisions in a TWINSPAN analysis compound the problem of displacement at the first dichotomy (Belbin & McDonald 1993). More recent research has also shown that divisions made by TWINSPAN are subject to variation in the data input sequence (Tausch *et al.* 1995, R.P. Duncan & R.K. Peet *unpub. data*). However, improved code is now available, so the latter problem is not really relevant to this project, though a failing in most.

Data standardization is used to increase the interpretability of a dataset and reduce or increase the weighting of specific individuals or groups of species (Noy-Meir *et al.* 1975, Faith *et al.* 1987). The ten-class cover system used in this present study represents a logarithmic transformation of species percentage cover. There are numerous methods for standardizing data, with each weighting different characteristics of a dataset (see Noy-Meir *et al.* 1975, van Tongeren 1995). The appropriateness of a standardization method is dataset-specific and dependent on such factors as the extent of compositional variation and variability in cover values, of both individual species and the dataset as a whole (see Noy-Meir *et al.* 1975). The need to standardize a dataset was determined by the discreteness of stand positions classified by their respective vegetation group on an ordination scatterplot and overall compositional similarity of stands within a dataset. Standardization might help distinguish subtle differences between stands with similar composition.

The two standardization methods species maxima and relative abundance were used. To standardize by species maxima, the abundances for each species were summed across all sites and divided by the total. This method gives uncommon and low-cover species higher weighting and downweights the common, abundant species (Noy-Meir *et al.* 1975, van Tongeren 1995). Standardizing by species maxima should give understory species greater weighting in a cluster analysis. This method is regularly used by some ecologists (P. Minchin *pers. comm.*). In the second method, where cover was standardized by site total, species were given a relative abundance within a stand. The cover scores of all species in a stand were summed and the abundance of each species was divided by the total (Noy-Meir *et al.* 1975, van Tongeren 1995). This gives equal weight to the compositional information from each site (Noy-Meir *et al.* 1975). Moreover, while the relative abundance of a species may change, its ranking within the stand will remain the same. Relative abundance and rank-order of a species may provide a better method for separating differences between compositionally similar stands.

The same general clustering strategy was used for all three landscape studies. TWINSPAN was rejected as a clustering method following initial preliminary landscape study analyses that placed compositionally similar stands on both sides of the first dichotomy. The two distance-based clustering methods were performed using presence/absence and species cover matrices of raw cover and cover standardized by species maxima and relative abundance. The results of each clustering method were evaluated subjectively by examining the distribution of classified stands on Detrended Correspondence Analysis axes (see below) and evaluating species composition for individual groups identified within each method.

Although similar clustering procedures were performed on each dataset, differences in the composition, breadth of compositional variation and the disturbance history of each wilderness suggested that no single clustering strategy would be appropriate in all three landscapes. The Linville Gorge dataset contains several small groups of compositionally extreme plots and a large number of stands with only subtle compositional differences. I needed a clustering approach that would recognize both the rare, extreme groups and the more common, floristically closely associated groups. For Shining Rock and Joyce Kilmer clustering procedures considered the possible effects of past disturbance by logging on species composition. Species abundance at a given site may reflect logging history rather than the specific environmental conditions at hand. Classifications based on species presence/absence were performed to eliminate any possible effects of inconsistent species cover due to logging history. In Joyce Kilmer I considered the impact of environmental and historical differences between the two watersheds on species composition. I hypothesized that the cooler, northerly-facing Slickrock Creek valley would have a different set of communities than the higher-rainfall, higher-elevation, southeastern-facing Little Santeetlah valley, and that compositional differences would also reflect differences in disturbance history, with logging taking place in the former watershed and chestnut death in the latter. Accordingly, a separate classification of plots in each valley might identify more biologically interpretable groups and produce a clearer hierarchical arrangement of the groups identified than those from one classification including both watersheds.

Preliminary classifications using presence/absence data were discounted due to difficulties in interpretation. These results did not differentiate well between floristically similar stands which separate by the density of one or two species. For example, a scattered *Rhododendron maximum* shrub layer (cover class of 4; 2-5% cover) could not be differentiated from stands with an extremely dense *R. maximum* stratum (cover class of 9; 75-95% cover).

In all three landscape analyses Ward's clustering method was chosen for the final classification. The results of this method were similar to UPGMA classifications, but produced more interpretable compositional separations within groups of problematic stands. For Joyce Kilmer and Shining Rock final classifications were based on raw species cover. The classification of Linville Gorge data based on relative abundance of species in a site was chosen.

2.3.2 <u>Linville Gorge Wilderness</u>

The final 180-stand analysis for Linville Gorge (plot 74 was eliminated due to its heterogeneous composition), based on relativized species cover, was run using TRIM=5. Five outliers were identified using the TRIM function, including a pond (plot 178), two alluvial forests (plots 142, 145) and river margin shrublands (plots 81, 88).

2.3.3 <u>Shining Rock Wilderness</u>

For Shining Rock analysis, TRIM=5 was used, removing 11 outliers from the 160-stand analysis. Outliers included 4 rock outcrop sites (plots 310, 316, 361, 383), an alluvial forest stand (plot 350), a grassland (plot 385), 4 high-elevation non-alluvial wetlands (plots 347, 354, 459, 460) and a high-elevation *Fagus* stand (plot 381).

2.3.4 <u>Joyce Kilmer/Slickrock Wilderness</u>

Two TRIM levels were used in the Joyce Kilmer analysis (TRIM=2.5, TRIM=5). Classifications based on TRIM=5 excluded additional plots to those eliminated in

TRIM=2.5, making subtle improvements to the internal clustering arrangement of the groups in the classification. For the TRIM=5 analysis, a total of ten outliers were identified, including a single rock outcrop site (plot 625), a planted *Abies fraseri* stand (plot 650; eliminated in future analyses due to its unnatural distribution in this Wilderness), four acidic, high-elevation stands (plots 512, 564, 628, 681), one alluvial forest plot (plot 544), a non-alluvial wetland (plot 595) and two acidic cove stands (plots 564, 600).

The classifications of the Joyce Kilmer dataset divided by valley, clustered data from each valley in the same groups as those identified in the final 183-stand classification. The hierarchical arrangement of groups was more interpretable than the 183-stand classification, however because not all groups were present in both watersheds it was not possible to determine the hierarchical relationships between all individual groups. For this reason the final classification was based on the single 183-stand cluster.

2.3.5 Regional classification

All regional classifications were based on Ward's clustering method. See Chapter 6 for detailed discussion of the regional classification.

2.3.6 Clarification of classification

In vegetation analyses ordination is used to find dominant gradients in complex, multidimensional data. Ordination methods enable us to arrange sites along axes (or dimensions) on the basis of species composition (ter Braak 1995). The ordination method Detrended Correspondence Analysis (DCA; Hill 1979a), as implemented in the program CANOCO (ter Braak 1987), was used to validate the subdivisions and groupings identified in the landscape cluster analyses. DCA extracts compositional gradients (represented as axes) by maximizing separation of those stands most different in composition (Gauch 1982, ter Braak & Prentice 1988). Consequently, plots within a community type identified by the cluster analysis should be grouped close to one another in ordination space. Ordinations of samples contained within successive subdivisions of a final cluster analysis validated community type and vegetation class sample plot membership. In a few instances, plots were positioned more closely to other community types on the DCA axes and potentially could be reassigned. My general strategy was to examine whether the questionable plot was more closely associated in terms of species cover and environment with its original group or the group it was more closely positioned to on the ordination diagram. For Joyce Kilmer, plots 564 and 600, eliminated from the classification using the TRIM=5 function, were reassigned to the groups they were classified with in the TRIM=2.5 classification. Four high-elevation outliers were assigned their own group on the basis that they had been grouped together in the TRIM=2.5 classification. Plots 655 and 657 were also reassigned to the group that they were closer to in ordination space. At Shining Rock plot 381, eliminated from the classification using the TRIM function, was the only questionable plot reassigned. This plot was added to the type with which it had closest compositional similarities. No plots were reassigned at Linville Gorge.

2.3.7 Standard community description scheme for landscape studies

To understand and describe the community types identified in each landscape study, it is helpful to place them in the context of the broader range of Southern Appalachian Mountain vegetation. A three-tier hierarchical classification scheme was developed for this purpose. At the broadest level, vegetation is grouped in vegetation classes. Twelve preliminary vegetation classes (Table 2.3), developed from the work of Schafale & Weakley (1990), Wentworth (1980), McLeod (1988), Patterson (1994), Wiser *et al.* (1996) and others, formed the basis of the hierarchy used in this present study. These twelve classes encompass all the broad-based vegetation groups present in the Southern Appalachian Mountains and in the three landscape studies they represent the top tier, or broadest level of the hierarchical classification.

Each vegetation class embodies a range of community types that have general structural, floristic and habitat similarities. Community types, the second level of the hierarchy, are the basic vegetation units described. These are mappable and recognizable in the field across several localities. They roughly correspond with the "association" level of the US National Vegetation Classification being developed by The Nature Conservancy (1996). Distinct, reoccurring subgroups within a community type are known as community sub-types and these represent the lowest level in the hierarchical scheme. A community sub-type may be occasionally subdivided into distinct subgroups, known as variants. Community type grouping within a vegetation class is typically based on membership in broader subdivisions of the Ward's classification. Community types and sub-types were accepted at different division levels in the Ward's classification, depending upon group compositional similarities and intergroup differences. Number of plots and ecological interpretability also helped determine at which level to accept groups. Divisions below the accepted level subdivided closely associated groups, while those above lumped groups easily recognizable in the field.

The standard description scheme, developed to facilitate interpretation and comparison between community types and vegetation classes, was developed from various methods used in Curtis (1959) and Rodwell (1991). Descriptions are divided hierarchically by vegetation class and community type. After a brief introduction of the vegetation class, each community type is described in detail in the following sequence. The community type, and sub-type if present, are introduced by a unique name and identifying code. Synonymous names are listed within the Synonymy category and are followed by p.p. (pro parte) where the group has only partial overlap in species composition. Nationally and regionally listed species (see Amoroso & Weakley 1995) observed to occur within the community type are also recorded and follow a listing of constant species (those with ≥75% constancy in the 0.1 ha plots). A detailed physiognomic description of existing vegetation is given, also describing sub-type subdivisions where present. Typical habitat conditions and specific site factors are summarized. The spatial distribution and relationship to other community types are also described within the habitat and distribution section. Features that distinguish the community type from others identified are noted. The final section describes evidence for disturbance, successional status and future successional development. The discussion section at the end of each vegetation class contrasts the community types identified within the class and compares them with similar vegetation groups in other Southern Appalachian studies. Separate tables for each vegetation class summarize community type floristic, structural and environmental features.

A standard strategy was used for naming both community types and sub-types. For both groups, a '-' separates species present in the same vertical stratum while a '/' separates

Table 2.3. Preliminary Vegetation Classes of the Southern Appalachian Mountains, developed in collaboration with K.D. Patterson, R.K. Peet, M.P. Schafale, and A.S. Weakley.

Non-Alluvial Wetlands
- temporary ponds, mountain bogs

Alluvial Forests
- alluvial forests, forested river margins

Rocky Streamside Shrublands
- herbaceous- and shrub-covered river margins

Xeric Evergreen Forests
- dominated by xeric *Pinus* and *Quercus* species and *Tsuga caroliniana*, with a predominantly evergreen shrub layer

Rich Cove and Slope Forests
- mesic, species-rich forests of coves and lower-slopes dominated by *Acer saccharum*, *Aesculus flava*, *Halesia tetraptera*, *Liriodendron tulipifera*, *Tilia americana* var. *heterophylla*; *Fagus* and *Quercus* species typically of minor importance

Acidic Cove and Slope Forests
- less nutrient-rich, more acidic than **Rich Cove and Slope Forests**, includes *Tsuga canadensis* forest; *Fagus* and *Quercus* can be dominant

Montane Oak Forests
- *Quercus* and *Quercus* - *Carya* dominated communities; with or without a distinctive shrub layer, highly variable in species richness, occur mainly on slopes

Rock Outcrops

Grasslands
- grasslands, fire meadows

Shrub Balds
- dense shrub thickets, typically with a predominant evergreen component

High-Elevation Mixed Hardwood Forests
- *Quercus rubra*, *Betula alleghenienisis* and *Fagus* dominated

Spruce-Fir Forests
- high-elevation forests dominated by *Picea* and/or *Abies*

species in different strata. Unless otherwise stated, species are listed in descending order of abundance, and strata by descending structural position; (i.e., canopy species always occur at the beginning of the name). Names or assignments that must remain tentative due to small numbers of samples (≤2) are enclosed in square brackets [ ]. Scientific names are used, and are referred to by genus only unless more than one species in the genus is likely to be present within the study area. Community type names include species with both high constancy (≥75%) and consistently high cover (≥3 for the **Rock Outcrops** vegetation class and ≥4 for all other vegetation classes). For successional groups the dominant species of the successional phase closest to climax were included in the name if their constancy was >60%.

To place the communities identified in each landscape in context with similar communities at the regional and national level, each community was cross-referenced with the nationally recognized classification scheme developed by The Nature Conservancy (1996; TNC) (see Appendices 1, 2, 3). This is a hierarchical classification scheme which divides vegetation by class (e.g., Forest versus Woodland or Shrubland), subclass (e.g., evergreen versus deciduous), group, subgroup, formation and alliance. An alliance is based on canopy dominants and typically encompasses communities that are distributed across a broad geographic region. Specific, localized variants within an alliance are known as associations. These are recognizable in the field and are generally at the same sampling scale as community types recognized in my studies. Where possible, my community type and sub-types were synonymized with an existing alliance or association within the TNC classification. In the appendices "new alliance" and "new association" identifies cases where the results of my analyses revealed communities that are potential additions or have been formally added to The Nature Conservancy classification as a consequence of this research.

2.3.8 Landscape study community summary information

Topographic and environmental information were summarized for each community type identified in a cluster analysis. The statistical significance of differences in average soil chemistry, texture and depth between individual vegetation groups were tested using multivariate analysis of variance.

Compositional features were also calculated for each group identified in each respective Wilderness. Species richness (the number of vascular species) was tabulated at 7 scales; $0.01m^2$, $0.1m^2$, $1\ m^2$, $10\ m^2$, $100\ m^2$, $400m^2$ and $1000\ m^2$ (0.1 ha) to compare species richness patterns between the different vegetation groups. The constancy and prevalence of individual species in each group were calculated. Constancy represents the percentage of plots in a group wherein a species occurs. Prevalence is determined by ranking species according to constancy and selecting the n species with the highest constancy where n = the average species richness of a vegetation group. Homoteneity, or mean constancy of the prevalent species, was also calculated to provide an indication of compositional variability between samples in each community type.

The vertical structure of each vegetation group was measured to quantify structural composition and to distinguish structural differences between types. Vertical structure was quantified by averaging the cover of each species in each height class.

2.3.9 Landscape study mapping

A detailed vegetation map of each landscape study was produced showing the distribution and approximate boundaries of the community types identified in each study (Appendices 4,5,6). Detailed quantitative site information is essential to accurately map vegetation units. Specific habitat information (including plot data), topographic in particular, was used in collaboration with aerial photograph color, texture and topographic relief. I am confident of the mapping accuracy of the evergreen-dominated communities, but have less confidence in the specific boundary locations of deciduous-dominated community types. **Grasslands**, paler in color than most deciduous communities, were most easily distinguished.

Winter-flown aerial photos were useful for differentiating between evergreen- and deciduous-dominated communities. Color aerial photos enabled us to distinguish between specific dominant evergreen species (e.g., *Kalmia latifolia*, *Rhododendron* species, *Pinus* species), but did not aid in the differentiation of particular dominant deciduous species.

Vegetation texture, another important photo characteristic, aided in the identification of specific evergreen species. For example, in all three landscapes olive-green, fine-textured, densely-covered evergreen areas represented xeric *Pinus* stands, whereas at Joyce Kilmer and Shining Rock smooth, pale olive-green areas represented **Shrub Balds**. Darker green, coarse-textured units, with individual tree crowns visible represented mature *Tsuga canadensis* stands. At Linville Gorge, *Pinus strobus* is characterized by similar coarse-textured, but slightly whiter units. Communities dominated by mixture of *Tsuga* and deciduous species had scattered grey tree crowns visible within the dark-green matrix. At Shining Rock areas dominated by *Picea rubens* were similar in color to *Tsuga*, but appeared finer-textured due to smaller crown sizes.

Differentiation between deciduous canopy forests with a *Kalmia* or *Rhododendron maximum* shrub stratum were also distinguishable by color and texture, with *Kalmia* represented as a lighter green, finer and more open texture (sometimes visible as a greyish cast) than the densely-textured, darker green of *R. maximum*. Topographic information also helped separate these latter two groups.

Deciduous-dominated community type mapping was somewhat less straight forward. I relied more heavily on topographic and habitat information and the presence or absence of an evergreen shrub layer. Color slides, representing much of each landscape during peak fall colors helped distinguish between different deciduous species. The use of a polarizing filter greatly enhanced coloration definition of and differentiation between specific species in these slides.

Vegetation was mapped onto 1:1,000 scale orthophotos. The smallest mapping polygon size was approximately 75 x 75 m. Locations of the spatially restricted vegetation classes and community types were not mapped if their spatial was smaller than the smallest polygon size. Vegetation boundaries were digitized into a geographic information system to produce a digital vegetation map.

2.4 Relationship of vegetation to the environment

The relationship between species composition and major environmental gradients was examined using ordination. Both nonmetric multidimensional scaling (NMDS; Kruskal 1964) and DCA extract compositional gradients independently of site variables, which subsequently can be correlated or regressed with such site variables (ter Braak 1986). Both ordination methods represent each plot as a point in a coordinate space with a specified number of dimensions, with the distances between each pair of points corresponding with compositional dissimilarities (Gauch 1982, Minchin 1987). NMDS ranks plots in order (i.e., "nonmetric" scaling) of dissimilarity with each other (Minchin 1987). For NMDS dissimilarities between plots were calculated using the Bray-Curtis dissimilarity coefficient, which has been shown to be one of the most robust and effective coefficients for the analysis of compositional data (Faith *et al.* 1987, Minchin 1987). NMDS was performed using the program DECODA (Minchin 1994). DCA is a metric ordination technique which uses reciprocal averaging to arrange plots in multidimensional space. Compositional dissimilarities are calculated in an iterative process, whereby species scores, weighted by sample scores and sample scores, weighted by species scores are used to find the final solution (Gauch 1982, ter Braak 1995). NMDS has been shown to have several advantages over DCA. The former method only assumes that species have a monotonic distribution, whereas DCA and other reciprocal averaging methods assume a more restrictive symmetric, unimodal distribution (Faith *et al.* 1987). Research has shown that species may have a skewed distribution along an environmental gradient (Austin *et al.* 1984, Austin *et al.* 1990), suggesting that NMDS may provide a more accurate representation of species compositional patterns. Research using simulated data supports such findings (Minchin 1987).

2.4.1 <u>Landscape studies</u>

Vegetation-environmental relationships of the three landscape studies were firstly investigated using the full dataset in each respective study. Each dataset was fragmented by vegetation class into closely associated community types to reduce dimensionality and underlying complexities within the dataset (Peet 1980). Each subset was subsequently reordinated. Geologic type was excluded from all analyses as not all sites could be accurately classified. Individual soil variables may provide more accurate information about the underlying lithology than a coarse-scale geologic map. However, surface soil is also known to be the result of the plants that grow on it.

A correlation analysis of all potential site factors in each landscape study was used to eliminate redundant variables from vegetation-environment analyses. Base saturation was highly correlated with pH (r=0.99 P=0.0001) in all three studies and was eliminated as a potential variable in each study. Log-transformed nitrogen values (highly correlated with organic matter; r=-0.91 P=0.0001) in the Joyce Kilmer dataset, cation exchange capacity (highly correlated with Ca and Mg, r=0.85 P=0.0001, r=0.80 P=0.0001, respectively) at Linville Gorge and sand (highly correlated with silt; r=-0.99, P=0.0001, r=0.94, P=0.0001), respectively in the Shining Rock and Linville Gorge datasets were eliminated as potential variables from each respective dataset. Although several topographic variables were highly correlated with each other (TSI with profile and section curvature and relative slope position, TMI with spring solar radiation at Linville Gorge; section curvature with digital TSI and profile curvature, relative slope position with distance to the nearest stream and ridge at Joyce Kilmer; section curvature with TSI, TMI with LFI, relative slope position with distance to the nearest stream and ridge, elevation with distance to the high-elevation area, and distance to the Escarpment X distance to the high-elevation area at Shining Rock), these were all included to determine their value as descriptors of vegetation distribution.

Field and digital LFI values were highly correlated in each landscape study (r=0.52 P=0.0001, Linville Gorge; r=0.67 P=0.0001, Joyce Kilmer; r=0.80 P=0.0001, Shining Rock). Correlations between digital and field TSI were low and marginally significant (r=0.18 P=0.02, Linville Gorge; r=0.16 P=0.03 Joyce Kilmer; r=0.26 P=0.0001 Shining Rock), reflecting differences in the scales of sampling. Field TSI values measure finer-scale topographic curvature than the digitally derived values (lowest resolution of 90 x 90 m) which provided more generalized, larger-scale characteristics. For all three landscapes digital TSI values were chosen after preliminary ordination analyses showed that the digital index had consistently stronger correlations with compositional variation. Digital LFI values were chosen for the analysis to the overcome possible inaccuracies of measuring LFI in the field in dense vegetation or during inclement weather.

In all three landscape studies, elevation, slope, transformed aspect, potential solar radiation and 8 landform characteristics (distance to the nearest ridge, distance to the nearest stream, LFI, profile curvature, relative slope position, section curvature, TMI, TSI) were used in the ordination analyses. For Linville Gorge 16 soil characteristics (silt, clay, density, CEC, pH, 13 nutrients) were used in the subsequent analyses. For Joyce Kilmer, and 18 soil characteristics (sand, silt, clay, density, CEC, pH, 12 nutrients) were retained as site variables in the analyses. In the Shining Rock study 18 soil characteristics (silt, clay, density, CEC, pH, 13 nutrients) and 3 rainfall surrogates (distance to the escarpment, distance to the nearest high-elevation area, distance to the escarpment X distance to the high-elevation area) were retained as site variables in the analyses.

To quantify how environmental factors might account for compositional variation identified in the ordination analyses, multiple regressions were performed. For each study, stand scores on axis 1 and axis 2 of a DCA or NMDS ordination were used to represent the primary and secondary compositional gradients and these were regressed against each of the site factors chosen for analysis.

2.4.2 Regional study

Similar analyses were used to examine the relationship between vegetation composition and environmental gradients in the regional 9-landscape study. See Chapter 6 for detailed discussion.

CHAPTER 3. VEGETATION OF LINVILLE GORGE WILDERNESS

3.1 Community classification

One hundred and eighty of the 181 sites sampled and all 404 species were used in the Wards classification with the remaining site (plot 74) omitted because of its heterogeneous nature. Groups were accepted in the classification at r-squared = 0.404. Twenty seven community types and 5 sub-types were recognized (Figure 3.1, Table 3.1, Appendix 1). Linville Gorge types are present in eight of the twelve vegetation classes found throughout the Southern Appalachian Mountains (Table 2.3, Appendix 1).

3.2 Mapping

A detailed map of Linville Gorge was produced showing the distribution and boundaries of the community types identified in this study (Appendix 4). Locations of the spatially restricted **[Alnus/Xanthorhiza Rocky Streamside]**, **[Scirpus cyperinus-Dulichium Temporary Pond]**, the **Pinus pungens/Gaylussacia baccata/Leiophyllum Forest** and the **Selaginella tortipila Outcrops** were not mapped. Their distribution (respectively on sand deposits along the Linville River margin, an upper-slope on the western side, upper bluff-ledge and on outcrop crests and small escarpment faces) was spatially smaller than the lowest mapping polygon size (75 x 75 m) used.

3.3 Relationship of vegetation composition to major environmental gradients

The ordination method, DCA was used to identify major compositional gradients within the Linville Gorge dataset to understand how vegetation classes are distributed across this landscape with respect to environmental conditions. Associations between the first two compositional gradients and specific site variables were quantified using regression to identify environmental factors that correspond with vegetation patterns.

Figure 3.1. Dendrogram showing divisions and final vegetation groupings in Linville Gorge Wilderness identified using the Bray Curtis dissimilarity measure in the Ward's clustering method. Species cover was relativized per plot for the 180 plots used in this classification. Cut-off level for community type groupings is shown by the dashed line. Ultimate groupings are represented by their abbreviation code. For full names see in Table 3.1. For group sample size and membership see Appendix 1. Groups not connected to the main dendrogram were eliminated using the TRIM function.

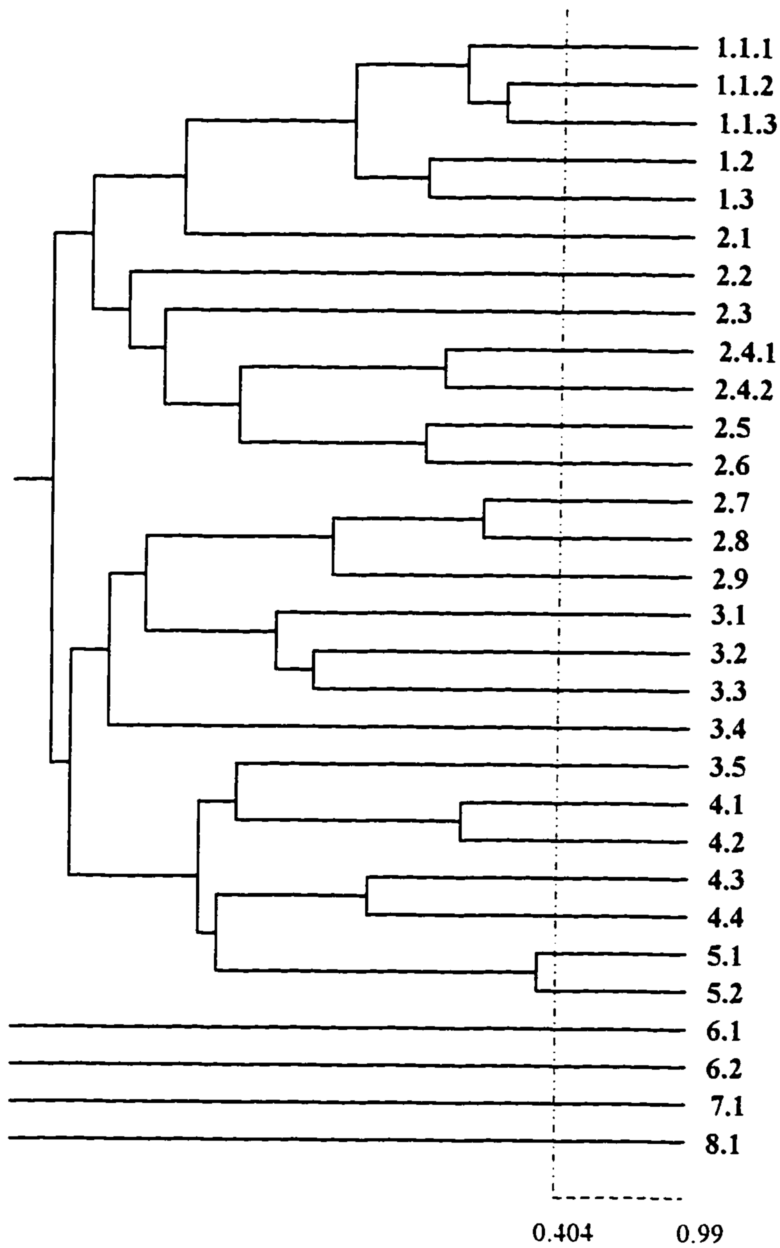


Table 3.1. Hierarchical community classification of Linville Gorge Wilderness vegetation. Each vegetation class is shown, listing all community types and community sub-types present within it. Names of the three levels of the hierarchy are as follows: Vegetation Class (e.g. code 1.), Community type (e.g. code 1.1), Community sub-type (e.g. code 1.1.1). A name enclosed by [] represents a tentative name owing to limited sample size. For the list of sample sites in each group see Appendix 1.

1. <u>Rock Outcrops</u>
1.1 **Rhododendron minus/Selaginella tortipila Outcrops**
   1.1.1 Rhododendron minus-Fothergilla/Leiophyllum/Selaginella tortipila sub-type
   1.1.2 Rhododendron minus/Leiophyllum/Selaginella tortipila-Hypericum densiflorum sub-type
   1.1.3 [Selaginella tortipila-Carex umbellata sub-type]
1.2 **[Cheilanthes tomentosa-Danthonia spicata Outcrops]**
1.3 **Selaginella tortipila Outcrops**

2. <u>Xeric Evergreen Forests</u>
2.1 **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest**
2.2 **Tsuga caroliniana/Rhododendron maximum Forest**
2.3 **Pinus virginiana-Pinus pungens/Kalmia Forest**
2.4 **Pinus pungens/Kalmia Forest**
   2.4.1 Pinus pungens-Quercus coccinea/Kalmia sub-type
   2.4.2 Pinus pungens-Pinus strobus/Leucothoe recurva sub-type
2.5 **Pinus rigida-Quercus montana/Fothergilla Forest**
2.6 **Quercus alba/Kalmia/Galax Forest**
2.7 **Quercus alba-Pinus strobus/Kalmia Forest**
2.8 **Quercus montana-Quercus coccinea/Kalmia Forest**
2.9 **Quercus montana/Galax Forest**

3. <u>Acidic Cove</u> and <u>Slope Forests</u>
3.1 **Quercus montana-Acer rubrum Forest**
3.2 **Quercus montana-Pinus strobus/Rhododendron maximum Forest**
3.3 **Quercus montana/Rhododendron maximum Forest**
3.4 **Tsuga canadensis/Rhododendron maximum Forest**
3.5 **Tsuga canadensis-Fagus/Ilex opaca Forest**

4. <u>Montane Oak Forests</u>
4.1 **Quercus montana/Oxydendrum/Cornus florida Forest**
4.2 **Quercus montana/Cornus florida Forest**
4.3 **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest**
4.4 **Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest**

5. <u>Rich Cove</u> and <u>Slope Forests</u>
5.1 **Carya glabra/Ageratina Forest**
5.2 **[Liriodendron-Carya glabra Forest]**

Table 3.1 *cont.* Hierarchical community classification of Linville Gorge Wilderness vegetation.

6. <u>Alluvial Forests</u>
6.1 [Liquidambar Rocky Streambed Forest]
6.2 [Platanus/Asimina/Microstegium Alluvial Forest]

7. <u>Rocky Streamside Shrublands</u>
7.1 [Alnus/Xanthorhiza Rocky Stream Margin]

8. <u>Non-Alluvial Wetlands</u>
8.1 [Scirpus cyperinus-Dulichium Temporary Pond]

A series of ordinations were performed on subsets of closely associated vegetation classes in an effort to understand the compositional and environmental relationship of each vegetation class. The results of an ordination are presented on a scatterplot diagram, that graphs stands by their scores on the first and second compositional gradient (Axis 1 & 2) of the respective DCA. Stands are classified by vegetation class, community type or rock type. Statistically significant relationships ($P \leq 0.01$) between the first two compositional gradients and environmental factors, identified in the regression analyses, are represented by a vector diagram. Each environmental variable is represented by a vector. Vector orientation corresponds to the direction of maximum correlation with the 2 compositional axes and the vector length indicates the strength of the association (ter Braak 1987). After the elimination of plot 74 (previously removed from the community classification) and the five most extreme samples (representing the **Alluvial Forests**, **Rocky Streamside Shrublands** and **Non-Alluvial Wetlands**), the remaining 175-plot dataset, representing 5 of the 8 vegetation classes, was used in the initial DCA analysis.

3.3.1 Ordination of the 175 stand dataset

The 5 major vegetation classes are distributed across Linville Gorge along soil nutrient, soil texture and microtopography gradients (Figures 3.2, 3.3). The vegetation classes are most clearly dispersed along the first compositional gradient. The **Rock Outcrops** vegetation class is positioned on the right of the scatterplot diagram, present on exposed, dry (high solar radiation, low TMI), generally steep, infertile sites. The four forest vegetation classes are separated from one another by soil nutrients (Al, Ca, Cu, Mn, pH), soil texture (silt, clay), and microtopography (TSI, section and profile curvature), with the **Rich Cove and Slope Forests**, on the right of the diagram, found on nutrient-rich, finer-textured soils. There is some separation by geologic type, with stands underlain by lower quartzite typically having less-fertile, coarser-textured soils (Figures 3.2, 3.4). A multiple regression analysis indicates that the 6 geologic types have statistically significantly different soil chemistry and texture (Table 3.6).

The influence of the **Rock Outcrops** on axis 2 is apparent with the extreme steepness and exposure of some stands in this vegetation class overriding the effect of any other site factors on this compositional axis (Figure 3.2). The extent of compositional dissimilarities between the **Rock Outcrops** and the four forest vegetation classes may control stand position on axis 2, and on the first compositional gradient to a lesser extent. In an attempt to overcome the problem of second axis dominance by the **Rock Outcrops**, this class was removed from the following ordination (Figure 3.5). The four non-alluvial forest vegetation classes (**Xeric Evergreen Forests**, **Acidic Cove and Slope Forests**, **Montane Oak Forests** and **Rich Cove and Slope Forests**) were reordinated to clarify differences in site conditions and determine how these classes are distributed relative one another across the Linville landscape.

3.3.2 Ordination of the four forest vegetation class dataset

Stands in the **Xeric Evergreen Forests**, **Acidic Cove and Slope Forests**, **Montane Oak Forests** and **Rich Cove and Slope Forests** classes separated by soil nutrients, soil texture, slope position and topographic moisture (Figures 3.5, 3.6). On the upper right of the diagram, the **Montane Oak Forests** and **Rich Cove and Slope Forests** classes are positioned on sites with more fertile (high Mn, pH, Al), finer-textured soils. The **Xeric Evergreen Forests** and **Acidic Cove and Slope Forests** are situated on the opposing end of the nutrient-texture gradient and have silty, infertile soils. The gneiss and lower quartzite rock types also separate along this gradient (Figures 3.6, 3.7). Sites underlain by upper and lower quartzite were restricted to low-nutrient, coarse-textured soils whereas those on gneiss bedrock have finer-textured soils with higher fertility.

There is a strong topographic gradient perpendicular to the soil nutrient-texture gradient. Sites in the **Xeric Evergreen Forests** class are more convex (high profile and low section curvature) than those in other classes (Figures 3.5, 3.6). The **Xeric Evergreen Forests** and **Montane Oak Forests** inhabit dryer (high solar radiation, low TMI) upper-slope sites than the remaining two vegetation classes. In general, the **Acidic Cove and**

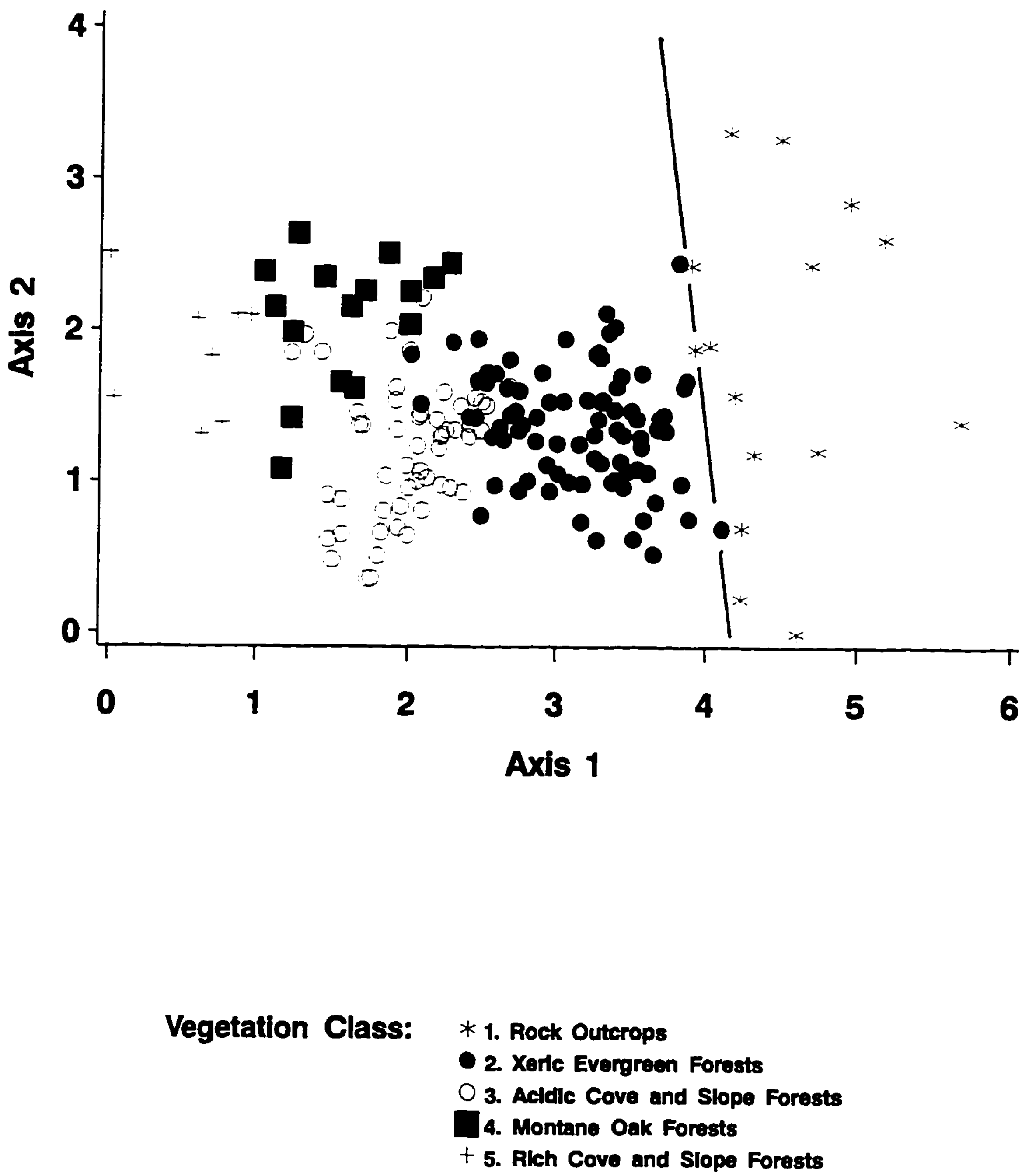
Slope Forests have infertile, cooler, lower-slope positions than the other three vegetation classes.

To help clarify site differences between community type within a vegetation class, the **Xeric Evergreen Forests, Montane Oak Forests** and **Acidic Cove and Slope Forests** were each ordinated separately. The results of each analysis are discussed at the beginning of the description for the respective vegetation class. The limited number of stands in the **Rich Cove and Slope Forests** class prevented a separate analysis of this class.

3.4 Summary soil and species richness information

To aid in accessibility and for ease of interpretation and comparisons between different vegetation classes and community types in Linville Gorge, average soil chemistry and textural information are summarized for the 8 vegetation classes in two tables (Tables 3.4, 3.5). These tables are presented before the vegetation class descriptions. Summary soil characteristics are given for each geologic type (Tables 3.2, 3.3). Multiple analyses of variance indicated that soil chemistry, texture and soil depth were statistically significantly different between vegetation classes and geologic types ($P \geq 0.001$; Tables 3.6, 3.7). Mean species richness values are also provided for all vegetation classes and associated community types at each of the seven spatial scales measured (Table 3.8).

Figure 3.2. DCA ordination diagram of 175 sample plots showing vegetation class distribution on the two major compositional gradients. The solid line represents separation of stands for subsequent ordinations, with the **Rock Outcrops** eliminated from further analyses.


Axis 2
4
3
2
1
0
0
1
2
3
4
5
6
Axis 1
Vegetation Class:
1. Rock Outcrops
2. Xeric Evergreen Forests
3. Acidic Cove and Slope Forests
4. Montane Oak Forests
5. Rich Cove and Slope Forests

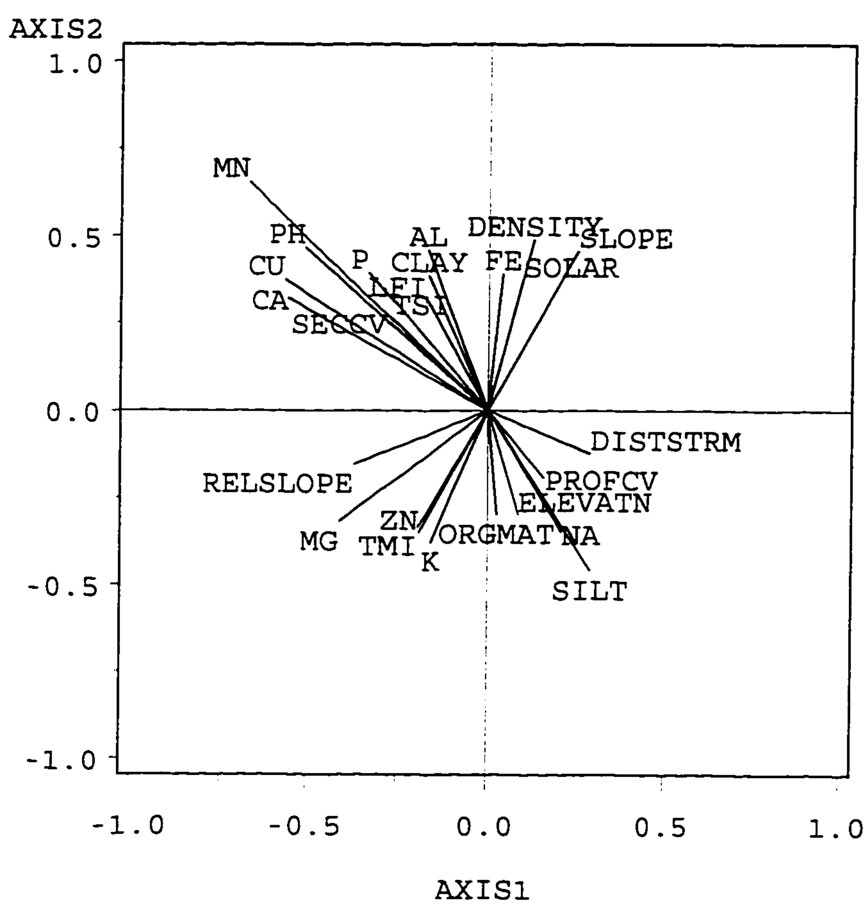
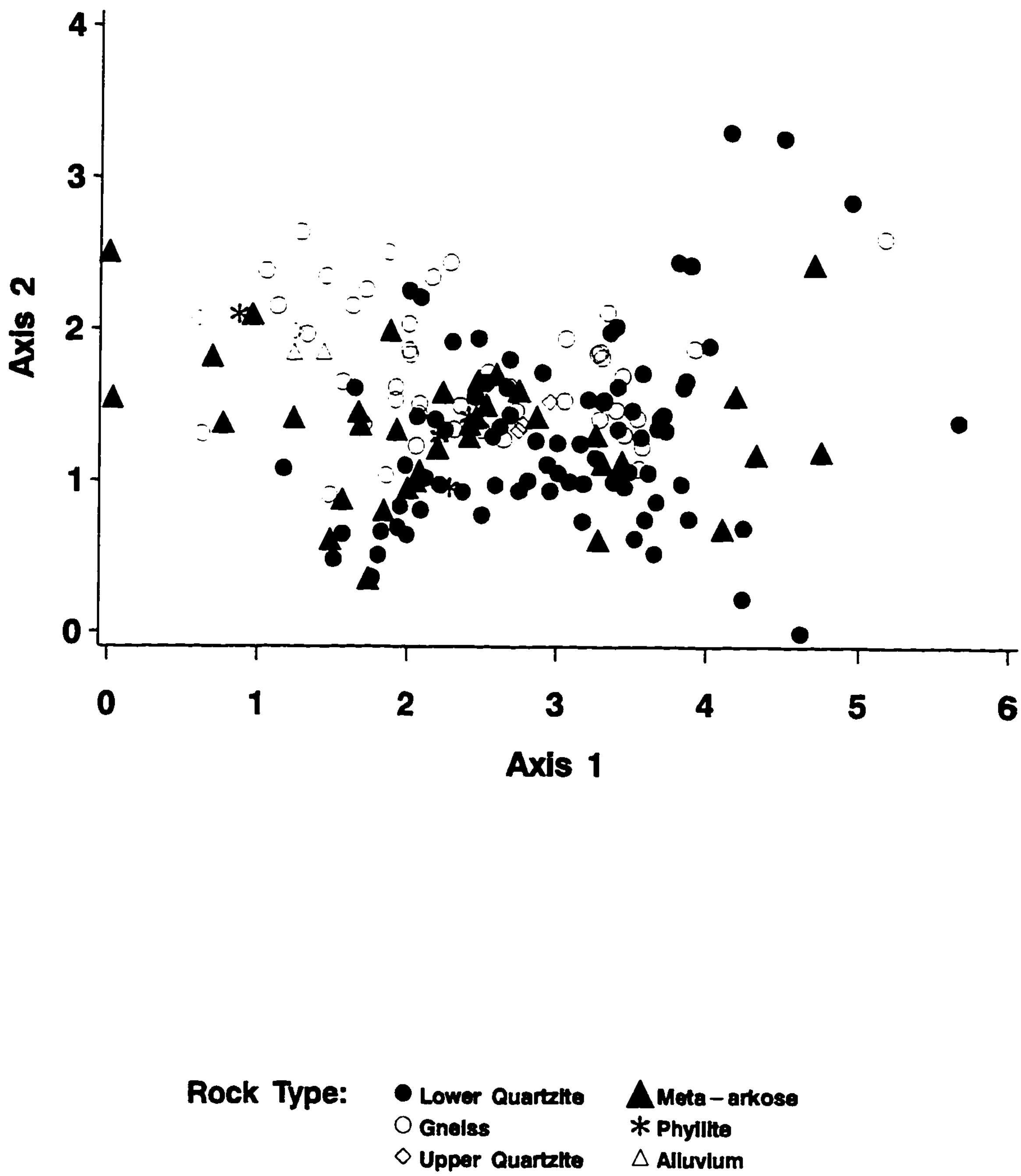


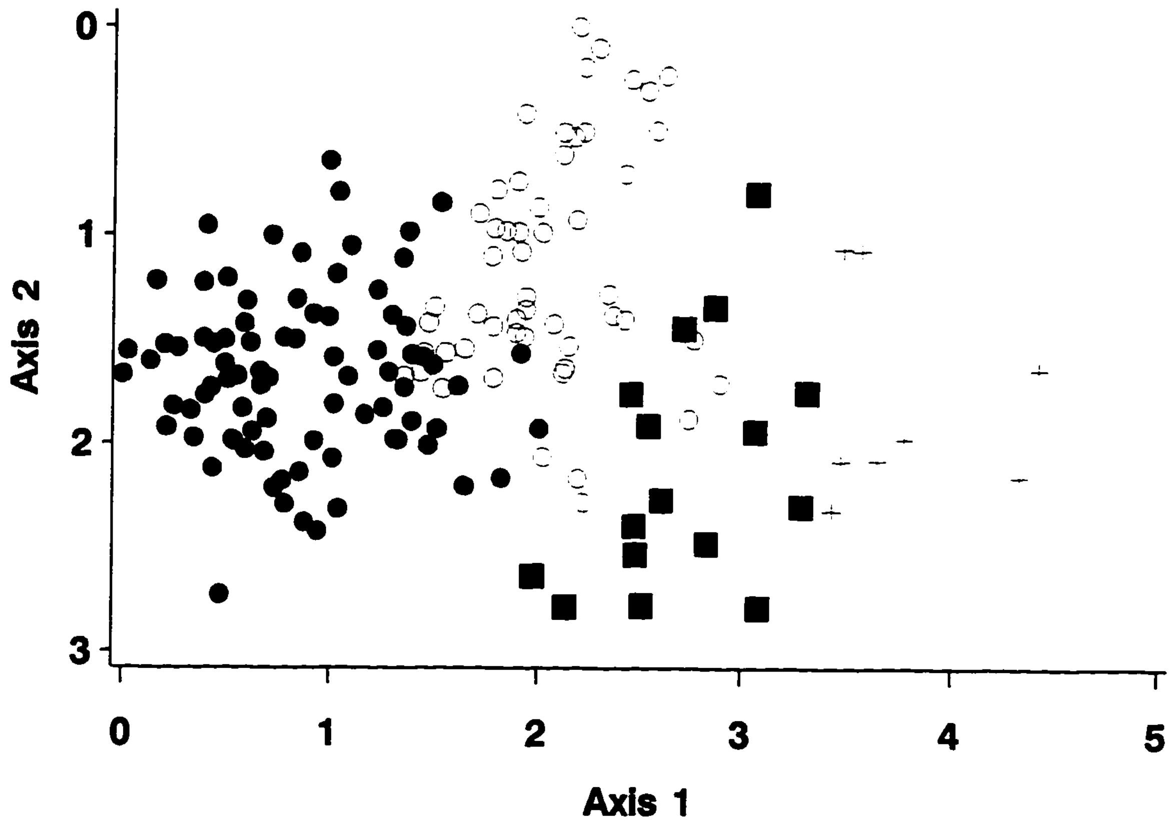
Figure 3.3. Vector diagram for DCA ordination of 175 sample plots showing association between species composition and major environmental gradients. PROFCV=profile curvature, SECCV=section curvature. Small LFI values represent unprotected upper-slopes progressing through to high values representing sheltered, lower-slopes and coves. Small TMI values represent low site moisture potential whereas large values represent high moisture. TSI values represent convex upper-slopes while high values represent concave lower-slopes.

Figure 3.4. DCA ordination diagram of 175 sample plots showing distribution by parent material type on the two major compositional gradients.



Axis 2
0
1
2
3
4
0
1
2
3
4
5
6
Axis 1
Rock Type:
Lower Quartzite
Gneiss
Upper Quartzite
Meta – arkose
Phyllite
Alluvium

Figure 3.5. DCA ordination diagram of the **Xeric Evergreen Forests, Acidic Cove and Slope Forests, Montane Oak Forests** and **Rich Cove and Slope Forests** classes and showing community type distribution on the two major compositional gradients.



Vegetation Class:
- ● 2. Xeric Evergreen Forests
- ○ 3. Acidic Cove and Slope Forests
- ■ 4. Montane Oak Forests
- + 5. Rich Cove and Slope Forests

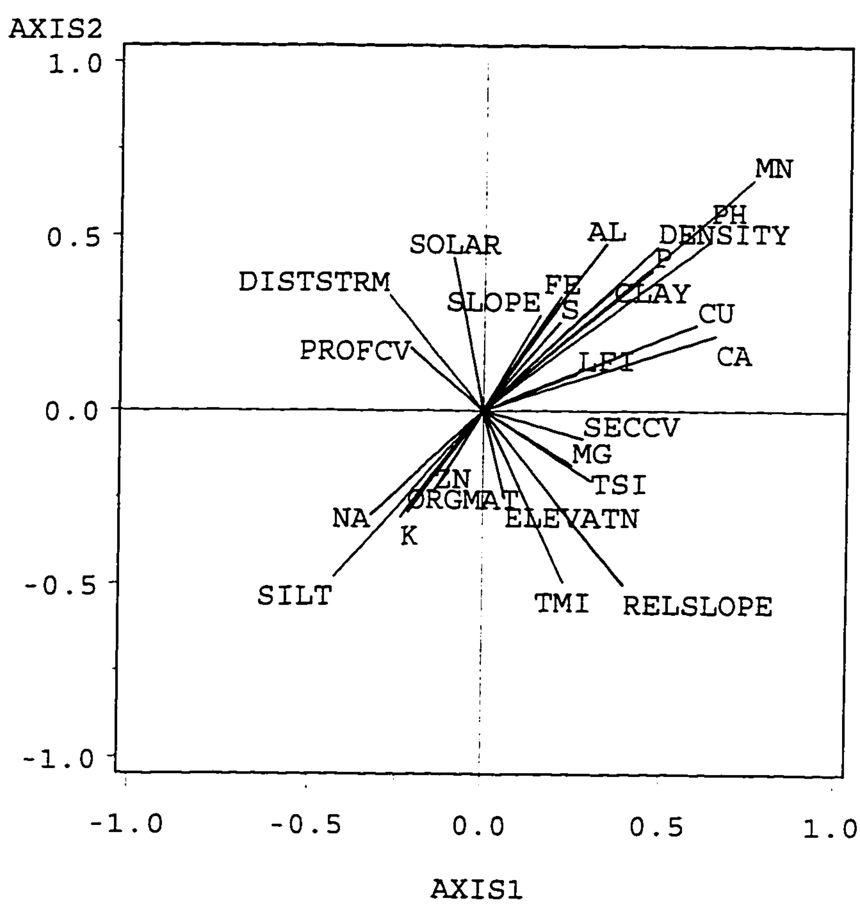


Figure 3.6. Vector diagram for DCA ordination of **Xeric Evergreen Forests, Acidic Cove and Slope Forests, Montane Oak Forests** and **Rich Cove and Slope Forests** classes showing association between species composition and major environmental gradients. PROFCV=profile curvature, SECCV= section curvature. Small LFI values represent unprotected upper-slopes progressing through to high values representing sheltered, lower-slopes and coves. Small TMI values represent low site moisture potential whereas large values represent high moisture. Low TSI values represent convex upper-slopes while high values represent concave lower-slopes.

Figure 3.7. DCA ordination diagram of **Xeric Evergreen Forests**, **Acidic Cove and Slope Forests**, **Montane Oak Forests** and **Rich Cove and Slope Forests** classes showing distribution by parent material type on the two major compositional gradients.

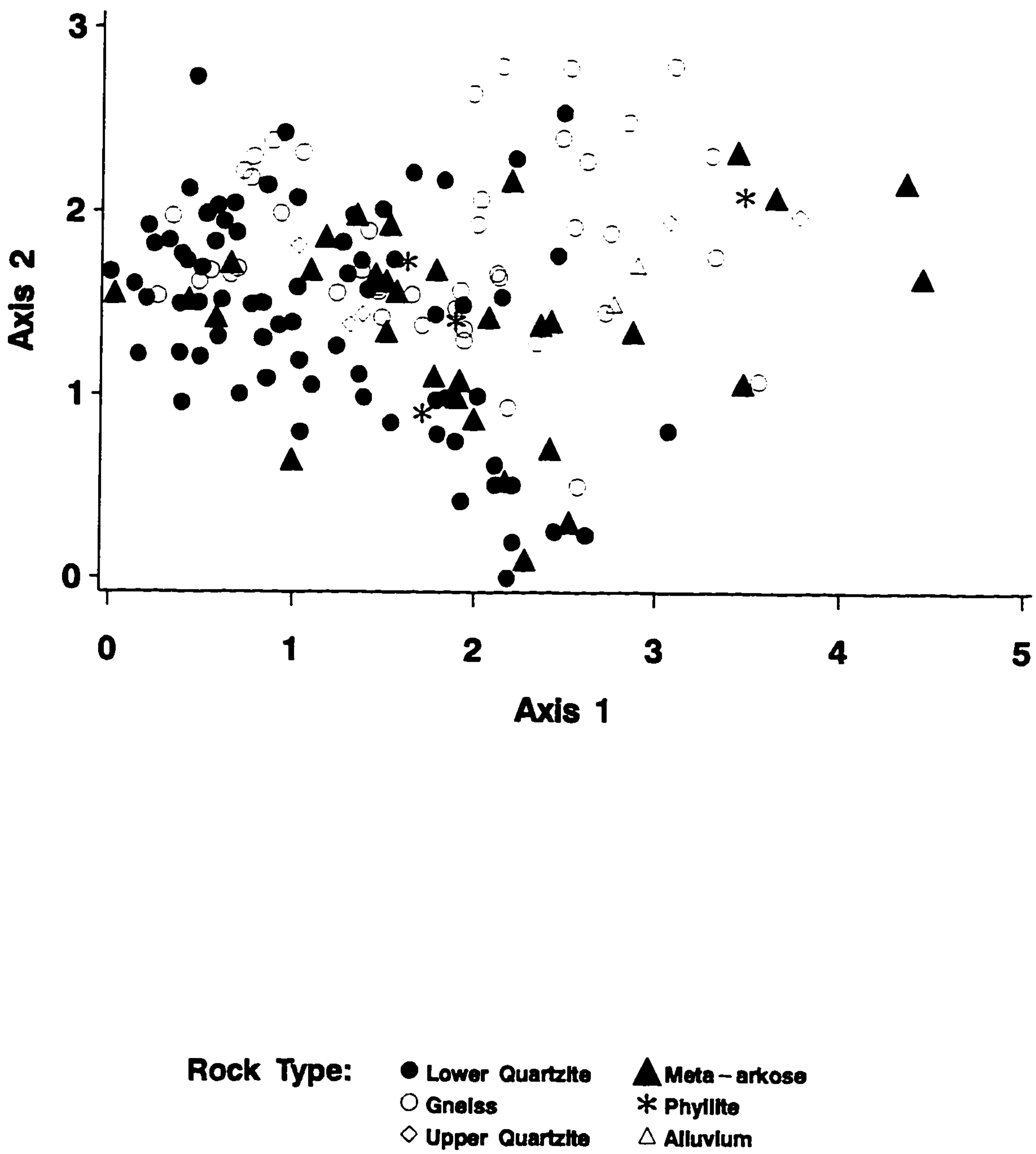

Axis 2
Axis 1
0
1
2
3
4
5
Rock Type:
Lower Quartzite
Gneiss
Upper Quartzite
Meta-arkose
Phyllite
Alluvium

Table 3.2. Mean soil nutrient values for sample sites in each parent material type. All 180 plots were used. Parent material type abbreviations are as follows: AL: alluvium, CL: lower quartzite, CP: phyllite, CU: upper quartzite, G: Grandfather Mountain Formation meta-arkose, W: Wilson Creek gneiss. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmt) (by loss on ignition) and soil bulk density (dens).

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
AL	726.50	0.40	749.25	0.80	284.00	49.50	90.25	107.75	71.50	15.25	44.75	57.00	5.37	14.60	4.38	46.14	0.86	42.63
CL	670.19	0.40	242.35	0.37	156.64	116.87	81.49	10.58	71.72	22.24	30.29	58.40	5.83	11.52	3.56	60.93	0.48	30.87
CP	960.40	0.33	391.00	1.05	225.60	106.60	90.20	154.60	67.60	14.00	48.80	64.20	6.34	12.26	3.90	47.39	0.56	35.05
CU	854.80	0.32	432.20	0.51	186.00	113.40	93.60	66.60	73.00	17.00	50.20	89.40	3.94	13.36	3.83	45.13	0.56	33.70
G	697.44	0.40	369.44	0.40	118.33	100.78	70.64	34.83	71.78	17.44	37.78	57.31	4.88	12.23	3.75	51.14	0.42	32.83
W	753.83	0.38	534.60	0.42	193.75	114.85	119.69	25.04	73.21	21.65	36.06	60.65	5.71	15.45	3.83	51.36	0.47	34.18

Table 3.3. Mean soil texture values for sample sites in each parent material type. All 180 plots were used. Parent material type abbreviations are as follows: AL: alluvium, CL: lower quartzite, CP: phyllite, CU: upper quartzite, G: Grandfather Mountain Formation meta-arkose, W: Wilson Creek gneiss. Values of sand, silt and clay are given as percentages. 'N' represents the number of stands in each parent material type.

	Sand	Silt	Clay	N
AL	38.15	56.10	5.75	4
CL	6.46	90.30	3.24	83
CP	9.26	85.94	4.80	5
CU	14.88	79.52	5.60	5
G	10.06	85.86	4.09	36
W	12.89	83.34	3.77	47

Table 3.4. Mean soil nutrient values by vegetation class and associated community types and sub-types. Groups are referenced by their abbreviation code. For full names see Table 3.1. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmat) (by loss on ignition) and soil bulk density (dens).

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
1.	852.13	0.43	265.93	0.29	228.60	73.87	52.53	3.60	71.07	27.00	33.93	71.60	3.87	10.38	3.60	38.97	0.87	31.00
1.1	782.18	0.35	276.36	0.21	204.82	85.27	55.18	3.82	72.64	29.91	29.36	69.82	4.35	10.19	3.73	46.42	0.57	32.36
1.1.1	563.00	0.59	251.75	0.19	126.00	104.75	63.50	1.50	71.50	60.50	32.25	102.50	4.93	11.84	3.51	51.06	0.57	30.13
1.1.2	583.20	0.27	347.00	0.26	168.60	89.80	58.20	6.80	72.60	12.20	34.80	55.60	5.06	11.15	3.80	51.95	0.38	33.10
1.1.3	1718.00	0.10	149.00	0.10	453.00	35.00	31.00	1.00	75.00	13.00	10.00	40.00	1.40	4.49	4.00	23.30	1.07	35.00
1.2	1252.67	0.54	217.67	0.67	362.33	51.00	49.00	3.67	68.67	14.00	56.00	85.33	2.80	11.22	3.13	21.60	1.95	26.33
1.3	420.00	0.92	296.00	0.10	89.00	17.00	34.00	1.00	61.00	34.00	18.00	50.00	1.80	9.97	3.50	9.10	0.83	30.00
2.	639.20	0.37	225.23	0.32	144.18	122.40	84.78	4.90	72.23	20.99	29.58	58.33	5.87	11.06	3.57	59.02	0.38	30.73
2.1	777.33	0.21	220.33	0.17	207.33	104.67	71.67	3.00	69.00	18.00	19.67	59.33	8.03	9.66	3.63	40.62	0.49	31.83
2.2	602.36	0.38	223.82	0.29	121.09	129.18	96.18	3.73	72.36	17.64	34.64	71.64	6.28	11.63	3.54	61.00	0.37	30.40
2.3	767.53	0.29	204.07	0.23	189.60	107.80	73.27	3.93	72.47	20.07	25.53	58.60	5.42	10.30	3.51	60.76	0.42	30.25
2.4	561.53	0.46	188.74	0.25	114.42	128.68	81.37	3.95	74.47	23.32	26.47	52.26	5.44	10.28	3.54	64.13	0.31	30.39
2.4.1	591.92	0.43	188.83	0.22	125.92	124.58	81.75	3.92	74.67	22.17	22.58	50.00	5.78	10.22	3.53	63.09	0.30	30.38
2.4.2	509.43	0.50	188.57	0.29	94.71	135.71	80.71	4.00	74.14	25.29	33.14	56.14	4.88	10.40	3.54	65.93	0.33	30.43
2.5	562.80	0.43	224.40	0.28	116.10	117.80	75.90	4.00	71.50	25.60	29.60	58.70	5.75	10.70	3.58	63.69	0.34	30.85
2.6	509.00	0.21	336.00	0.64	127.67	154.67	120.33	4.00	75.00	19.33	29.33	51.67	9.46	17.27	3.38	75.53	0.37	28.92
2.7	871.40	0.27	275.80	0.45	211.00	98.40	114.80	9.20	64.20	17.60	25.60	44.40	5.03	11.71	3.75	29.34	0.60	32.65
2.8	602.60	0.34	292.40	0.50	119.40	171.20	103.20	9.20	72.60	23.00	35.60	64.80	7.43	13.64	3.63	63.16	0.36	31.25
2.9	615.75	0.42	235.92	0.46	149.92	114.33	75.75	6.58	72.17	19.42	36.58	59.58	5.08	10.49	3.63	54.14	0.36	31.23
3.	592.23	0.44	409.96	0.43	136.47	116.68	98.96	14.53	72.96	21.57	31.75	52.23	5.72	14.46	3.71	61.33	0.39	32.31
3.1	645.14	0.40	269.71	0.40	140.36	106.86	80.79	7.21	74.07	18.71	26.29	43.21	4.83	10.91	3.68	60.74	0.37	32.05
3.2	510.00	0.58	357.33	0.41	113.67	123.00	117.56	17.56	70.44	25.67	42.11	62.67	5.38	14.49	3.68	54.79	0.35	31.84
3.3	730.89	0.44	379.22	0.48	149.22	131.78	99.11	12.22	70.67	23.44	33.00	56.89	5.60	14.54	3.68	52.18	0.43	31.86
3.4	467.61	0.42	458.72	0.40	121.06	120.39	102.06	6.17	74.67	22.00	27.72	49.61	6.53	16.30	3.66	69.63	0.36	31.67
3.5	923.67	0.38	1022.00	0.68	241.00	76.00	109.00	96.67	72.00	14.33	46.67	64.67	6.44	19.57	4.25	61.43	0.63	40.08

Table 3.4. *cont.* Mean soil nutrient values by vegetation class and associated community types and sub-types. Groups are referenced by their abbreviation code. For full names see Table 3.1. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmt) (by loss on ignition) and soil bulk density (dens).

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
4.	1025.31	0.29	798.00	0.60	273.88	108.94	123.88	74.06	72.81	15.31	41.88	68.38	5.41	19.06	3.98	49.05	0.64	36.30
4.1	941.33	0.34	623.00	0.48	255.50	89.00	155.17	82.67	74.17	15.17	50.83	63.33	4.63	15.73	3.97	50.84	0.57	36.21
4.2	1003.00	0.30	1019.67	0.90	267.67	99.67	115.67	61.67	71.00	15.67	54.67	102.00	6.28	22.30	4.11	44.83	0.69	37.92
4.3	966.00	0.22	1205.25	0.43	335.50	147.00	123.00	56.75	70.50	16.00	27.00	50.25	7.12	27.43	3.96	43.96	0.70	36.71
4.3	1294.67	0.25	383.33	0.75	234.67	107.33	70.67	92.33	75.00	14.33	31.00	69.00	3.81	11.31	3.90	56.50	0.65	34.33
5.	1404.13	0.33	629.88	1.07	147.13	71.25	82.13	235.63	72.13	10.75	81.88	87.13	4.73	12.72	4.27	36.11	0.70	40.47
5.1	1269.50	0.42	1003.00	0.99	143.00	87.00	109.50	237.50	74.00	11.00	85.50	84.00	4.18	18.04	4.39	48.15	0.73	42.75
5.2	1449.00	0.31	505.50	1.10	148.50	66.00	73.00	235.00	71.50	10.67	80.67	88.17	4.92	10.95	4.23	32.10	0.69	39.71
6.	652.00	0.43	621.00	0.98	259.50	38.00	75.00	119.00	72.50	15.50	52.00	51.00	5.32	10.40	4.60	41.50	1.02	47.00
6.1	462.00	0.51	346.00	0.61	264.00	28.00	60.00	111.00	75.00	16.00	22.00	24.00	5.90	5.79	4.75	59.50	1.34	50.00
6.2	842.00	0.34	896.00	1.34	255.00	48.00	90.00	127.00	70.00	15.00	82.00	78.00	4.73	15.00	4.45	23.50	0.69	44.00
7.	540.00	0.23	253.00	0.67	381.50	38.00	51.00	93.00	37.50	9.50	30.00	37.50	4.93	5.52	4.58	3.93	1.05	48.75
8.	918.00	0.10	162.00	0.10	121.00	78.00	67.00	2.00	75.00	35.00	94.00	98.00	3.00	8.27	3.60	71.30	0.28	31.00

Table 3.5. Mean soil texture values for each vegetation class and associated community types and sub-types. All groups are represented by their abbreviation code. For full names see Table 3.1. Values of sand, silt and clay are given as percentages.

GROUP	Sand	Silt	Clay
1.	10.09	84.87	5.04
1.1	8.94	87.06	4.00
1.1.1	8.53	89.48	2.00
1.1.2	11.08	85.32	3.60
1.1.3	4.40	86.60	9.00
1.2	14.33	76.13	9.53
1.3	10.00	87.00	3.00
2.	7.05	89.78	3.17
2.1	10.40	85.60	4.00
2.2	3.68	93.50	2.82
2.3	8.44	88.29	3.27
2.4	5.31	91.85	2.84
2.4.1	5.36	91.47	3.17
2.4.2	5.23	92.48	2.29
2.5	7.93	88.77	3.30
2.6	3.80	92.87	3.33
2.7	14.68	81.92	3.40
2.8	4.68	91.52	3.80
2.9	8.23	88.60	3.17
3.	7.81	89.27	2.93
3.1	8.09	88.69	3.22
3.2	9.16	87.18	3.67
3.3	8.03	89.52	2.45
3.4	5.11	92.50	2.39
3.5	17.93	78.07	4.00
4.	22.35	72.34	5.31
4.1	25.23	70.43	4.33
4.2	21.33	74.00	4.67
4.3	23.95	69.30	6.75
4.4	15.47	78.53	6.00
5.	18.50	73.87	7.63
5.1	29.80	65.20	5.00
5.2	14.73	76.77	8.50
6.	55.30	36.70	8.00
6.1	93.40	1.60	5.00
6.2	17.20	71.80	11.00
7.	7.40	88.10	4.50
8.	1.40	95.60	3.00

Table 3.6. Results from a multivariate analysis of variance to determine the significance of soil characteristics (nutrients and texture) per parent material type. These analyses were performed using the General Linear Models Procedure for unbalanced designs. Information of all 180 stands and 6 parent material types (see Table 3.2 for listing, Figure 3.5 for distribution) was included.

a) *nutrient differences.*

Statistic	F value	Pr > F
Wilks' Lamba	3.438	0.0001
Pillai's Trace	3.131	0.0001
Hotelling-Lauley Trace	3.545	0.0001
Roy's Greatest Root	6.615	0.0001

b) textural differences.

Statistic	F value	Pr > F
Wilks' Lamba	6.508	0.0001
Pillai's Trace	6.184	0.0001
Hotelling-Lauley Trace	6.830	0.0001
Roy's Greatest Root	12.921	0.0001

Table 3.7. Results from a multivariate analysis of variance to determine the significance of soil characteristics (nutrients and texture) per vegetation class. These analyses were performed using the General Linear Models Procedure for unbalanced designs. The 180 plots were included (see Table 3.1 for listing, Figure 3.2 for distribution).

a) *nutrient differences.*

Statistic	F value	Pr > F
Wilks' Lamba	6.570	0.0001
Pillai's Trace	5.450	0.0001
Hotelling-Lauley Trace	7.810	0.0001
Roy's Greatest Root	24.951	0.0001

b) *textural differences.*

Statistic	F value	Pr > F
Wilks' Lamba	10.308	0.0001
Pillai's Trace	9.303	0.0001
Hotelling-Lauley Trace	11.333	0.0001
Roy's Greatest Root	20.295	0.0001

Table 3.8. Species richness at 7 spatial scales. Separate partitions within this table show values for each vegetation class and associated community type and sub-types. Each group is represented by its abbreviation code. For full names see Table 3.1. Values with a '*' indicate low and/or lower average richness for a specific spatial scale than the next smallest scale. This is usually the result of a smaller number of plots sampled at the larger scale.

Group	1000 m	400 m	100 m	10 m	1 m	0.1 m	0.01 m
1.	.	.	18.07	8.09	2.97	0.67	0.24
1.1	.	.	18.45	8.74	3.41	0.73	0.22
1.1.1	.	.	15.88	7.64	3.05	0.69	0.13
1.1.2	.	.	21.90	10.07	4.28	0.90	0.33
1.1.3	.	.	15.00	6.50	0.50	0.00	0.00
1.2	.	.	15.67	5.94	1.50	0.50	0.33
1.3	.	.	21.00	.	.	.	.
2.	*30.56	29.88	19.85	9.24	3.43	1.13	0.33
2.1	.	.	26.67	11.67	5.25	2.92	0.75
2.2	.	30.50	17.08	7.26	2.35	0.66	0.17
2.3	.	36.67	22.98	9.70	3.26	0.99	0.22
2.4	*23.00	26.27	18.16	8.76	3.53	1.07	0.31
2.4.1	*23.00	23.86	16.98	8.06	3.07	0.93	0.27
2.4.2	.	30.50	20.18	9.97	4.32	1.32	0.38
2.5	*28.00	28.56	19.90	10.65	4.36	1.60	0.57
2.6	.	37.00	22.50	10.50	4.29	1.88	0.84
2.7	32.50	26.80	17.25	7.58	2.58	0.60	0.05
2.8	27.00	24.60	14.85	6.98	2.48	0.48	0.10
2.9	35.00	33.60	21.92	10.48	3.59	1.22	0.41
3.	28.50	24.64	14.58	6.24	1.99	0.50	0.11
3.1	28.00	23.46	15.36	6.58	2.09	0.48	0.06
3.2	32.33	24.33	13.89	5.49	1.47	0.35	0.05
3.3	33.67	28.38	16.81	6.61	1.93	0.49	0.08
3.4	*11.67	19.00	12.06	5.49	2.10	0.55	0.18
3.5	41.00	37.67	21.58	9.92	2.50	0.84	0.13
4.	56.14	47.75	30.42	12.55	4.10	1.00	0.30
4.1	52.67	41.83	24.50	8.98	2.80	0.57	0.19
4.2	66.00	62.50	35.50	15.46	4.33	1.08	0.25
4.3	.	43.00	33.42	13.46	4.68	1.11	0.52
4.4	56.33	51.33	33.17	15.54	5.71	1.63	0.29
5.	68.33	62.38	36.69	17.72	7.56	2.53	0.57
5.1	*61.00	61.00	34.75	14.82	4.69	1.32	0.19
5.2	69.80	62.83	37.33	18.69	8.52	2.94	0.69
6.	54.00	47.00	27.25	12.69	5.57	1.94	1.07
6.1	.	.	26.50	10.75	3.00	0.50	0.25
6.2	54.00	47.00	28.00	14.63	8.13	3.38	1.88
7.	.	.	25.25	10.13	2.25	0.63	0.50
8.	.	.	6.00	.	.	.	.

3.5 Description of vegetation classes and community types

3.5.1 VEGETATION CLASS: 1. Rock Outcrops

The **Rock Outcrops** vegetation class has limited distribution, scattered throughout the Southern Appalachian Mountains on exposed summits and bluffs (Wiser 1993, Wiser 1994, Wiser *et al.* 1996). In Linville Gorge this vegetation class inhabits the bluffs and the exposed Hawksbill and Tablerock Mountain summits where sites are typically infertile, steep and highly exposed (Figures 1.2, 3.2, 3.3). This vegetation class represents 8% of the sites sampled in this study of Linville Gorge.

COMMUNITY TYPE: Rhododendron minus/Selaginella tortipila Outcrops (1.1)

Synonymy

Quartzite variant of High Elevation Rocky Summit, Montane Acidic Cliffs (Schafale & Weakley 1990), Herb sere & Shrub sere (Poudrier 1972), *Aronia arbutifolia/Kalmia latifolia outcrop* community p.p. (Wiser *et al.* 1996).

Constant species

Rhododendron minus, Selaginella tortipila, Carex umbellata.

Listed species

Fothergilla major, Hudsonia montana, Liatris helleri, Scirpus caespitosa, Zigadenus leimanthoides.

Physiognomy

The **Rhododendron minus/Selaginella tortipila Outcrops** have a low stature and variable structure. In some instances there is a dense shrub layer, occasionally with a few stunted *Pinus* trees (Tables 3.9, 3.10, 3.11). In other cases the shrub layer is shorter in height and more patchy in distribution with open areas of exposed rock, scattered mats of prostrate vegetation and isolated clumps of herbaceous species. *Rhododendron minus*, *Kalmia latifolia* and *Leiophyllum buxifolium* are the dominant shrub species with *Selaginella tortipila* the major prostrate mat component (Table 3.9). Three distinct sub-types are recognized.

Community sub-types:

Rhododendron minus-Fothergilla/Leiophyllum/Selaginella tortipila sub-type (1.1.1)
Synonymy: quartzite variant of High Elevation Rocky Summit p.p., Heath Bald p.p. (Schafale & Weakley 1990).

This outcrop sub-type varies greatly in structure and dominant species (mean height 3.05 m) (Tables 3.9, 3.10, 3.11). This reflects, to some extent, the variability of the habitat of this sub-type, which ranges from steep slopes to flat ledges within the bluffs, and shallow slopes above the bluff escarpments. *Rhododendron minus* forms a dense shrub layer on larger ledges (Tables 3.9, 3.10, 3.11). Flat, less exposed areas above the bluffs support dense patches of *Rhododendron minus*, *Gaylussacia baccata* and *Leiophyllum buxifolium* sometimes overtopped by scattered stunted *Pinus pungens* and *P. rigida*. *Fothergilla major* and *Kalmia latifolia* are also present in the shrub layer. On steeper sites, the shrubs are very stunted and patchy with *Leiophyllum buxifolium* and *Selaginella tortipila* dominant and *Scirpus caespitosa* present. This is most extreme on the escarpment faces where the vegetation is sparse, mat-like and restricted to small crevices and ledges. On the exposed, flat areas immediately above escarpment faces, most of the *L. buxifolium* and *S. tortipila* mats have been removed by recreation-related abrasion.

Rhododendron minus/Leiophyllum/Selaginella tortipila-Hypericum densiflorum sub-type (1.1.2)
Synonymy: quartzite variant of High Elevation Rocky Summit p.p. (Schafale & Weakley 1990), xeric type of outcrops p.p. (DuMond 1970).

Rhododendron minus and *Leiophyllum buxifolium* form low, dense thickets (mean height 0.5 m) (Tables 3.9, 3.10, 3.11). Areas with taller shrubs contain *Kalmia latifolia* with an occasional stunted *Pinus pungens* or *P. rigida* tree present. More open areas include a mixture of exposed rock and *Selaginella tortipila* mats and *Hypericum densiflorum* clumps with *Carex umbellata*, *Danthonia sericea*, *Vaccinium pallidum*, *Coreopsis major* and *Schizachyrium scoparium* also present. The species richness of this sub-type is higher than in the ***Rhododendron minus-Fothergilla/Leiophyllum/ Selaginella tortipila sub-type*** and the **[*Selaginella tortipila-Carex umbellata sub-type*]** (Table 3.8).

[*Selaginella tortipila-Carex umbellata sub-type*] (1.1.3)

Synonymy: Montane Acidic Cliffs (Schafale & Weakley 1990), xeric type of outcrops p.p. (DuMond 1970), *Selaginella tortipila/Carex umbellata* Outcrop community (Wiser *et al.* 1996).

Selaginella tortipila mats lie prostrate over smooth exposed rock surfaces (Tables 3.9, 3.10, 3.11). Bryophytes and lichens (Table 3.12) largely cover areas where *Selaginella* is not present. Both dominant woody species (*Nyssa sylvatica, Pinus pungens, Rhododendron minus)* and herbaceous species (*Carex umbellata, Hypericum densiflorum, Chionanthus virginicus, Coreopsis major, Liatris graminifolia)* are concentrated in rock crevices where at least a small amount of soil has been able to accumulate. Species richness is low at all spatial scales in comparison to the two other sub-types (Table 3.8). This sub-type also has fewer endangered species (Table 3.9).

Habitat and Distribution

The **Rhododendron minus/Selaginella tortipila Outcrops** are restricted to the highly exposed, rocky bluff areas on the eastern side of Linville Gorge. Shrubbier forms of the **Rhododendron minus/Selaginella tortipila Outcrops** inhabit larger, shallow sloping ledges and less exposed summit areas with deeper soils. Mat vegetation is associated with steep, rocky bluff sites and highly exposed, flat areas immediately above the escarpment faces. Plant distribution is very sparse on rough-textured, steep sites, restricted to small ledges and crevices. Mat vegetation distribution is generally more widespread on flat bluff summits and on smooth-sloping rock faces in areas protected from hikers and rock climbers. On flat summit areas, vegetation height and shrubbiness increases with increasing distance away from the escarpment edge and decreasing exposure, gradually grading into the **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest**.

The sub-types within this community type vary in slope, orientation and geologic substrate (Table 3.12). The ***Rhododendron minus-Fothergilla/Leiophyllum/Selaginella tortipila sub-type*** inhabits the lower quartzite bluffs in the vicinity of The Chimneys and southwards to Shortoff Mountain. Sites are southeast to northwest-facing with an elevational range of 1050 m to 1060 m. Topography and slope are variable, ranging from near flat ledges within the bluff faces and slopes at the top of the escarpments, to the steep escarpment faces themselves (average slope 37°). The ***Rhododendron minus/ Leiophyllum/Selaginella tortipila-Hypericum densiflorum sub-type*** occurs on south- to southwest-facing meta-arkose sites, on Hawksbill and the bluff tops near Sitting Bear. Sites are moderately sloped (21°) occurring at elevations (1159 to 1215 m) higher than the other 2 sub-types in this community type. However, there is also a low elevation variant (600 m) on lower quartzite on the southeast-facing slope of Shortoff Mountain. The ***[Selaginella tortipila-Carex umbellata sub-type]*** inhabits the steepest sites (on average 50°), and is found on north-facing gneiss bluffs situated mid-slope below Tablerock Mountain and Little Tablerock (960 m to 982 m in elevation). This community type grades into the **Tsuga caroliniana/Rhododendron maximum Forest** in sheltered small gullies within the bluffs.

The soils of this community type are heterogeneous, ranging from bare rock to thin coverage. They are typically low in Mn, Cu and Zn in comparison to other vegetation classes present in LGW (Figures 3.2, 3.3, Table 3.4). The soil texture is similar in the three sub-types with sites in the ***[Selaginella tortipila-Carex umbellata sub-type]*** marginally higher in clay and lower in sand content (Table 3.5). Soil nutrient status varies between the sub-types in this community type probably reflecting differences in bedrock. The

Rhododendron minus-Fothergilla/Leiophyllum/Selaginella tortipila sub-type soils have, on average, higher Na, S and K. The ***Rhododendron minus/Leiophyllum/ Selaginella tortipila-Hypericum densiflorum sub-type*** has soils with higher levels of Ca and lower percent organic matter. In contrast, the ***[Selaginella tortipila-Carex umbellata sub-type]*** soils have highest levels of Al of any group identified in Linville Gorge. Fe levels are also high in this sub-type with B, Ca, K, Na, P and cation exchange capacity low in comparison to the other 2 sub-types.

The highly exposed habitats occupied by the **Rhododendron minus/Selaginella tortipila Outcrops** mean that this community type incurs the most extreme temperature variation of any group present in LGW. Temperatures recorded by Poudrier (1972) near the summit of Hawksbill Mountain give some indication of summer extremes with July rock surface temperatures of 38° C (bare rock) and 43° C (rock covered in lichen).

Distinguishing Features

This community type contains the greatest number of nationally rare species of any vegetation group present in Linville Gorge. Rare species include those that are disjunct from the north and thought to be possible Pleistocene relicts (*Scirpus caespitosa*, *Sibbaldiopsis tridentata*), broad Southern Appalachian endemics (*Asplenium montanum*) and Southern Appalachian endemics with restricted ranges (*Hudsonia montana*, *Liatris helleri*) (Schafale & Weakley 1990, Wiser 1994). The ***[Selaginella tortipila-Carex umbellata sub-type]*** lacks rare species probably owing to is low-elevation habitat. The **Rhododendron minus/Selaginella tortipila Outcrops** community type is fragile and subject to the most extensive direct degradation by recreational activities.

Succession and Disturbance

This community type is in the early stages of primary succession. However, high exposure, continual small-scale erosion and fire, will limit soil accumulation and development and maintain these sub-types in their present successional state (Schafale & Weakley 1990, Frost 1993). Shrubby areas with deeper soils and less exposure may eventually succeed into forms of the **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest**.

At least some rock outcrop species are maintained by periodic fire. *Hudsonia montana*, a shade intolerant species, undergoes vigorous sprouting and seedling establishment after fire which reduces the competition from shade tolerant, faster growing species such as *Leiophyllum buxifolium* and *Cladonia* lichens (Frost 1993). *Hudsonia* requires a 10 to 15 year fire frequency to be maintained (Frost 1990).

Community type survival is threatened by human disturbance, mainly in the form of trampling. This is particularly apparent on the flat areas immediately above the bluffs. Rock climbers also disturb the herbaceous vegetation in escarpment face crevices and ledges.

COMMUNITY TYPE: [Cheilanthes tomentosa-Danthonia spicata Outcrops] (1.2)

Synonymy

Low Elevation Rocky Summit (Schafale & Weakley 1990).

Listed species

Cheilanthes tomentosa, *Minuartia groenlandica*.

Physiognomy

Only a limited number of species are present in this community type (Tables 3.8, 3.9). The species present are low in cover abundance and sparse in distribution, restricted to the few small ledges and crevices within this very rocky habitat (rock 94% of the surface substrate; Table 3.12).

Habitat and Distribution

This community type inhabits the east side of the Linville valley on the lower quartzite bluffs at the southern end of Shortoff Mountain (elevation 689 m). The area is exposed, and steep (70°) to overhanging (Table 3.12). Vegetation is restricted to the few areas where soil can accumulate. The soils have higher B levels and lower K and organic matter than the other **Rock Outcrops** community types (Tables 3.4, 3.5).

Distinguishing Features

This is one of two non-woody community types in Linville Gorge. The other, the **[Scirpus cyperinus-Dulichium Temporary Pond]** is restricted to a totally different habitat. The **[Cheilanthes tomentosa-Danthonia spicata Outcrops]** have closest affiliation with the **Selaginella tortipila Outcrops,** but lacks the woody species present in the latter. The former type is distributed at lower-elevations on steeper sites. On these sites plant distribution is much more restricted to small crevices and ledges. The distinctiveness of this type is shown by the fact that nearly half the species are unique to this type in Linville Gorge.

Succession

Due to the steep topography and limited soil depth, this community will be maintained in its present form.

COMMUNITY TYPE: Selaginella tortipila Outcrops (1.3)

Synonymy

Low Elevation Rocky Summit p.p., Montane Acidic Cliffs p.p. (Schafale & Weakley 1990), xeric type of outcrops (DuMond 1970), *Selaginella tortipila/Carex umbellata* Outcrop community (Wiser *et al.* 1996).

Constant species

Danthonia sericea, Pinus strobus, Pinus virginiana, Rhododendron minus, Selaginella tortipila.

Physiognomy

This community type is characterized by a combination of dense *Selaginella tortipila* mats (9 cm average canopy height), high lichen and bryophytic cover and a high degree of exposed bare rock (Tables 3.9, 3.12). Other species have much more restricted distribution with *Danthonia sericea*, *Pinus strobus* and *P. virginiana* seedlings and stunted *Rhododendron minus* shrubs having greatest abundance and most consistent cover (Tables 3.9, 3.10, 3.11). Cover of other species varies from site to site, dependent on the degree of site shelter.

Habitat and Distribution

This community type inhabits the lower quartzite rock outcrops on the west side of the Linville valley occurring on small sheltered escarpments and on shaded bluff crests at the summit of the major bluff system. Sites vary in slope (average of 53°) and are xeric with southeast- to south-facing aspects (Table 3.12). As a consequence, vegetation is restricted to sites sheltered by adjacent the **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest**. The **Selaginella tortipila Outcrops** rapidly diminish in extent with increasing exposure and do not occur on the escarpment faces of the major bluff system. For the most part, the bluffs on the west side are bare rock with stunted forms of the **Xeric Evergreen Forests**, particularly the **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest** and in the south, the **Pinus virginiana-Pinus pungens/Kalmia Forest**, present in isolated, less extreme sites and ravines. The **Selaginella tortipila Outcrops** also occurs on small, sheltered rock bluffs (approximately 200 to 500 m^2 in size) above the major bluff system with *Selaginella* forming extensive mats on smooth, shallower sloping sites, or on steep escarpment faces where the vegetation is restricted to small ledges.

The thin soils are high in Al, B, Cu, Fe, P and S in comparison to other types and sub-types in the **Rock Outcrops** vegetation class. The **Selaginella tortipila Outcrops** has highest base saturation levels of any **Rock Outcrops** type or sub-type indicating slightly higher soil fertility (Tan 1993). However, pH levels are the lowest of any group in this vegetation class. Soil sand and clay content is higher than in the other **Rock Outcrops** vegetation types (Tables 3.4, 3.5).

Distinguishing Features

The **Selaginella tortipila Outcrops** have closest floristic association with the **[Cheilanthes tomentosa-Danthonia spicata Outcrops]**, although only 55% of the species are present in both groups. The differences are attributable, in part, to habitat, topographic and elevational differences. The **Selaginella tortipila Outcrops** differ from the remaining types in the **Rock Outcrops** class in elevation, slope position, exposure-moisture regime and community habitat size. The **Selaginella tortipila Outcrops** inhabit lower-elevation sites which have high heating potential from sun exposure. The mid-slope position of this group protects it from the high levels of exposure to adverse climatic conditions (including shrouding by fog and ridge-top exposure) facing the **Rhododendron minus/Selaginella tortipila Outcrops**. The **Selaginella tortipila Outcrops** do not contain any listed species and have more consistent cover of *Pinus* than the **Rhododendron minus/Selaginella tortipila Outcrops.** The small spatial extent of the **Selaginella tortipila Outcrops,** scattered on small outcrops and sheltered bluff crests amongst predominantly the *Pinus*-dominated **Xeric Evergreen Forests**, accounts for the consistent *Pinus* abundance. Although two vegetation groups are dominated by *Selaginella tortipila* mats, the **Selaginella tortipila Outcrops** differs from the ***[Selaginella-Carex umbellata sub-type]*** in that the latter group has higher total species diversity with much greater diversity and density of woody species. The latter group also contains several listed species. Both groups inhabit mid-slope outcrops, but the ***[Selaginella-Carex umbellata sub-type]*** occurs on moist, north-facing outcrops underlain by gneiss bedrock, in contrast to the south-facing slopes on lower quartzite bedrock inhabited by the **Selaginella tortipila Outcrops**.

The **Selaginella tortipila Outcrops** is the only **Rock Outcrops** type or sub-type inhabiting the bluffs on the western side of the Linville valley and, in conjunction with xeric **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest** and stunted forms of the **Pinus virginiana-Pinus pungens/Kalmia Forest,** dominate the rock bluffs on the western side.

On the western side, in the forest below the major bluff system, *Asplenium montanum* inhabits crevices on sparsely distributed, moist rock faces found within other community types, such as the **Tsuga canadensis/Rhododendron maximum Forest**.

Succession and Disturbance

Human disturbance is not a critical issue for this community type because of its isolation from walking trails and highly visited regions. Exposure to adverse climatic conditions, particularly dryness, small-scale erosion and fire are the major disturbance factors influencing the development of this community type. These factors, coupled with restricted soil accumulation and development will maintain this community type in its present succesional state.

Table 3.9. Average cover class and constancy of species present in the **<u>Rock</u> <u>Outcrops</u>** vegetation class. Values are given for the vegetation class as a whole as well as within each community type and sub-type. Each group is represented by its abbreviation code. For full group names see Table 3.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are <u>underlined</u>. Homoteneity is the mean constancy of the prevalent species.

Group:	1.	1.1	1.1.1	1.1.2	1.1.3	1.2	1.3
Number of plots:	15	11	4	5	2	1	3
Homoteneity:	0.499	0.538	0.659	0.70	0.813	1.0	0.647
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species							
ACER RUBRUM VAR RUBRUM	3 27	3 27	<u>3 50</u>		<u>4 50</u>		1 33
AGROSTIS PERENNANS	2 7					2 100	
AMELANCHIER LAEVIS	2 27	2 36	1 25	2 20	<u>2 100</u>		
ANDROPOGON VIRGINICUS	2 13	2 18	1 25		<u>2 50</u>		
ARONIA ARBUTIFOLIA	2 27	2 36	<u>1 50</u>	2 40			
ASPLENIUM MONTANUM	1 13	1 18	<u>1 50</u>				
AUREOLARIA LAEVIGATA	1 13	1 18		1 40			
BETULA LENTA	1 7	1 9		1 20			
CAMPANULA DIVARICATA	1 7	1 9		1 20			
CAREX UMBELLATA	<u>2 93</u>	<u>2 100</u>	<u>2 100</u>	<u>2 100</u>	<u>3 100</u>	2 100	<u>2 67</u>
CARYA OVATA	1 7	1 9		1 20			
CHASMANTHIUM LAXUM	2 7					2 100	
CHEILANTHES TOMENTOSA	2 7					2 100	
CHIONANTHUS VIRGINICUS VAR VIRGINICUS	2 27	2 36		2 40	<u>2 100</u>		
CLETHRA ACUMINATA	2 27	2 36	<u>2 75</u>	1 20			
COREOPSIS MAJOR VAR RIGIDA	<u>2 60</u>	<u>2 64</u>		<u>2 100</u>	<u>2 100</u>		<u>2 67</u>
CORYDALIS SEMPERVIRENS	2 13					2 100	1 33
DANTHONIA SERICEA	<u>2 67</u>	<u>2 55</u>	1 25	<u>3 100</u>		2 100	<u>2 100</u>
DANTHONIA SPICATA	3 13					2 100	3 33

Group:	1.	1.1	1.1.1	1.1.2	1.1.3	1.2	1.3
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
DESCHAMPSIA FLEXUOSA VAR FLEXUOSA	1 7	1 9		1 20			
DICHANTHELIUM ACUMINATUM VAR FASCICULATUM	1 20	1 27		1 60			
DICHANTHELIUM COMMUTATUM	1 7						1 33
DICHANTHELIUM DEPAUPERATUM	1 13	1 9			1 50		1 33
DICHANTHELIUM DICHOTOMUM VAR DICHOTOMUM							1 33
DICHANTHELIUM DICHOTOMUM VAR 3 (=LUCIDUM)	1 13						1 67
DICHANTHELIUM MERIDIONALE	2 7					2 100	
DICHANTHELIUM CF. SABULORUM	2 13	2 18	2 50				
DIOSPYROS VIRGINIANA	3 7	3 9		3 20			
ERECHTITIES HIERACIFOLIA VAR HIERACIFOLIA	1 7						1 33
EUPATORIUM ROTUNDIFOLIUM VAR ROTUNDIFOLIUM	2 7						2 33
FOTHERGILLA MAJOR*	3 20	3 27	3 75				
GALAX URCEOLATA	2 40	2 55	2 50	2 60	2 50		
GAULTHERIA PROCUMBENS	2 20	2 27		2 60			
GAYLUSSACIA BACCATA	4 27	4 36	4 75	3 20			
GOODYERA REPENS	1 7	1 9	1 25				
HAMAMELIS VIRGINIANA	2 13	2 18		1 20	2 50		
HEXASTYLIS SHUTTLEWORTHII VAR SHUTTLEWORTHII	2 13	2 18		2 40			
HUDSONIA MONTANA*	1 7	1 9	1 25				
HYPERICUM DENSIFLORUM	3 53	4 55		4 80	3 100	2 100	3 33
HYPERICUM STAGALUM	1 7						1 33
ILEX MONTANA	3 27	3 36	3 75	1 20			
ILEX OPACA VAR OPACA	2 7	2 9		2 20			
IRIS VERNA	1 7	1 9	1 25				
KALMIA LATIFOLIA	3 47	3 55	3 75	3 60			3 33

Group:	1.	1.1	1.1.1	1.1.2	1.1.3	1.2	1.3
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
LECHEA RACEMOSA	1 7						1 33
LEIOPHYLLUM BUXIFOLIUM	4 60	4 82	4 100	5 100			
LEUCOTHOE RECURVA	2 20	2 27	2 75				
LIATRIS GRAMINIFOLIA	2 33	2 45		1 60	2 100		
LIATRIS HELLERI*	2 20	2 27	2 50	2 20			
LYONIA LIGUSTRINA VAR LIGUSTRINA	2 13	2 18	2 50				
LYSIMACHIA QUADRIFOLIA	2 27	2 36	2 50	1 40			
MELAMPYRUM LINEARE	1 20	1 18		1 40			1 33
MINUARTIA GROENLANDICA*	2 7					2 100	
NYSSA SYLVATICA	2 53	2 55	1 25	2 60	2 100	2 100	1 33
OXYDENDRUM ARBOREUM	2 7						2 33
PARONYCHIA ARGYROCOMA	2 7	2 9	2 25				
PINUS PUNGENS	4 33	4 45	6 25	5 40	3 100		
PINUS RIGIDA	4 33	5 36	5 25	5 60		2 100	
PINUS STROBUS	2 53	2 36	2 25	3 40	2 50	2 100	2 100
PINUS VIRGINIANA	3 20						3 100
POLYPODIUM APPALACHIANUM	1 7						1 33
QUERCUS MONTANA	4 20	4 27		5 40	2 50		
QUERCUS MARILANDICA	2 7	2 9		2 20			
QUERCUS RUBRA	3 13	3 18		2 20	3 50		
RHODODENDRON CATAWBIENSE	4 7	4 9	4 25				
RHODODENDRON MAXIMUM	3 13	4 9			4 50		2 33
RHODODENDRON MINUS	4 100	5 100	6 100	5 100	3 100	2 100	3 100
RHUS COPALLINA VAR LATOFOLIA	3 13						3 67
ROBINIA PSEUDOACACIA	1 13	1 18		1 40			
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	2 20					2 100	2 67
SASSAFRAS ALBIDUM	1 7	1 9		1 20			
SAXIFRAGA MICHAUXII	1 7						1 33
SCHIZACHYRIUM SCOPARIUM	2 33	2 45		2 100			
SCIRPUS CESPITOSUS*	3 13	3 18	3 50				

Group:	1.	1.1	1.1.1	1.1.2	1.1.3	1.2	1.3
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
SELAGINELLA TORTIPILA	4 100	4 100	3 100	5 100	4 100	2 100	6 100
SIBBALDIOPSIS TRIDENTATA*	2 13	2 18		2 40			
SMILAX GLAUCA VAR GLAUCA	2 40	2 36	1 25	2 60		2 100	1 33
SMILAX ROTUNDIFOLIA	2 33	3 18		3 40		2 100	1 67
SOLIDAGO ARGUTA SSP CAROLINIANA	1 7	1 9		1 20			
SOLIDAGO PUBERULA	2 13	2 18		2 20	2 50		
SORBUS AMERICANA	1 7	1 9		1 20			
STENANTHIUM GRAMINEUM VAR MICRANTHUM	2 13	2 18	2 25	1 20			
SYMPLOCOS TINCTORIA	1 7						1 33
TSUGA CANADENSIS	4 13	4 9		4 20			3 33
TSUGA CAROLINIANA	2 47	3 45	2 25	3 80		2 100	2 33
VACCINIUM CORYMBOSUM	3 27	3 36	3 50	3 40			
VACCINIUM PALLIDUM	2 40	2 55	2 25	2 100			
VACCINIUM STAMINEUM	3 13	3 9		3 20		2 100	
VIBURNUM NUDUM VAR CASSINOIDES	1 7	1 9	1 25				
VITIS ROTUNDIFOLIA	2 7					2 100	
XEROPHYLLUM ASPHODELOIDES	3 40	3 55	2 75	3 60			
ZIGADENUS LEIMANTHOIDES*	1 13	1 18	1 25	1 20			

Table 3.10. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Rock Outcrops** vegetation class and associated community types and sub-types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

1. Rock Outcrops

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
PINUS PUNGENS	10.00	100.00	0.00	110.00	2.00	3.49	15.03	9.26
PINUS RIGIDA	73.33	126.67	0.00	200.00	0.56	8.55	13.21	10.88
PINUS STROBUS	13.33	10.00	0.00	23.33	0.03	2.29	5.80	4.05
PINUS VIRGINIANA	6.67	20.00	0.00	26.67	0.10	3.68	9.13	6.41
RHODODENDRON MINUS	940.00	586.67	0.00	1526.67	0.84	23.25	10.74	18.00
ALL	1583.33	1150.00	0.00	2733.33	4.49	65.21	66.56	65.88

1.1 Rhododendron minus/Selaginella Outcrops

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
PINUS PUNGENS	13.64	136.36	0.00	150.00	2.73	4.76	20.50	12.63
PINUS RIGIDA	100.00	172.73	0.00	272.73	0.76	11.66	18.02	14.84
PINUS STROBUS	9.09	13.64	0.00	22.73	0.03	1.61	7.11	4.36
RHODODENDRON MINUS	1190.91	763.64	0.00	1954.55	1.08	23.98	15.00	19.49
ALL	2040.91	1477.27	0.00	3518.18	5.67	72.73	72.73	72.73

1.1.1 Rhododendron minus-Fothergilla/Leiophyllum/Selaginella tortipila sub-type

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ILEX MONTANA	212.50	462.50	0.00	675.00	0.88	3.74	4.88	4.31
PINUS PUNGENS	37.50	100.00	0.00	137.50	2.67	1.66	16.29	8.97
RHODODENDRON MINUS	3162.50	2100.00	0.00	5262.50	2.95	57.36	40.81	49.08
ALL	4037.50	3212.50	0.00	7250.00	8.62	75.00	75.00	75.00

1.1.2 Rhododendron minus/Leiophyllum/Selaginella tortipila-Hypericum densiflorum sub-type

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
AMELANCHIER LAEVIS	20.00	0.00	0.00	20.00	0.00	8.00	1.35	4.68
KALMIA LATIFOLIA	200.00	0.00	0.00	200.00	0.00	8.00	0.35	4.17
PINUS PUNGENS	0.00	100.00	0.00	100.00	2.68	5.71	14.94	10.33
PINUS RIGIDA	200.00	310.00	0.00	510.00	1.01	24.57	35.57	30.07
PINUS STROBUS	0.00	20.00	0.00	20.00	0.02	2.86	15.31	9.08
QUERCUS MONTANA	40.00	30.00	0.00	70.00	0.77	7.43	7.85	7.64
ALL	740.00	500.00	0.00	1240.00	4.62	80.00	80.00	80.00

1.1.3 (Selaginella tortipila-Carex umbellata sub-type)

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
PINUS PUNGENS	0.00	300.00	0.00	300.00	2.99	8.57	42.83	25.70
RHODODENDRON MAXIMUM	1050.00	0.00	0.00	1050.00	0.13	30.00	1.89	15.94
ALL	1300.00	450.00	0.00	1750.00	3.49	50.01	50.00	50.00

1.2 (Cheilanthes tomentosa-Danthonia spicata Outcrops)

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
KALMIA LATIFOLIA	33.33	66.67	0.00	100.00	0.08	5.26	3.14	4.20
PINUS STROBUS	33.33	0.00	0.00	33.33	0.01	5.56	2.94	4.25
PINUS VIRGINIANA	33.33	100.00	0.00	133.33	0.49	18.42	45.67	32.05
RHODODENDRON MINUS	333.33	133.33	0.00	466.67	0.22	28.36	8.69	18.53
ALL	433.33	333.33	0.00	766.67	0.95	59.36	66.12	62.74

Table 3.11. Vertical structure of woody species in the **Rock Outcrops** vegetation class and associated community types and sub-types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

1. Rock Outcrops

	<0.5m	6-0.5m	15-6m	35-15m	>35m
KALMIA LATIFOLIA	1	1			
LEIOPHYLLUM BUXIFOLIUM	1	1			
PINUS PUNGENS	1	1			
PINUS RIGIDA	1	1			
QUERCUS MONTANA	1	1			
RHODODENDRON MINUS	2	3			

1.1 Rhododendron minus/Selaginella tortipila Outcrops

	<0.5m	6-0.5m	15-6m	35-15m	>35m
KALMIA LATIFOLIA	1	1			
LEIOPHYLLUM BUXIFOLIUM	1	1			
PINUS PUNGENS	1	2	1		
PINUS RIGIDA	1	2			
QUERCUS MONTANA	1	1			
RHODODENDRON MINUS	3	3			

1.1.1 Rhododendron minus-Fothergilla/Leiophyllum/Selaginella sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1			
FOTHERGILLA MAJOR	1	2			
ILEX MONTANA	1	2			
KALMIA LATIFOLIA	1	2			
LYONIA LIGUSTRINA					
VAR LIGUSTRINA	1	1			
PINUS PUNGENS	1	2	2		
PINUS RIGIDA	1	1			
RHODODENDRON MINUS	4	5			

1.1.2 Rhododendron minus/Leiophyllum/Selaginella tortipila-Hypericum densiflorum sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
HYPERICUM DENSIFLORUM	1				
KALMIA LATIFOLIA	2	2			
LEIOPHYLLUM BUXIFOLIUM	3	2			
PINUS PUNGENS	1	2			
PINUS RIGIDA	1	3			
QUERCUS MONTANA	1	2			
RHODODENDRON MINUS	3	2			
TSUGA CANADENSIS	1				
TSUGA CAROLINIANA	1	1			
VACCINIUM STAMINEUM	1	1			

1.1.3 [Selaginella tortipila-Carex umbellata sub-type]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	2				
HAMAMELIS VIRGINIANA	1				
NYSSA SYLVATICA	1				
PINUS PUNGENS	1	2			
PINUS STROBUS	1				
QUERCUS MONTANA	1				
QUERCUS RUBRA	2				
RHODODENDRON MAXIMUM	2				

1.2 [Cheilanthes tomentosa-Danthonia spicata Outcrops]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
KALMIA LATIFOLIA	1	1			
PINUS STROBUS	1	1			
PINUS VIRGINIANA	1	2			
RHODODENDRON MINUS	1	2			
TSUGA CANADENSIS	1	1			

Table 3.12. Site information for the **Rock Outcrops** vegetation class. Groups represented by their abbreviation code. For full names see Table 3.1. Average values of site variables are given. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**CL**=lower quartzite, **G**=gneiss, **M**=meta-arkose), Landform types (representing micro-scale topographic units) (**Rav**=ravine, **R**=ridge, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**Escarp**=escarpment, **Ledg**=ledge/terrace, **US**=upper-slopes).

1. Rock Outcrops

	Group						
	1.	1.1	1.1.1	1.1.2	1.1.3	1.2	1.3
Site Characteristics:							
Elevation (m)	1014	1043	1053	1066	971	689	748
Slope (o)	36	32	37	21	50	80	32
Aspect (o)			SE-SW	SW	NW	S	SE-S
Parent material		CL	G	M	CL	CL	
Surface Substrate (%):							
Moss/Lichen	16	17	11	16	30	10	32
Wood	1	1	1	1	3	1	2
Rock	42	37	43	29	45	94	55
Organic matter	46	50	46	63	25	5	44
Water	0	0	0	0	0	0	0
Topographic Characteristics:							
Relative Slope (%)	10	10	4	13	15	7	46
LFI	0.13	0.12	0.06	0.11	0.27	0.03	0.49
TSI	-0.06	-0.07	-0.07	-0.08	-0.03	0.00	-0.08
Landform type	Rav,SS	Rav,SS,R	Rav	SS	R	Rav	SS
Topographic position	Escarp	Escarp	Escarp	US,Ledg	Escarp	Escarp	Escarp

3.5.2 VEGETATION CLASS: 2. Xeric Evergreen Forests

This vegetation class inhabits xeric sites with thin soils and is restricted to lower-elevation areas of the Southern Appalachian Mountains (Schafale & Weakley 1990). In Linville Gorge this group is one of the two largest vegetation classes identified, accounting for 46% of all sites sampled and 40% of the area mapped (Appendices 1, 4). The **Xeric Evergreen Forests** class dominates xeric, infertile sites (Figures 3.2, 3.3, 3.5, 3.6) on the slopes above the bluffs, less-extreme areas within the bluffs and also occurs on ridges below the bluffs. Low nutrient status reflects thin soil profiles, limited soil moisture retention and downslope leaching of nutrients from these sites (Racine 1966). Canopy height, stature and composition of types in this class vary according to site exposure, slope and soil depth. This group is characterized by canopy dominance of the xeriphytic conifers (*Pinus pungens*, *P. rigida*, *P. virginiana*, *Tsuga caroliniana*) and *Quercus* species (*Q. montana*, *Q. coccinea* var. *coccinea*) and a dense evergreen shrub stratum.

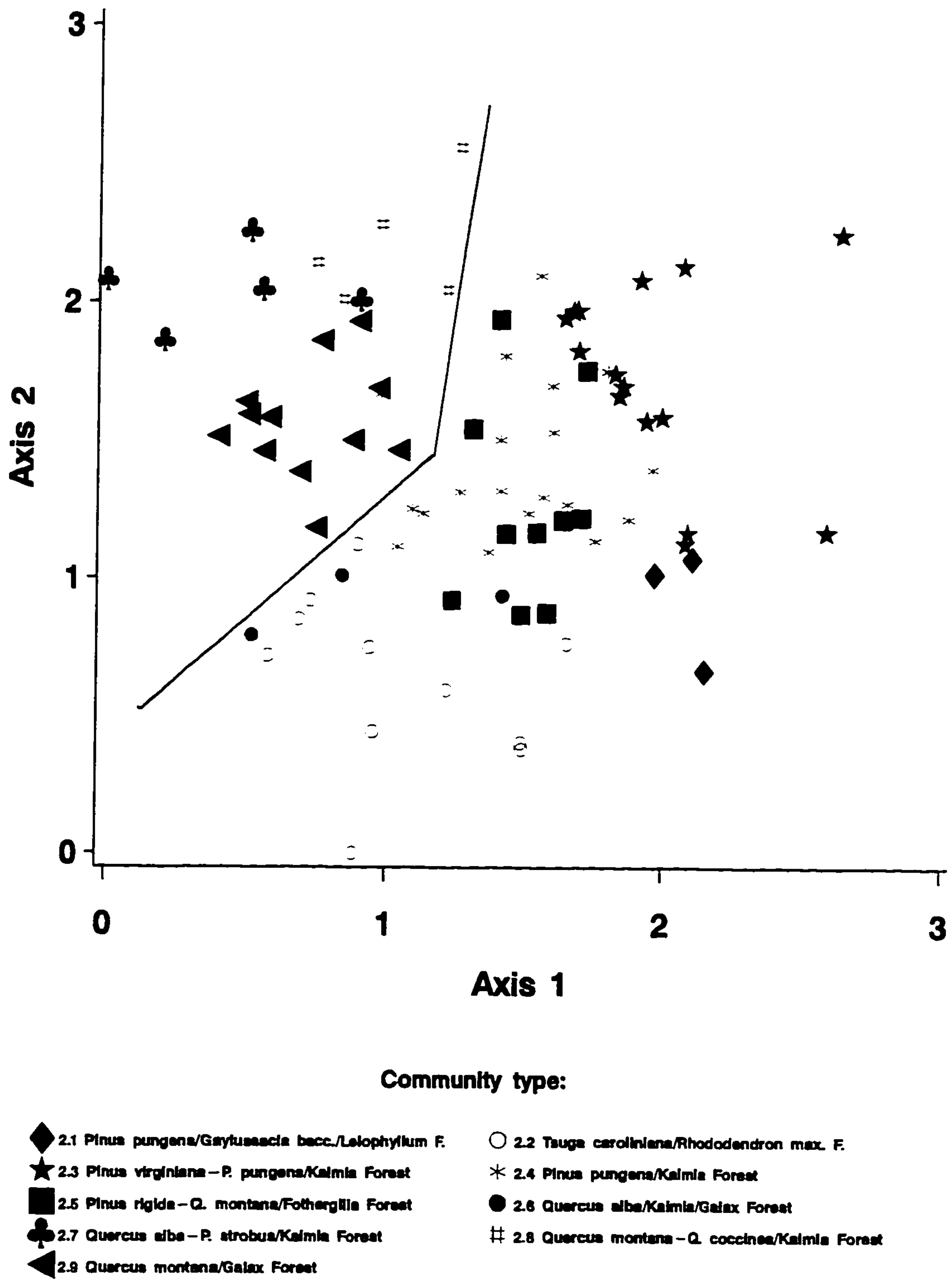
The **Xeric Evergreen Forests** separate from the other four non-alluvial forest vegetation classes primarily on the basis of soil nutrients, texture and topographic position (Figures 3.5, 3.6). Within the **Xeric Evergreen Forests** community types separate from one another by differences in elevation, exposure (solar radiation), soil nutrient status (Mn, Cu) and section curvature (Figures 3.8, 3.9). Underlying geologic type shows only very weak correspondence to the major environmental gradients identified, with most stands underlain by lower quartzite (Figure 3.10).

Community types dominated by *Pinus pungens*, *P. virginiana*, *P. rigida* and *Tsuga caroliniana* inhabit less fertile (lower Mn, Cu) sites than those dominated by *Quercus alba* and *Q. montana* (Figures 3.8, 3.9). Three of the four *Quercus*-dominated types are well separated from each other. The **Quercus montana/Galax Forest** inhabits less fertile and less convex sites than the **Quercus alba-Pinus strobus/Kalmia Forest** and the **Quercus montana-Quercus coccinea/Kalmia Forest**. The latter two groups are separated by solar radiation, with the **Quercus montana-Quercus coccinea/Kalmia Forest** typically occurring on dryer, lower-elevation sites. Stands in the fourth *Quercus* type, the **Quercus alba/Kalmia/Galax Forest** are not closely grouped together, but occur on less fertile, higher-elevation sites.

Of the types inhabiting less fertile conditions, the **Tsuga caroliniana/ Rhododendron maximum Forest** is situated on moister (low solar radiation, high TMI), higher-elevation sites (Figures 3.8, 3.9). The **Pinus virginiana-Pinus pungens/Kalmia Forest** and the **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest** inhabit less fertile sites than other types. However, in general, stands were not well separated by community type in the infertile *Pinus* and *Tsuga* types, and these were reordinated in an effort to clarify site differences.

The subsequent ordination of infertile *Pinus* and *Tsuga* types reiterates the position of the **Tsuga caroliniana/Rhododendron maximum Forest** on moister, higher-elevation sites than the *Pinus*-dominated types (Figures 3.11, 3.12). The *Pinus* types all inhabit dry (high solar radiation, low TMI) convex sites. The **Pinus rigida-Quercus montana/ Fothergilla Forest** is well separated from the other *Pinus* types, occurring on more fertile sites with higher Cu, Mg and lower Al. The **Pinus virginiana-Pinus pungens/Kalmia Forest** is situated at the opposing end of the soil gradient with the remaining two types intermediate along this gradient. Some sites in the **Pinus virginiana-Pinus pungens/Kalmia Forest** are dryer and more convex than other *Pinus*-dominated sites.

Figure 3.8. DCA ordination diagram of the **Xeric Evergreen Forests** class showing community types distribution on the two major compositional gradients. The solid line represents separation of stands for a subsequent ordination.



3
2
1
0
Axis 2
0
1
2
3
Axis 1
Community type:
2.1 Pinus pungens/Gaylussacia bacc./Leiophyllum F.
2.2 Tsuga caroliniana/Rhododendron max. F.
2.3 Pinus virginiana – P. pungens/Kalmia Forest
2.4 Pinus pungens/Kalmia Forest
2.5 Pinus rigida – Q. montana/Fothergilla Forest
2.6 Quercus alba/Kalmia/Galax Forest
2.7 Quercus alba – P. strobus/Kalmia Forest
2.8 Quercus montana – Q. coccinea/Kalmia Forest
2.9 Quercus montana/Galax Forest

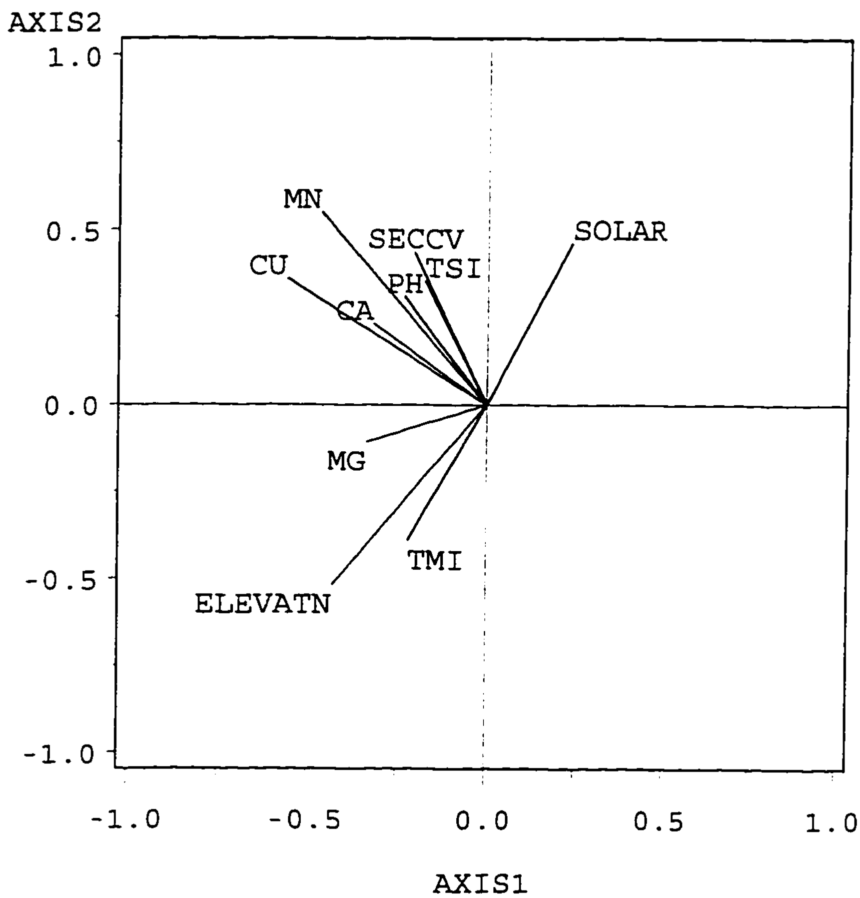


Figure 3.9. Vector diagram for DCA ordination of the **Xeric Evergreen Forests** class showing association between species composition and major environmental gradients. SECCV=section curvature. Small TMI values represent low site moisture potential whereas large values represent high moisture. TSI values represent convex upper-slopes while high values represent concave lower-slopes.

Figure 3.10. DCA ordination diagram of **Xeric Evergreen Forests** class showing distribution by parent material type on the two major compositional gradients.

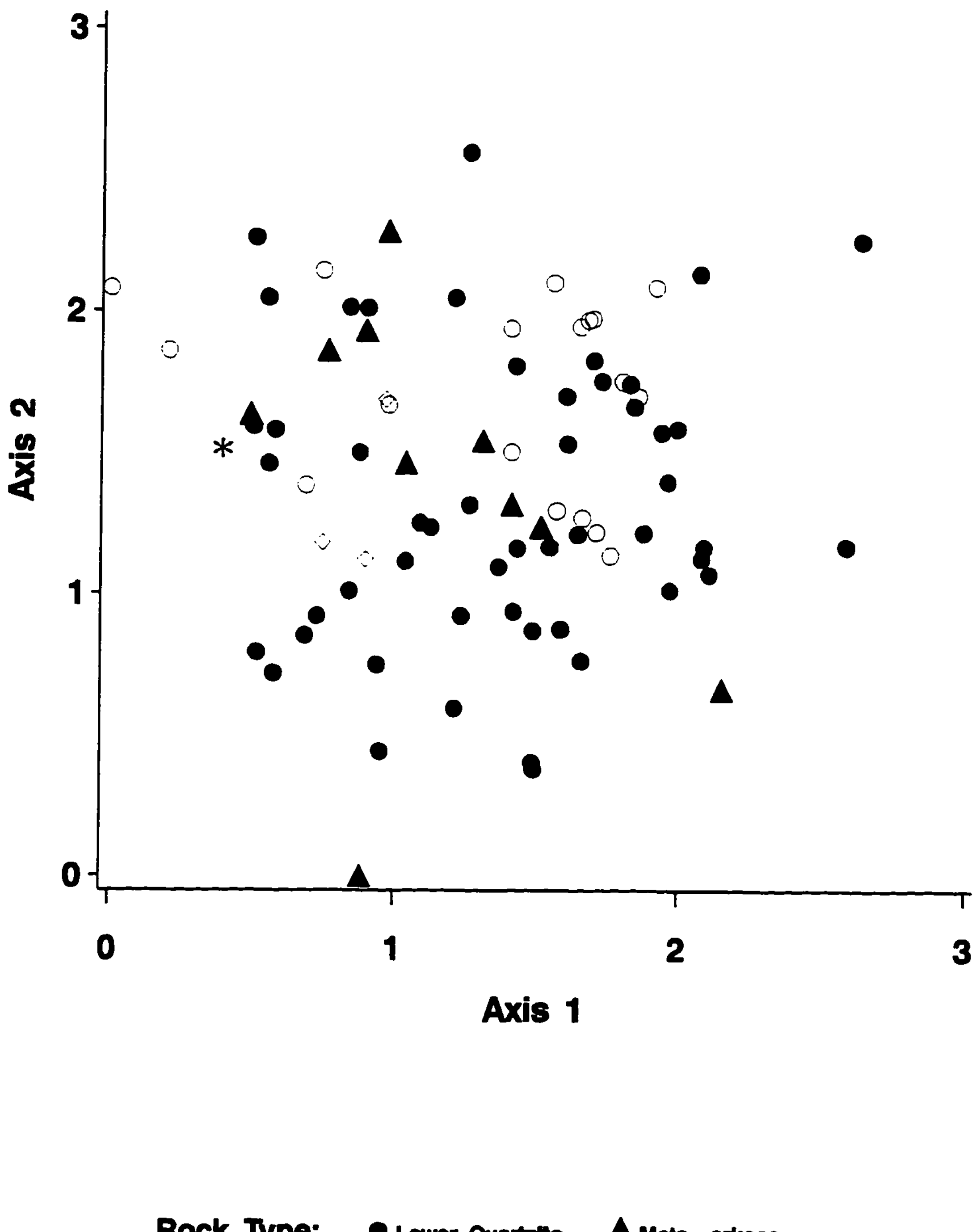
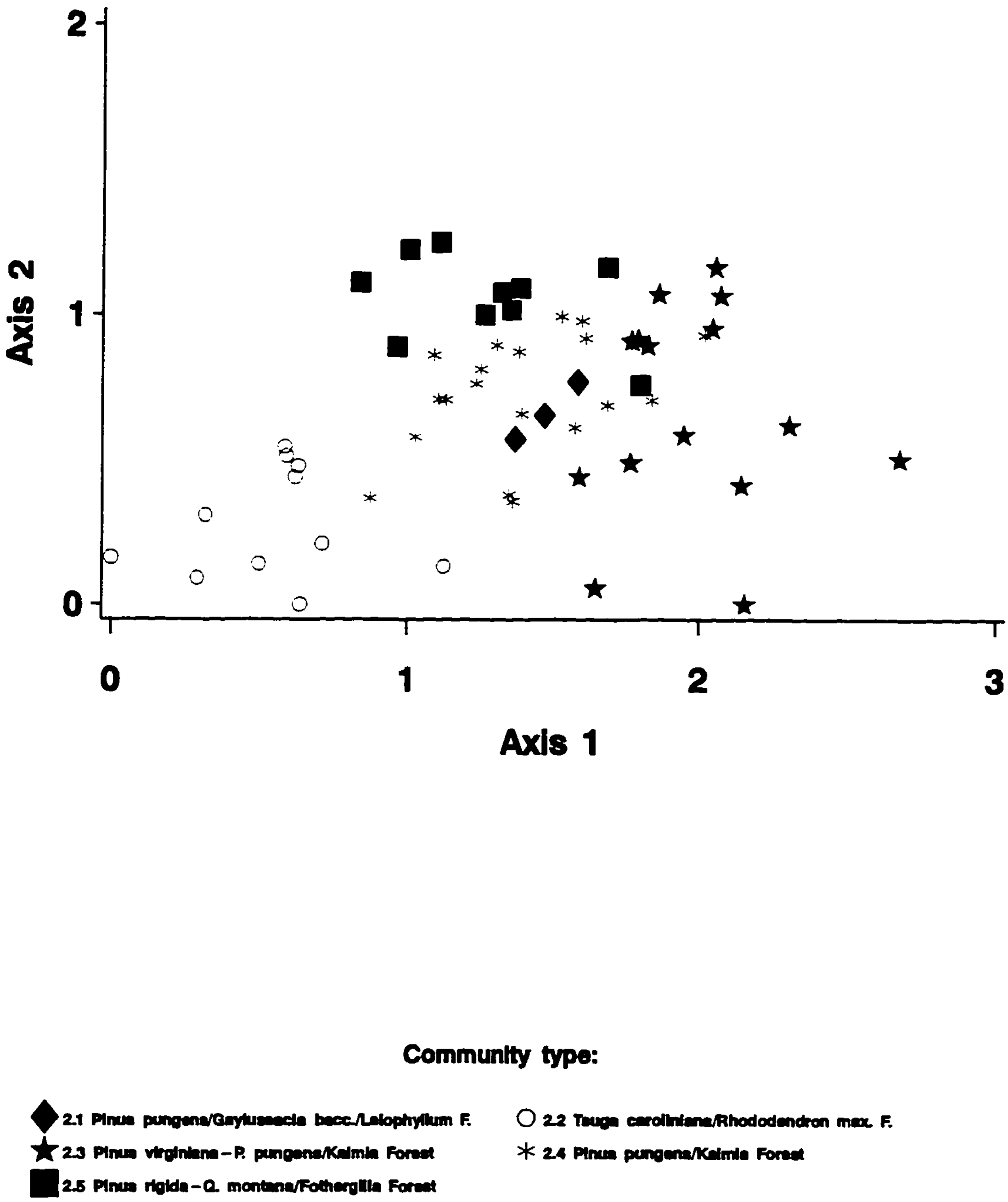

3
2
1
0
Axis 2
0
1
2
3
Axis 1
Rock Type:
Lower Quartzite
Gneiss
Upper Quartzite
Meta-arkose
Phyllite

Figure 3.11. DCA ordination diagram of the *Tsuga caroliniana*- and *Pinus*-dominated types in the **Xeric Evergreen Forests** class showing distribution on the two major compositional gradients.


2
1
0
Axis 2
0
1
2
3
Axis 1
Community type:
2.1 Pinus pungens/Gaylussacia bacc./Leiophyllum F.
2.2 Tsuga caroliniana/Rhododendron max. F.
2.3 Pinus virginiana – P. pungens/Kalmia Forest
2.4 Pinus pungens/Kalmia Forest
2.5 Pinus rigida – Q. montana/Fothergilla Forest

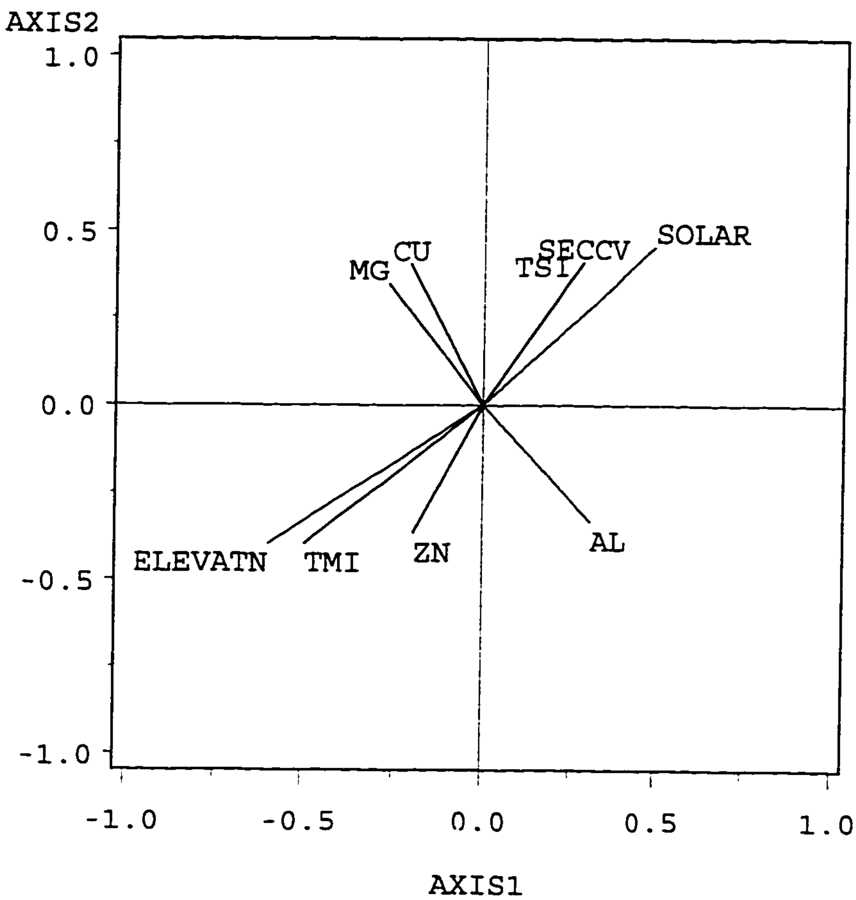


Figure 3.12. Vector diagram for DCA ordination of the *Tsuga caroliniana*- and *Pinus*-dominated types in the **Xeric Evergreen Forests** class showing association between species composition and major environmental gradients. SECCV= section curvature, Small TMI values represent low site moisture potential whereas large values represent high moisture. TSI values represent convex upper-slopes while high values represent concave lower-slopes.

COMMUNITY TYPE: Pinus pungens/Gaylussacia baccata-Leiophyllum Forest (2.1)

Synonymy

Pine--Oak/Heath (Schafale & Weakley 1990), Xeric Pine Forests p.p. (Whittaker 1956), Pine Community Type p.p. (Cooper & Hardin 1970), Pine-Oak Heath (Rohrer 1983), Xeric Pine Forests p.p. (McLeod 1988).

Constant species

Acer rubrum var. *rubrum, Amelanchier laevis, Galax urceolata, Gaultheria procumbens, Gaylussacia baccata, Iris verna, Kalmia latifolia, Leiophyllum buxifolium, Leucothoe recurva, Lyonia ligustrina* var. *ligustrina, Pinus pungens, Pinus rigida, Rhododendron minus, Smilax rotundifolia, Tsuga caroliniana, Xerophyllum asphodeloides, Vaccinium pallidum*.

Listed species

Fothergilla major.

Physiognomy

Pinus pungens and *P. rigida* are the major components of the stunted canopy (1.5 m to 9 m canopy height range) (Tables 3.13, 3.14, 3.15). Below, *Gaylussacia baccata* and *Leiophyllum buxifolium* form a dense, prostrate shrub mat. Clumps of *Rhododendron minus* are scattered within this stratum. The shrub layer decreases in stature with increasing exposure and proximity to the bluff rim. Where shrub cover is absent or extremely low, *Xerophyllum asphodeloides, Galax urceolata* and *Gaultheria procumbens* persist. Other species are scattered amongst this matrix, which is indicated by the high small-scale diversity in this type (Table 3.8). This type has highest richness for the **Xeric Evergreen Forests** type between 0.1 m^2 and 10 m^2.

Habitat and Distribution

The **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest** occurs on both sides of the valley. It inhabits the exposed, flat ledges at the summit of the bluffs and some sheltered, steep crevices within the bluffs (Figures 3.8, 3.9, Table 3.16). This community forms a stunted, narrow, krummholz-like band along bluff ledges. In more sheltered positions away from the bluff edge, the **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest** grades into the **Pinus pungens/Kalmia Forest**. In crevice sites the **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest** tends to have a greater shrub dominance and reduced canopy cover. Two of the three sites are underlain by lower quartzite bedrock and the third by meta-arkose.

The **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest** has coarser-textured soils than the majority of other types in the **Xeric Evergreen Forests** class. The soils have higher Fe and lower Mg and organic matter values than other types in this class (Tables 3.4, 3.5). Limited abundance of evergreen species such as *Kalmia* and *Rhododendron* may account for the lower organic matter levels.

Succession and Disturbance

There is no evidence of fire in this type. Although periodic fires are typically necessary for the maintenance of *Pinus pungens*, this species is thought to be self-perpetuating without fire on extremely xeric sites (Whittaker 1956, Racine 1966, Zobel 1969). Zobel (1969) suggested that self-maintaining populations of *P. pungens* might exist on rock outcrops, corresponding to the conditions inhabited by the **Pinus pungens/ Gaylussacia baccata-Leiophyllum Forest**. Abundant *P. pungens* seedlings in the **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest** suggests that this type inhabits conditions that are sufficiently extreme enough for this species to be maintained without fire. Summary information indicates that *P. pungens* will be maintained in the future canopy of this community type (Table 3.14).

COMMUNITY TYPE: **Tsuga caroliniana/Rhododendron maximum Forests** (2.2)

Synonymy

Carolina Hemlock Forest (Schafale & Weakley 1990), Hemlock-Rhododendron-Galax (McCurdy 1975), Carolina Hemlock (McLeod 1988).

Constant species

Galax urceolata, Kalmia latifolia, Leucothoe recurva, Rhododendron maximum, Rhododendron minus, Smilax rotundifolia, Tsuga caroliniana.

Listed species

Fothergilla major.

Physiognomy

The dominance of *Tsuga caroliniana* in the canopy sets this community type apart from other types or sub-types in Linville Gorge. Tree-sized *T. caroliniana* trees are mostly 40 to 55 cm in diameter, with the largest observed measuring 82 cm. Large (>40 cm) emergent *Pinus strobus* trees occur on some tall-forest sites, where *Nyssa sylvatica* and *P. pungens* are consistent minor components of the canopy (Tables 3.13, 3.14, 3.15). Exposed, stunted heath-like variants of this type are dominated by *T. caroliniana* and ericaceous shrub species. Canopy height varies considerably (2 to 26m) and is influenced by site slope, exposure and soil depth. The shrub layer is denser than any other type or sub-type recognized in this study, containing stems mostly below 2.5 cm in diameter. *Rhododendron maximum*, *R. minus* and *Kalmia latifolia* dominate this stratum with *Leucothoe recurva* and *Smilax rotundifolia* common. *Clethra acuminata* and *Fothergilla major* are present at some sites. *Kalmia* is replaced by *R. minus* and/or *R. catawbiense* on some, mostly rocky sites. The ground is generally rocky (21% average surface substrate, Table 3.16) with dense patches of *Galax urceolata* typically present.

Habitat and Distribution

This community type occurs on both sides of the valley on comparatively moist, sheltered, north-to-east and west-facing, moderately steep (27° on average) sites (817 to 1177m in elevation; Figures 3.8, 3.9, 3.11, 3.12, Table 3.16). The **Tsuga caroliniana/ Rhododendron maximum Forest** sites are mostly underlain by the lower quartzite rock type. This community type inhabits small, sheltered, forested gullies in the bluffs or, occasionally, sheltered toeslopes at the base of the bluff system. This type also occurs in small, steep creek beds above the bluffs, and on upper-slopes of the gorge in the northern section of the valley. This type is often found in close proximity to the **Pinus pungens/ Kalmia Forest** and the **Pinus virginiana-Pinus pungens/Kalmia Forest**.

The **Tsuga caroliniana/Rhododendron maximum Forest** have soils with similar nutrient values to **Xeric Evergreen Forests** class averages (Tables 3.4, 3.5), but are finer-textured than some **Xeric Evergreen Forests** types.

Distinguishing Features

This is the only vegetation group in Linville Gorge where *Tsuga caroliniana* is the major canopy component. The **Tsuga caroliniana/Rhododendron maximum Forest** has the highest basal area and density of all groups in the **Xeric Evergreen Forests** class (Table 3.14) and has highest stem density of any other vegetation group recognized in this study. These high values can be attributed to the exceptionally dense sapling-sized shrub stratum.

Succession and Disturbance

Evidence of past fire was observed in 55% of the sites in this type. The evidence varies and is less distinct than in the **Pinus pungens/Kalmia Forest** community type. This suggests that the **Pinus pungens/Kalmia Forest** has burnt more recently and more extensively. Fire would reduce the hardwood component in **Tsuga caroliniana/ Rhododendron maximum Forests**. However this community type does not rely on fire to be self-sustaining.

Summary woody stem data (Table 3.14) indicates the presence of *Tsuga caroliniana* saplings, suggesting that this community type can be self-sustaining. Moreover, Humphrey (1989) suggests that the long life span of this species, and its ability to tolerate and reproduce in shady conditions, enable it to not only maintain itself but eventually replace other species. Further study of this community type is needed.

COMMUNITY TYPE: Pinus virginiana-Pinus pungens/Kalmia Forest (2.3)

Synonymy

Pine--Oak/Heath (Schafale & Weakley 1990), Xeric Pine Forests p.p., Virginia Pine Forest (Whittaker 1956), Table Mountain Pine-Virginia Pine Association (Racine 1966), Pine Community Type (Cooper & Hardin 1970), Pine Type (Cooper & Hardin 1970), Pine-Oak Heath (Rohrer 1983), Xeric Pine Forests (McLeod 1988).

Constant species

Acer rubrum var. *rubrum, Kalmia latifolia, Nyssa sylvatica, Pinus pungens, Pinus rigida, Pinus strobus, Pinus virginiana, Quercus montana, Smilax glauca* var. *glauca, Smilax rotundifolia, Vaccinium pallidum.*

Listed species

Fothergilla major, Monotropsis odorata.

Physiognomy

Pinus pungens and *P. virginiana* typically are the major canopy species with the abundance of *P. rigida* and *Quercus montana* varying between sites (Tables 3.13, 3.14, 3.15). *Nyssa sylvatica, Oxydendrum* and *Acer rubrum* dominate the understory. *Kalmia latifolia* is consistently the major shrub species with scattered *Smilax glauca* var. *glauca* and *S. rotundifolia* present. *Rhododendron minus* and *Symplocus tinctoria* have variable cover, with the former concentrated in rockier sites. *Vaccinium pallidum*, *Gaylussacia baccata* and *Gaultheria procumbens* have variable presence on the forest floor.

Habitat and Distribution

The **Pinus virginiana-Pinus pungens/Kalmia Forest**, mostly underlain by lower quartzite, inhabits mid-elevations (500 to 829 m range) in the lower section of the valley. Site slope angle varies considerably (7 to 67°, average 27°), reflecting the broad range of topographic positions inhabited by this type. The **Pinus virginiana-Pinus pungens/ Kalmia Forest** dominates the southeastern slopes of Shortoff Mountain and warmer southeast-facing ridgelines below the bluffs on the western-side of the main valley (Figures 3.8, 3.9, 3.11, 3.12). This type also occurs on dryer areas within or immediately above the bluffs.

The soils are silty and have similar nutrient status to average **Xeric Evergreen Forests** class values (Tables 3.4, 3.5).

Distinguishing Features

The **Pinus virginiana-Pinus pungens/Kalmia Forest** is distributed at lower elevations than other xeric *Pinus*-dominated types. This probably explains the co-dominance of *P. virginiana* in this type. *P. virginiana* is typically considered a lower-elevation species with greater affinities to the piedmont (Whittaker 1956, Racine 1966).

Succession and Disturbance

Charred wood was noted in 40% of the sites in this type. High densities of *Pinus rigida* saplings and much lower levels of small-sized *P. virginiana* and *P. pungens* stems point to a future change in the *Pinus* canopy composition of this community type (Table 3.14). I expect that the present canopy dominants will recede in abundance with the presence of *P. rigida* increasing in the canopy.

COMMUNITY TYPE: Pinus pungens/Kalmia Forest (2.4)

Synonymy

Pine--Oak/Heath (Schafale & Weakley 1990), Xeric Pine Forests (Whittaker 1956), Pine Community Type (Cooper & Hardin 1970), Pine Type (Cooper & Hardin 1970), Pine-Oak Heath (Rohrer 1983), Xeric Pine Forests (McLeod 1988), *Pinus pungens-Quercus montana/Kalmia* Forest (Chapter 4).

Constant species

Acer rubrum var. *rubrum, Galax urceolata, Kalmia latifolia, Nyssa sylvatica, Pinus pungens, Pinus strobus, Quercus coccinea* var. *coccinea, Quercus montana, Smilax glauca* var. *glauca, Simplocus tinctoria, Vaccinium pallidum.*

Listed species

Fothergilla major.

Physiognomy

Pinus pungens dominates the canopy (19 m mean height) of this community type. The presence of other species in the canopy varies with *P. rigida, P. strobus, Quercus montana* and *Q. coccinea* each codominating with *P. pungens* in certain sites (Tables 3.13, 3.14, 3.15). *Nyssa sylvatica* and *Acer rubrum* typically dominate the understory while *Kalmia latifolia* is the primary component of the evergreen shrub layer. *Galax urceolata* is common in the forest floor stratum. Species diversity is low across all spatial scales (Table 3.8).

Canopy height varies considerably with site exposure, slope and soil depth. Stand structure, however, is fairly uniform. Stem density is high with most canopy trees <40 cm in stem diameter. The shrub layer is dense, composed of mainly 1-2.5 cm diameter stems (Tables 3.14, 3.15).

Community sub-types:

Pinus pungens-Quercus coccinea/Kalmia sub-type (2.4.1)

Synonymy: Table Mountain Pine Heath (Whittaker 1956), Table Mountain Pine Association (Racine 1966), Pitch Pine-heath sere (Poudrier 1972).

The co-dominance of *Quercus coccinea* in the canopy distinguishes this sub-type from the second sub-type. *Pinus pungens* is the major canopy species with *Q. coccinea*, *P. rigida*, and *Q. montana* are also present (Tables 3.13, 3.14, 3.15). *Acer rubrum, Nyssa sylvatica, Oxydendrum arboreum* and *Pinus strobus* typically occur in the subcanopy. *Kalmia* forms a distinct shrub stratum in association with *Symplocus tinctoria* and, in some sites, *Rhododendron minus* and *Hamamelis virginiana*. *Galax urceolata* is most common on the forest floor, with *Vaccinium pallidum*, *Xerophyllum asphodeloides* and *Gaylussacia baccata* having low cover across most sites.

Pinus pungens-Pinus strobus/Leucothoe recurva sub-type (2.4.2)

Synonymy: Table Mountain Pine Heath (Whittaker 1956), Table Mountain Pine Association (Racine 1966).

Large-sized *Pinus pungens* and *P. strobus* (stems between 40 and 50 cm) dominate the canopy of this sub-type. *Quercus montana* has consistent cover throughout (Tables 3.13, 3.14, 3.15). Shrub species diversity is higher in this sub-type. *Kalmia latifolia* predominates with *Tsuga caroliniana*, *Hamamelis virginiana*, *Leucothoe recurva*, *Rhododendron maximum* and *Smilax glauca* var. *glauca* consistent throughout. The density of *Galax urceolata* is higher in this sub-type, and is intermixed with scattered *Gaultheria procumbens*. High shrub diversity probably accounts for the high mid-scale species richness levels within this sub-type in comparison to other **Xeric Evergreen Forests** types and sub-types (Table 3.8).

Habitat and Distribution

The **Pinus pungens/Kalmia Forest** inhabits moderately exposed slopes above the bluffs and ridgelines below the bluffs. It is mostly underlain by lower quartzite bedrock with some sites on gneiss (Table 3.16, Figures 3.8, 3.10).

This type tends to be stunted on sites adjacent to the bluffs and highly exposed ridgelines. On such sites the shrub layer can be almost impenetrable and species such as *Rhododendron minus* are abundant. More open forms of this community type occur on less exposed sites with deeper soils. Mid-slope sites are the most sheltered and support species such as *Hamamelis virginiana* and *Quercus montana* characteristic of the ***Pinus pungens-Pinus strobus/Leucothoe recurva sub-type***.

The two sub-types differ in distribution relative to slope, orientation and elevation. The ***Pinus pungens-Quercus coccinea/Kalmia sub-type*** has a narrower elevational range (668 to 921 m), typically found on steeper, southwest- to northwest-facing slopes (36 to 65 ° range; Table 3.16). This sub-type dominates cooler ridgelines below the bluffs than those dominated by the **Pinus virginiana-Pinus pungens/Kalmia Forest**, which have either higher-elevation positions in the northern half of the Wilderness, are comparatively sheltered, or have west- to northwest orientations. The ***Pinus pungens-Quercus coccinea/Kalmia sub-type*** also inhabits the forested slopes immediately up-slope of the bluffs. Sites inhabited by this sub-type are underlain by lower quartzite and gneiss.

The ***Pinus pungens-Pinus strobus/Leucothoe recurva sub-type*** is distributed between 445 and 1201 m in elevation (Table 3.16). This sub-type typically inhabits flatter (8 to 40° range), mid-topographic position on the slopes above the bluffs. Sites are less exposed and have deeper soils than the former sub-type. The ***Pinus pungens-Pinus strobus/Leucothoe recurva sub-type*** is mostly underlain by lower quartzite.

The **Pinus pungens/Kalmia Forest** has silty, infertile soils, with similar nutrient status to average values for the <u>**Xeric Evergreen Forests**</u> class (Figures 3.8.3.9, Tables 3.4, 3.5). The ***Pinus pungens-Pinus strobus/Leucothoe sub-type*** has lower Fe levels than the other sub-type in this community type.

On highly exposed bluff edges and escarpment faces, stunted forms of the **Pinus pungens/Kalmia Forest** grade into the **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest**. In less exposed gullies within the bluffs, the **Pinus pungens/Kalmia Forest** is replaced by the **Tsuga caroliniana/Rhododendron maximum** community type. On more sheltered, mesic, mid-slope areas with deeper soils the **Pinus pungens/Kalmia Forest** grades into the **Pinus rigida-Quercus montana/Fothergilla Forest** (Figures 3.11, 3.12).

Succession and Disturbance

Past fire was noted in over 65% of sites in this community type. Charred stumps and stems were the most abundant form of evidence suggesting that fire occurred relatively recently, probably in the last 10 to 20 years.

The **Pinus pungens/Kalmia Forest** contains several fire-adapted species, in particular *Pinus pungens* and *P. rigida*; fire is necessary to open the serotinous cones of these two species. Fire also burns litter, exposes mineral soil and eliminates competing vegetation (Zobel 1969). Work by Barden (1977) suggests that only very infrequent fires are necessary for *P. pungens* to successfully reproduce. Accordingly, periodic fires will be necessary for the **Pinus pungens/Kalmia Forest** to maintain itself in its present state. Lack of *P. pungens* and *P. rigida* saplings in this type suggests that the present fire regime is not sufficient to sustain these species in this community type (Table 3.14).

Floristic similarities between the **Pinus pungens/Kalmia Forest** and the **Quercus montana-Quercus coccinea/Kalmia Forest**, and the presence of stands intermediate between these two community types suggest that on less xeric sites, without periodic fire, the **Pinus pungens/Kalmia Forest** may gradually succeed into the **Quercus montana-Quercus coccinea/Kalmia Forest**.

COMMUNITY TYPE: Pinus rigida-Quercus montana/Fothergilla Forest (2.5)

Synonymy

Pine--Oak/Heath (Schafale & Weakley 1990), Pitch Pine Heath, Table Mountain Pine Heath (Whittaker 1956), Pine Community Type (Cooper & Hardin 1970), Pine Type (Cooper & Hardin 1970), Pine-Oak Heath (Rohrer 1983), Xeric Pine Forests (McLeod 1988), *Pinus pungens-Pinus rigida-Quercus montana/Kalmia* Forest p.p. (Chapter 4), *Quercus montana-Pinus rigida/Vaccinium pallidum* Forest p.p. (Chapter 5).

Constant species

Acer rubrum var. *rubrum, Fothergilla major, Galax urceolata, Gaylussacia baccata, Kalmia latifolia, Leucothoe recurva, Lyonia ligustrina* var. *ligustrina, Nyssa sylvatica, Pinus rigida, Pinus strobus, Quercus montana, Rhododendron catawbiense, Smilax glauca* var. *glauca, Simplocus tinctoria, Vaccinium pallidum.*

Listed species

Fothergilla major.

Physiognomy

Pinus rigida and *Quercus montana* are the major canopy species, with *P. pungens* less abundant (Tables 3.13, 3.12, 3.14). The presence of *Quercus coccinea* varies between sites. *Nyssa sylvatica* forms a distinctive subcanopy stratum in conjunction with *Acer rubrum* and *Oxydendrum*. The shrub stratum is dense and dominated by *Kalmia latifolia* and *Fothergilla major. Rhododendron catawbiense* and *Leucothoe recurva* are less abundant in this stratum. There is also a patchy low-shrub layer of *Gaylussacia baccata* and *Vaccinium pallidum*. *Galax urceolata* forms dense mats on the forest floor.

Habitat and Distribution

The **Pinus rigida-Quercus montana/Fothergilla Forest** occurs at mid-elevations (780-1073 m, average 933 m) on sites with variable slope angle (1-40° range, average 20°). This type typically inhabits shallow, southwest- to northwest-facing slopes above the bluffs on both sides of the valley (Table 3.16). These sites are underlain by lower quartzite. The **Pinus rigida-Quercus montana/Fothergilla Forest** occurs on more sheltered sites, that are further from the bluffs than those inhabited by the **Pinus pungens/Kalmia Forest** and the **Pinus virginiana-Pinus pungens/Kalmia Forest**.

The soils have similar nutrient status and textural content to average **Xeric Evergreen Forests** values (Tables 3.4, 3.5).

Distinguishing Features

The regionally rare *Fothergilla major* is an important shrub component in the **Pinus rigida-Quercus montana/Fothergilla Forest** and reaches highest abundance in this type (Table 3.13).

Succession and Disturbance

Evidence of charcoal in 50% of sites indicates that fires were not as recent as those that disturbed the **Pinus pungens/Kalmia Forest**. Both major species in the **Pinus rigida-Quercus montana/Fothergilla Forest** show little regeneration, suggesting that the current fire regime is insufficient to maintain present canopy composition. Higher numbers of *Quercus coccinea* and *Nyssa sylvatica* saplings indicate these species may replace *Q. montana* and *Pinus rigida* in the canopy, suggesting a gradual change towards the **Quercus montana-Quercus coccinea/Kalmia Forest** (Table 3.14).

COMMUNITY TYPE: Quercus alba/Kalmia/Galax Forest (2.6)

Synonymy

Dry--Oak Hickory Forests p.p., Montane White Oak Forest p.p. (Schafale & Weakley 1990), White Oak-Chestnut Forest p.p. (Whittaker 1956), White Oak Ridge Forest p.p. (Patterson 1994).

Constant species

Acer rubrum var. *rubrum, Amelanchia laevis, Castanea dentata, Galax urceolata, Kalmia latifolia, Leucothoe recurva, Lyonia liguistrina* var. *liguistrina, Nyssa sylvatica, Rhododendron catawbiense, Symplocus tinctoria, Tsuga caroliniana, Xerophyllum asphodeloides.*

Physiognomy

Canopy composition varies between plots. *Quercus alba* is generally the canopy dominant with variable *Pinus rigida* cover. *Acer rubrum* is a major component throughout (Tables 3.13, 3.14, 3.15). *Acer* also dominates the subcanopy in association with Nyssa. *Kalmia latifolia* forms a dense shrub stratum throughout all plots, joined by *Rhododendron catawbiense* and *Hamamelis virginiana* on ridge sites at the northern end of the Wilderness on Gingercake Mountain. The forest floor is densely covered by *Galax urceolata.*

Habitat and Distribution

This group inhabits high-elevation, west- to northwest-facing upper-sideslopes and ridge-crests (elevational range 1073 to 1258 m, Table 3.16). The **Quercus alba/Kalmia/ Galax Forest** is restricted to the high-elevation ridgeline on the eastern side of the Wilderness. All sites are underlain by lower quartzite.

The **Quercus alba/Kalmia/Galax Forest** has soils with highest Ca, cation exchange capacity, Mg and organic matter in comparison to other **Xeric Evergreen Forests** types

(Tables 3.4, 3.5). The dense, ericaceous shrub layer may contribute to high organic matter levels.

Distinguishing Features

This community type has the highest elevation position of any vegetation group identified in this study.

Succession and Disturbance

Two of the 3 sites have limited charcoal deposits in the soil, suggesting that fires has not been widespread in this community type in recent years.

Of the three dominant canopy species, only *Acer rubrum* has regeneration. This points to the future decline in the presence of *Quercus alba* and *Pinus rigida* and an increasing dominance by *Acer rubrum* in the canopy (Table 3.14).

COMMUNITY TYPE: Quercus alba-Pinus strobus/Kalmia Forest (2.7)

Synonymy

Dry--Oak Hickory Forests p.p., Montane White Oak Forest p.p. (Schafale & Weakley 1990), White Oak-Chestnut Forest p.p. (Whittaker 1956), White Oak Forest p.p. (McLeod 1988), White Oak Ridge Forest p.p. (Patterson 1994).

Constant species

Acer rubrum var. *rubrum, Chimaphila maculata* var. *maculata, Galax urceolata, Kalmia latifolia, Liriodendron tulipifera, Nyssa sylvatica, Oxydendrum arboreum, Pinus strobus, Quercus alba, Quercus montana, Quercus rubra, Smilax glauca* var. *glauca, Smilax rotundifolia, Simplocus tinctoria, Tsuga canadensis, Tsuga caroliniana, Vaccinium pallidum, Viola hastata.*

Physiognomy

Quercus alba and *Pinus strobus* dominate the somewhat open canopy of this community type, in association with *Q. montana* and *Q rubra*. *Acer rubrum*, *Nyssa sylvatica* and *Oxydendrum arboreum* form a distinctive subcanopy. *Kalmia latifolia* is the dominant shrub species with scattered *Tsuga canadensis* present (Tables 3.13, 3.14, 3.15). The forest floor is sparsely covered with a limited range of low-cover species, as indicated by low small-scale species richness (Table 3.8).

There are two variants of this type, which differ in elevation and slope position. The high-elevation ridge variant is consistent with typical descriptions of this type. In the low-elevation, lower-slope variant *Quercus alba*, *Q. velutina* and *Q. rubra* share dominance of the canopy. *Rhododendron maximum* and *Tsuga canadensis* join *Kalmia* in the shrub layer of this variant. These two variants may separate into two distinct community types at some future time when more data are available.

Habitat and Distribution

The high-elevation variant (927 to 1021 m elevational range) of the **Quercus alba-Pinus strobus/Kalmia Forest** inhabits the ridgeline and southeast-facing upper-slopes on the western ridgeline of the Wilderness. The low-elevation occurs on dry, east-facing mid-slopes (481 to 540 m elevational range). All sites in this type have shallow- to moderate-slopes. Sites are underlain by either lower quartzite or gneiss (Table 3.16).

The soils are coarser-textured and less organic than other types in the **Xeric Evergreen Forests** class, with higher sand content and lower organic matter levels (Tables 3.4, 3.5). This type also has higher Al and pH and lower Fe than other types in this class.

Distinguishing Features

This type is one of three **Xeric Evergreen Forests** types (co)dominated by *Quercus alba* that inhabit high-elevation ridgelines. The two types separate by elevation and distribution. The **Quercus alba/Kalmia/Galax Forest** inhabits higher-elevation sites and is confines to the ridgeline on the eastern of Linville Gorge. The **Quercus alba-Pinus**

strobus/Kalmia Forest inhabits dryer and exposed ridgelines on the western ridgeline with the **Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest** present in more fertile, sheltered areas. The former type lacks the dense *Galax* ground cover and *Rhododendron catawbiense* shrub layer characteristic of the former type. The **Quercus alba-Pinus strobus/Kalmia Forest** inhabits dryer, east-facing sites.

Succession and Disturbance

There is no evidence of past firing in this type. Limited regeneration by all *Quercus* species in present canopy of this community type points to a decline in dominance by this genus. Higher *Pinus strobus* and *Tsuga canadensis* sapling numbers suggests the increasing presence of these two species in the canopy (Table 3.14).

COMMUNITY TYPE: Quercus montana-Quercus coccinea/Kalmia Forest (2.8)

Synonymy

Chestnut Oak Forest (Schafale & Weakley 1990), Chestnut Oak-Chestnut Heath (Whittaker 1956), Pine-Oak Community Type (Racine 1966), Oak-Maple sere (Poudrier 1972), Scarlet Oak Forests, Red Maple Forests, Chestnut Oak Forests p.p. (McLeod 1988), Chestnut Oak Forest (Patterson 1994), *Quercus montana-Quercus rubra/Kalmia* Forest p.p. (Chapter 4), *Quercus montana-Quercus coccinea/Galax* Forest p.p. (Chapter 5).

Constant species

Acer rubrum var. *rubrum, Chimaphila maculata* var. *maculata, Kalmia latifolia, Nyssa sylvatica, Oxydendrum arboreum, Pinus strobus, Quercus alba, Quercus coccinea* var. *coccinea, Quercus montana, Smilax glauca* var. *glauca, Smilax rotundifolia, Symplocus tinctoria, Vaccinium pallidum.*

Physiognomy

Quercus montana and *Q. coccinea* dominate the canopy in association with *Acer rubrum* (Tables 3.13, 3.14, 3.15). *Quercus alba* is a minor canopy component. The hardwood species *Oxydendrum arboreum* and *Nyssa sylvatica* form a distinctive subcanopy. There is a characteristically dense *Kalmia* shrub layer. *Symplocus tinctoria* and *Pinus strobus* are scattered throughout this stratum. The forest floor is dry, with scattered vascular cover.

Habitat and Distribution

This community type mostly occurs on shallow- to moderate-slopes on predominantly southeast-facing sideslopes above the bluffs (elevational range of 549 to 988 m, average of 802 m), although this group occasionally inhabits ridgelines and sideslopes below the bluffs. Sites are mostly underlain by lower quartzite (60%) (Table 3.16) and occur on both sides of the Linville valley.

The **Quercus montana-Quercus coccinea/Kalmia Forest** soils have similar nutrient and texture values to **Xeric Evergreen Forests** class averages (Table 3.4, 3.5).

Succession and Disturbance

Eighty percent of the plots in this community type contain evidence of past fire. Charcoal deposited as a dark layer at the top of the A horizon is the main evidence, suggesting that fires have not occurred within the last 30 years or so. Woody stem information suggests a future decline in the dominance of *Quercus montana* and *Q. coccinea* var. *coccinea*, and an increase in *Acer rubrum* canopy dominance (Table 3.14).

COMMUNITY TYPE: Quercus montana/Galax Forest (2.9)

Synonymy

Chestnut Oak Forest (Schafale & Weakley 1990), Chestnut Oak-Chestnut Heath (Whittaker 1956), Pine-Oak Community Type (Racine 1966), Oak-Maple sere (Poudrier 1972), Scarlet Oak Forests, Red Maple Forests, Chestnut Oak Forests p.p. (McLeod 1988), Chestnut Oak Forest (Patterson 1994), *Quercus montana-Quercus coccinea/Galax* Forest p.p. (Chapter 5).

Constant species

Acer rubrum var. *rubrum*, *Amelanchier laevis*, *Castanea dentata*, *Chamaelirium luteum*, *Galax urceolata*, *Kalmia latifolia*, *Nyssa sylvatica*, *Oxydendrum arboreum*, *Pinus strobus*, *Quercus montana*, *Quercus rubra*, *Sassafras albidum*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Simplocus tinctoria*, *Tsuga caroliniana*, *Uvularia puberula* var. *puberula*, *Vaccinium pallidum*.

Physiognomy

Large-diameter *Quercus montana* (43 to 58 cm), *Pinus strobus* (42-57 cm) and *Q. alba* (40 to 58 cm) are the major canopy species in this type (Tables 3.13, 3.14, 3.15). *Q. rubra* has lower abundance in most sites, whereas the presence of *Q. coccinea* varies. *Oxydendrum* is the dominant shrub species, with more limited *Nyssa sylvatica* cover. The shrub stratum is dominated by *Kalmia latifolia* throughout all sites, with *Symplocus tinctoria* and *Sassafras albidum* also present. Cover by *Hamamelis virginiana* and *Rhododendron maximum* in this stratum varies. The ground is densely covered by *Galax urceolata*.

Habitat and Distribution

On both sides of the valley this community type dominates shallow-sloping, high-elevation, southwest- to northwest-facing upper-slopes (768 to 1226 m elevation range, 1059 m mean; Table 3.16). Sites are underlain by a range of rock types, including the band of upper quartzite on the western ridgeline of the Wilderness.

The soils are fine-textured with similar nutrient status to average values for the **Xeric Evergreen Forests** class (Tables 3.4, 3.5).

Succession and Disturbance

Charcoal in the soil provides evidence for fire in 42% of sites. *Quercus montana* has comparatively high regeneration in this type in comparison to most types dominated by the *Quercus* genus. High saplings numbers of both this species and *Pinus strobus* suggest that these two species will maintain their position in the canopy. Limited regeneration points to the declining dominance of *Q. alba* (Table 3.14).

Table 3.13. Average cover class and constancy of species present in the **Xeric Evergreen Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type and sub-type. Each group is represented by its abbreviation code. For full group names see Table 3.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Groups:	2.	2.1	2.2	2.3	2.4	2.4.1	2.4.2	2.5	2.6	2.7	2.8	2.9
Number of plots:	83	3	11	15	19	12	7	10	3	5	5	12
Homoteneity:	0.610	0.828	0.640	0.667	0.715	0.754	0.749	0.745	0.758	0.740	0.723	0.738
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species												
ACER PENSYLVANICUM	1 16		1 27	1 13	1 11	1 8	1 14			1 60	1 20	1 17
ACER RUBRUM VAR RUBRUM	4 96	2 100	3 73	3 100	4 100	4 100	5 100	3 100	4 100	4 100	6 100	4 100
AGROSTIS STOLONIFERA	1 1			1 7								
AMELANCHIER LAEVIS	2 45	4 100	2 27	2 60	3 32	2 25	3 43	1 20	3 100	1 20		1 83
AMIANTHIUM MUSCAETOXICUM	1 13		1 9						1 67	1 20		1 58
ANDROPOGON VIRGINICUS	1 12	2 67		1 33	1 5	1 8		1 10			1 20	
ARALIA NUDICAULIS	1 6		1 9						2 33			1 25
ARALIA SPINOSA	1 1			1 7								
ARISAEMA TRIPHYLLUM	1 2		1 9		1 5		1 14					
ARONIA ARBUTIFOLIA	3 2	3 67										
ARUNDINARIA GIGANTEA	1 1				1 5		1 14					
ASPLENIUM MONTANUM	1 5		1 27	1 7								
ASTER ACUMINATUS VAR ACUMINATUS	1 2		1 9									1 8
ASTER DIVARICATUS	1 1											1 8
ASTER UNDULATUS	1 2				1 5	1 8		1 10				
ATHYRIUM ASPLENIOIDES	1 1											1 8
AUREOLARIA FLAVA	1 1			1 7								
AUREOLARIA LAEVIGATA	1 7			1 27				1 10			1 20	
BETULA LENTA	2 20		2 64	1 7	1 5		1 14	4 20	2 67	1 20		1 25
CAMPANULA DIVARICATA	1 4			1 7	1 5	1 8					1 20	
CAREX NIGROMARGINATA	1 1										1 20	
CAREX UMBELLATA	2 4	2 33	2 9		1 5	1 8						
CAREX VIRESCENS	1 1			1 7								
CARYA ALBA	2 2							1 10			2 20	
CARYA GLABRA	2 7				1 5	1 8		1 10		2 40	2 20	1 8
CARYA OVATA	1 4			1 13						1 20		
CARYA PALLIDA	1 4			1 7						1 40		
CASTANEA DENTATA	2 30		1 18	3 13	1 21	2 17	1 29	3 40	2 100	1 20		2 75
CASTANEA PUMILA VAR PUMILA	2 22	2 33		2 33	1 11	1 8	1 14	2 60	2 33	1 20		1 17
CHAMAELIRIUM LUTEUM	1 31			1 20	1 32	1 33	1 29	1 20	1 67	1 20	1 60	1 75
CHASMANTHIUM LAXUM	1 1			1 7								

Groups:	2.	2.1	2.2	2.3	2.4	2.4.1	2.4.2	2.5	2.6	2.7	2.8	2.9
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
CHIMAPHILA MACULATA VAR MACULATA	1 37		1 18	1 47	1 26	1 25	1 29	1 50		1 80	1 80	1 33
CHIONANTHUS VIRGINICUS VAR VIRGINICUS	2 1							2 10				
CLETHRA ACUMINATA	2 14	1 67	3 55		1 16	1 8	1 29		2 33			
CLINTONIA UMBELLULATA	2 1								2 33			
COMPTONIA PEREGRINA	1 1							1 10				
COREOPSIS MAJOR VAR RIGIDA	1 14			1 60	1 5	1 8		1 10		1 20		
CORNUS FLORIDA	1 8									2 60		1 33
CRATAEGUS SP.#1	1 1			1 7								
CYPRIPEDIUM ACAULE	1 5	1 33			1 5		1 14		1 33	1 20		
DANTHONIA COMPRESSA	1 1							1 10				
DANTHONIA SERICEA	2 12	1 67		2 47				1 10				
DANTHONIA SPICATA	1 2			1 13								
DENNSTAEDTIA PUNCTILOBULA	2 2											2 17
DESMODIUM NUDIFLORUM	1 1			1 7								
DICHANTHELIUM SP. #1	1 1									1 20		
DICHANTHELIUM BOSCII	1 2										1 20	1 8
DICHANTHELIUM COMMUTATUM	2 11			2 53	2 5	2 8						
DICHANTHELIUM DEPAUPERATUM	2 1			2 7								
DICHANTHELIUM DICHOTOMUM VAR DICHOTOMUM	1 7			1 13	1 5	1 8		1 20			1 20	
DICHANTHELIUM LATIFOLIUM*	1 1											1 8
DICHANTHELIUM RIDIONALE	1 1			1 7								
DICHANTHELIUM CF. SABULORUM	2 2			2 13								
DICHANTHELIUM SPP 7 =TENUE)	1 1			1 7								
DICOT SP. #1	1 1									1 20		
DIOSCOREA QUATERNATA	1 10								1 67	1 20		1 42
DIOSPYROS VIRGINIANA	2 12			2 47	1 5	1 8		1 10		1 20		
DRYOPTERIS MARGINALIS	1 2		1 9								1 20	
EPIGAEA REPENS	1 28		2 9	1 40	1 47	1 58	1 29	1 50			1 20	1 8
FAGUS GRANDIFOLIA	1 8			2 13	1 16	1 17	1 14			1 20	1 20	
FOTHERGILLA MAJOR*	5 18	4 67	4 27	3 7	6 5	6 8		5 80				
GALAX URCEOLATA	4 84	4 100	4 100	2 60	4 89	4 83	5 100	6 100	7 100	1 80	2 40	5 92
GAULTHERIA PROCUMBENS	2 47	3 100	2 18	2 60	2 47	2 33	2 71	2 70	2 100			3 50
GAYLUSSACIA BACCATA	3 52	6 100	2 18	3 53	2 74	2 100	2 29	3 80	3 33	2 20	1 20	2 42
GENTIANA DECORA	1 13				1 5	1 8		1 10		1 20		1 67
GOODYERA PUBESCENS	1 16		1 9		1 11	1 17		2 20	1 33	1 60	1 20	1 25
GOODYERA REPENS	1 20		1 27		1 11	1 17		1 50	1 100			1 33
HALESIA TETRAPTERA VAR MONTICOLA	2 2				2 5	2 8						1 8
HAMAMELIS VIRGINIANA	3 49	3 33	3 73	2 40	4 74	4 58	4 100	1 20	3 67	1 20		3 58
HEXASTYLIS HUTTLEWORTHII VAR SHUTTLEWORTHII	1 20	1 33	1 9		1 26	1 8	1 57	2 20	2 67			1 50
HEXASTYLIS VIRGINICA	1 24	1 33	1 36	1 7	1 26	1 8	1 57	1 10	1 33	1 20		2 50

Groups:	2.	2.1	2.2	2.3	2.4	2.4.1	2.4.2	2.5	2.6	2.7	2.8	2.9
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
HIERACIUM VENOSUM	1 6			1 27							1 20	
HOUSTONIA PURPUREA VAR PURPUREA	1 1										1 20	
HYPERICUM DENSIFLORUM	2 2	1 33		2 7								
HYPERICUM HYPERICOIDES	1 1			1 7								
HYPERICUM STRAGULUM	1 1			1 7								
HYPOXIS HIRSUTA	1 2				1 5	1 8				1 20		
ILEX BEADLEI	2 1	2 33										
ILEX MONTANA	2 10		2 36					1 10				1 25
ILEX OPACA VAR OPACA	1 12			1 27	3 5		3 14			2 40	1 40	1 8
IRIS VERNA	1 24	1 100		1 40	1 26	1 25	1 29	1 20				1 33
KALMIA LATIFOLIA	6 99	5 100	6 91	6 100	7 100	7 100	6 100	6 100	7 100	5 100	6 100	6 100
LEIOPHYLLUM BUXIFOLIUM	4 7	6 100	1 9	2 7				1 10				
LEUCOTHOE RECURVA	3 60	3 100	3 82	2 33	3 63	2 58	4 71	4 100	3 100			2 67
LILIUM MICHAUXII	1 4								1 33			1 17
LIQUIDAMBAR STYRACIFLUA	2 7			2 7	3 11		3 29	2 10		1 40		
LIRIODENDRON TULIPIFERA	2 12			1 7						2 80	2 60	1 17
LISTERA SMALLII	1 2		1 18									
LYONIA LIGUSTRINA VAR LIGUSTRINA	2 63	3 100	2 36	2 60	2 58	1 58	2 57	2 90	1 100	3 40	1 60	1 67
LYSIMACHIA QUADRIFOLIA	1 5		1 9							1 20		1 17
MAGNOLIA FRASERI	1 29		1 27	1 33	2 37	1 17	2 71	1 10		1 20	3 60	1 33
MAIANTHEMUM RACEMOSUM	1 2								1 33			1 8
MEDEOLA VIRGINIANA	1 13		1 27		1 5		1 14					1 58
MELAMPYRUM LINEARE	1 12		2 9	1 20	1 11	1 17		1 20		1 20	1 20	
MELANTHIUM PARVIFLORUM	1 1									1 20		
MENZIESIA PILOSA	2 1								2 33			
MITCHELLA REPENS	1 11		1 18		2 16		2 43			1 60	1 20	
MONOTROPA HYPOPITHYS	1 2							1 10			1 20	
MONOTROPSIS ODORATA*	1 1			1 7								
MONOTROPA UNIFLORA	1 1		1 9									
NYSSA SYLVATICA	4 93	5 67	4 73	3 87	5 100	5 100	5 100	6 100	4 100	3 100	3 100	3 100
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	1 6				1 5		1 14	1 20	1 67			
OXYDENDRUM ARBOREUM	4 73	2 67	4 55	3 73	3 63	3 58	3 71	4 70	1 33	4 100	5 100	5 100
PARTHENOCISSUS UINQUEFOLIA VAR QUINQUEFOLIA	1 2			1 7							1 20	
PHORADENDRON SEROTINUM	1 1							1 10				
PHYTOLACCA AMERICANA	1 1			1 7								
PINUS PUNGENS	5 59	6 100	4 27	5 100	6 100	6 100	4 100	4 70			2 20	6 8
PINUS RIGIDA	4 58	5 100	4 27	4 87	4 74	4 75	3 71	5 90	4 67	4 40	1 20	1 8
PINUS STROBUS	3 87	3 33	4 73	2 93	5 89	4 83	5 100	3 90	1 67	4 100	3 80	4 100
PINUS VIRGINIANA	4 34	4 33		5 100	3 42	3 42	1 43	1 10		1 20	1 40	
PITYOPSIS GRAMINIFOLIA VAR LATIFOLIA	2 2			2 13								

Groups:	2.	2.1	2.2	2.3	2.4	2.4.1	2.4.2	2.5	2.6	2.7	2.8	2.9
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
POLYGONATUM BIFLORUM												
VAR BIFLORUM	1 7			1 7				1 10		1 40		1 17
POLYPODIUM APPALACHIANUM	2 2		2 18									
POLYPODIUM VIRGINIANUM	1 8		1 36					1 10	1 33			1 8
PORTERANTHUS TRIFOLIATUS	1 1							1 10				
POTENTILLA CANADENSIS												
VAR CANADENSIS	1 2				1 5	1 8						1 8
PRENANTHES ALTISSIMA	1 2								1 33			1 8
PRUNUS PENSYLVANICA	1 1								1 33			
PRUNUS SEROTINA	1 1		1 9									
PTERIDIUM AQUILINUM VAR												
LATIUSCULUM	1 23	3 33		2 53	1 21	1 25	1 14	1 30	1 33		1 20	1 8
PYRULARIA PUBERA	1 13		1 9		1 16	1 8	2 29		2 33	1 20	1 60	2 17
QUERCUS ALBA	3 35		2 18	2 20	2 21	1 8	2 43	1 10	5 67	4 100	3 80	5 67
QUERCUS COCCINEA VAR												
COCCINEA	4 53	3 67		3 60	4 79	4 92	3 57	6 50	3 33		5 100	4 58
QUERCUS MONTANA	4 80	3 33	3 64	4 80	4 84	4 83	4 86	5 100		3 80	5 100	4 92
QUERCUS MARILANDICA	1 5			1 27								
QUERCUS RUBRA	2 40		1 27	2 53	2 16	2 8	2 29		2 67	3 100	1 20	3 92
QUERCUS VELUTINA	2 8			2 27						3 60		
QUERCUS X BUSHII	2 1							2 10				
QUERCUS X SAULII	2 1											2 8
RHODODENDRON CALENDULACEUM	1 4		1 9									1 17
RHODODENDRON CATAWBIENSE	4 30	4 67	5 55		2 16		2 43	4 80	4 100			1 25
RHODODENDRON MAXIMUM	3 52	2 33	6 100	2 7	3 47	2 25	3 86	2 60		2 60	1 80	4 67
RHODODENDRON MINUS	5 43	4 100	5 82	4 67	6 42	6 50	3 29	6 20	5 33		2 40	2 8
RHODODENDRON PERICLYMENOIDES	2 4										3 20	2 17
RHUS COPALLINA VAR												
LATIFOLIA	1 2			1 13								
ROBINIA PSEUDOACACIA	1 19	1 67		2 20	1 5		1 14	2 20		1 40	1 40	1 33
RUBUS ALLEGHENIENSIS												
VAR ALLEGHENIENSIS	1 2			1 13								
SASSAFRAS ALBIDUM	2 49	2 67	2 73	3 47	2 32	1 25	2 43	2 30	2 33	1 40	1 40	3 83
SAXIFRAGA MICHAUXII	1 2		1 9	1 7								
SCHIZACHYRIUM SCOPARIUM	1 17			2 67	1 16	1 25		1 10				
SELAGINELLA TORTIPILA	2 11	2 33	6 9	1 40	1 5	1 8						
SERICOCARPUS ASTEROIDES	1 1			1 7								
SMILAX BONA-NOX	2 1								2 33			
SMILAX GLAUCA VAR GLAUCA	2 89	2 67	1 45	2 87	2 100	2 100	1 100	2 100	2 100	1 100	2 100	2 100
SMILAX HERBACEA	2 2		1 9	3 7								
SMILAX ROTUNDIFOLIA	2 80	3 100	4 82	3 80	2 74	2 67	3 86	1 60	1 33	1 100	2 80	2 100
SOLIDAGO ARGUTA SSP.												
CAROLINIANA	1 8			1 40							1 20	
SOLIDAGO CURTISII	1 1											1 8
SOLIDAGO ODORA VAR ODORA	1 5									1 20		1 25

Groups:	2.	2.1	2.2	2.3	2.4	2.4.1	2.4.2	2.5	2.6	2.7	2.8	2.9
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
SORGHASTRUM NUTANS	1 1			1 7								
SPIRANTHES SP.	1 6			1 13							1 40	1 8
SYMPLOCOS TINCTORIA	3 71		1 27	4 47	4 95	4 100	3 86	3 90	1 67	2 80	2 80	3 100
THASPIUM BARBINODE	1 10		1 9		1 5		1 14	1 20			1 20	1 25
THELYPTERIS NOVEBORACENSIS	2 5									1 20	1 20	4 17
TRILLIUM UNDULATUM	1 7		1 36									2 17
TSUGA CANADENSIS	2 47	1 33	3 36	1 27	2 63	2 42	2 100	1 30	1 33	3 100	2 40	2 58
TSUGA CAROLINIANA	3 63	2 100	5 82	2 53	5 42	5 25	4 71	3 60	2 67	1 80	1 60	2 75
UVULARIA PUBERULA VAR PUBERULA	1 27		1 9	1 20	1 5	1 8		1 10	1 67	1 40	1 40	1 83
VACCINIUM CORYMBOSUM	2 28	4 67	4 18	3 53	2 21	1 17	3 29	2 10	2 67			1 33
VACCINIUM FUSCATUM	1 1				1 5	1 8						
VACCINIUM PALLIDUM	2 72	4 67	2 9	3 80	2 89	2 100	1 71	2 90	1 33	2 80	1 100	1 75
VACCINIUM SIMULATUM	2 30		1 27	5 13	2 21	2 8	1 43	2 30	2 67	2 20	1 40	2 67
VACCINIUM STAMINEUM	2 40	2 67	2 9	3 60	2 32	2 25	2 43	2 70		1 20	1 20	1 50
VIBURNUM ACERIFOLIUM	1 1				1 5	1 8						
VIBURNUM NUDUM VAR CASSINOIDES	1 4	2 33		1 13								
VIOLA BLANDA	1 1									1 20		
VIOLA HASTATA	1 20				1 5	1 8		1 20		2 80	1 60	1 58
VITIS AESTIVALIS	1 2									1 40		
XEROPHYLLUM ASPHODELOIDES	2 40	3 100	2 36	2 47	2 58	1 58	3 57	3 40	2 100			1 8
ZIZIA TRIFOLIATA	1 4											1 25

Table 3.14. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Xeric Evergreen Forests** vegetation class and associated community types and sub-types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

2. Xeric Evergreen Forests

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	50.43	182.14	0.64	233.22	2.40	3.40	6.14	4.77
KALMIA LATIFOLIA	2262.29	1475.77	0.00	3738.06	2.78	36.86	7.31	22.08
NYSSA SYLVATICA	64.87	298.73	0.87	364.47	2.27	4.51	5.82	5.17
PINUS PUNGENS	47.79	232.70	3.05	283.54	6.96	2.88	18.32	10.60
PINUS RIGIDA	45.78	111.01	3.03	159.83	3.52	1.93	9.33	5.63
PINUS STROBUS	31.58	71.40	9.88	112.85	3.58	1.76	8.19	4.97
QUERCUS MONTANA	13.86	97.48	6.48	117.81	3.75	2.28	10.90	6.59
RHODODENDRON MINUS	867.17	434.64	0.00	1301.81	0.64	8.98	1.73	5.36
ALL	6840.81	4021.70	37.29	10899.80	38.27	99.98	99.99	99.99

2.1 Pinus pungens/Gaylussacia baccata-Leiophyllum Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
KALMIA LATIFOLIA	5316.67	0.00	0.00	5316.67	0.63	32.85	2.76	17.80
NYSSA SYLVATICA	433.33	222.22	0.00	655.56	1.28	6.86	5.11	5.98
PINUS PUNGENS	541.67	627.78	0.00	1169.44	10.73	12.15	47.86	30.00
PINUS RIGIDA	41.67	711.11	0.00	752.78	10.69	5.94	36.13	21.04
RHODODENDRON MINUS	1258.33	0.00	0.00	1258.33	0.06	9.66	0.29	4.98
ALL	11675.00	1933.33	0.00	13608.33	25.47	99.64	99.99	99.81

2.2 Tsuga caroliniana/Rhododendron maximum Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
KALMIA LATIFOLIA	3775.91	1277.85	0.00	5053.76	3.50	18.18	10.08	14.13
PINUS STROBUS	18.18	39.24	18.18	75.61	5.71	0.82	11.58	6.20
RHODODENDRON MAXIMUM	2663.64	1303.32	0.00	3966.96	4.09	19.79	10.08	14.94
RHODODENDRON MINUS	2434.09	506.82	0.00	2940.91	0.94	18.21	2.85	10.53
SMILAX ROTUNDIFOLIA	3372.73	0.00	0.00	3372.73	0.07	12.88	0.20	6.54
TSUGA CAROLINIANA	63.33	163.34	41.85	268.52	13.50	3.01	26.21	14.61
ALL	18088.94	4230.05	78.67	22397.66	43.32	100.01	100.00	100.00

2.3 Pinus virginiana-Pinus pungens/Kalmia Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
KALMIA LATIFOLIA	2064.23	637.22	0.00	2701.45	1.15	33.94	3.62	18.78
PINUS PUNGENS	85.00	385.56	1.11	471.67	8.47	5.88	26.62	16.25
PINUS RIGIDA	238.33	191.11	8.89	438.33	5.86	6.15	14.45	10.30
PINUS VIRGINIANA	13.33	380.56	0.00	393.89	8.04	7.73	27.05	17.39
QUERCUS MONTANA	35.00	105.56	6.67	147.22	3.28	3.72	11.86	7.79
RHODODENDRON MINUS	1491.67	310.56	0.00	1802.22	0.61	15.03	2.36	8.70
ALL	5526.25	2604.44	18.89	8149.58	32.28	100.00	100.00	100.00

2.4 Pinus pungens/Kalmia Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
KALMIA LATIFOLIA	2184.56	2357.85	0.00	4542.41	3.93	44.89	8.39	26.64
NYSSA SYLVATICA	58.86	423.60	0.00	482.46	2.99	5.88	6.43	6.15
PINUS PUNGENS	0.00	493.99	8.95	502.94	16.63	4.82	36.54	20.68
PINUS STROBUS	35.44	148.90	15.79	200.13	6.40	2.59	13.73	8.16
RHODODENDRON MINUS	484.21	968.42	0.00	1452.63	1.24	11.39	2.68	7.03
ALL	4366.67	5676.14	39.74	10082.54	46.39	100.00	100.00	100.00

2.4.1 Pinus pungens-Quercus coccinea/Kalmia sub-type

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
KALMIA LATIFOLIA	2418.61	2632.92	0.00	5051.53	4.36	47.76	9.23	28.50
NYSSA SYLVATICA	43.19	396.39	0.00	439.58	2.36	5.86	5.25	5.55
PINUS PUNGENS	0.00	676.94	1.67	678.61	20.50	6.44	44.96	25.70
PINUS RIGIDA	0.00	107.50	4.31	111.81	3.83	1.01	8.33	4.67
PINUS STROBUS	32.50	135.42	8.33	176.25	4.19	2.01	8.48	5.24
RHODODENDRON MINUS	700.00	1441.67	0.00	2141.67	1.82	16.91	3.92	10.41
ALL	4304.17	6311.53	18.47	10634.17	46.13	100.00	100.00	100.00

2.4.2 Pinus pungens-Pinus strobus/Leucothoe recurva sub-type

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	38.10	331.55	0.00	369.64	3.74	4.92	7.41	6.16
HAMAMELIS VIRGINIANA	430.95	275.00	0.00	705.95	0.42	8.75	0.92	4.84
KALMIA LATIFOLIA	1783.33	1886.31	0.00	3669.64	3.19	39.97	6.96	23.46
LEUCOTHOE RECURVA	883.33	100.00	0.00	983.33	0.24	7.98	0.52	4.25
NYSSA SYLVATICA	85.71	470.24	0.00	555.95	4.08	5.92	8.46	7.19
PINUS PUNGENS	0.00	180.36	21.43	201.79	9.99	2.05	22.11	12.08
PINUS STROBUS	40.48	172.02	28.57	241.07	10.19	3.58	22.72	13.15
TSUGA CAROLINIANA	92.86	201.79	14.29	308.93	4.77	4.07	7.83	5.95
ALL	4473.81	4586.90	76.19	9136.90	46.84	100.00	100.00	100.00

2.5 Pinus rigida-Quercus montana/Fothergilla Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
FOTHERGILLA MAJOR	1948.33	289.00	0.00	2237.33	0.61	19.14	1.46	10.30
KALMIA LATIFOLIA	1965.83	1264.17	0.00	3230.00	2.24	26.35	6.97	16.66
LEUCOTHOE RECURVA	2185.00	6.00	0.00	2191.00	0.34	12.00	0.98	6.49
NYSSA SYLVATICA	155.00	794.00	0.00	949.00	4.81	7.57	12.85	10.21
PINUS PUNGENS	6.67	193.17	0.00	199.83	6.94	1.82	17.10	9.46
PINUS RIGIDA	10.00	196.83	5.00	201.83	6.16	2.13	16.54	9.33
QUERCUS COCCINEA VAR COCCINEA	50.00	168.33	0.00	218.33	2.22	3.08	8.53	5.81
QUERCUS MONTANA	1.67	200.33	0.00	202.00	4.17	2.95	15.06	9.01
RHODODENDRON MINUS	745.00	737.50	0.00	1482.50	0.97	6.21	2.41	4.31
ALL	8538.33	4694.50	14.17	13247.00	35.20	100.00	100.00	100.00

2.6 Quercus alba/Kalmia/Galax Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	266.67	433.33	0.00	700.00	6.47	5.34	16.45	10.90
AMELANCHIER LAEVIS	0.00	305.56	0.00	305.56	2.11	2.07	7.10	4.59
KALMIA LATIFOLIA	3347.22	2180.56	0.00	5527.78	3.90	39.10	11.23	25.17
NYSSA SYLVATICA	147.22	555.56	0.00	702.78	3.15	3.78	11.02	7.40
PINUS RIGIDA	0.00	73.89	5.56	79.44	5.58	0.62	17.10	8.86
QUERCUS ALBA	0.00	150.00	0.00	150.00	5.03	1.45	13.36	7.41
RHODODENDRON CATAWBIENSE	1294.44	1502.78	0.00	2797.22	3.54	20.90	9.51	15.20
ALL	8836.11	5714.45	5.56	14556.11	34.69	100.00	99.98	100.00

2.7 Quercus alba-Pinus strobus/Kalmia Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	17.67	281.33	0.00	299.00	3.16	9.22	9.74	9.48
KALMIA LATIFOLIA	626.00	571.00	0.00	1197.00	0.95	36.36	3.05	19.70
NYSSA SYLVATICA	43.00	159.83	0.00	202.83	0.88	6.91	2.53	4.72
OXYDENDRUM ARBOREUM	24.00	199.33	0.00	223.33	2.10	7.33	6.00	6.66
PINUS STROBUS	93.50	77.50	6.67	177.67	3.99	5.71	11.08	8.40
QUERCUS ALBA	10.00	106.33	22.67	139.00	8.30	4.10	25.01	14.56
QUERCUS MONTANA	0.00	32.83	7.50	40.33	3.61	1.25	9.48	5.37
QUERCUS RUBRA	4.00	84.33	5.33	93.67	3.57	2.73	11.33	7.03
TSUGA CANADENSIS	165.00	322.67	0.00	487.67	1.74	14.16	4.59	9.37
ALL	1079.00	2141.17	47.17	3267.33	34.77	99.91	99.96	99.93

2.8 Quercus montana-Quercus coccinea/Kalmia Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	25.33	282.33	3.33	311.00	5.05	10.28	13.05	11.66
KALMIA LATIFOLIA	799.33	2313.67	0.00	3113.00	4.55	53.83	10.63	32.23
NYSSA SYLVATICA	28.33	168.00	0.00	196.33	0.54	6.84	1.46	4.15
OXYDENDRUM ARBOREUM	12.00	281.33	0.00	293.33	2.83	9.12	7.28	8.20
QUERCUS ALBA	0.00	37.00	7.00	44.00	3.53	0.91	8.07	4.49
QUERCUS COCCINEA VAR COCCINEA	0.00	92.33	17.00	109.33	7.49	3.02	18.88	10.95
QUERCUS MONTANA	6.67	124.33	16.33	147.33	10.30	5.56	27.51	16.54
ALL	1010.33	3570.67	45.67	4626.67	39.37	100.01	100.00	100.00

2.9 Quercus montana/Galax Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	26.04	278.19	1.67	305.90	4.54	5.01	12.64	8.82
KALMIA LATIFOLIA	1749.03	1705.69	0.00	3454.72	3.05	47.24	8.49	27.87
OXYDENDRUM ARBOREUM	55.35	331.39	0.00	386.74	3.45	5.86	9.93	7.90
PINUS STROBUS	60.69	85.76	13.47	159.93	4.27	2.05	10.55	6.30
QUERCUS ALBA	8.33	84.03	11.81	104.17	5.68	1.60	15.83	8.71
QUERCUS MONTANA	47.92	175.90	11.39	235.21	6.33	4.00	18.54	11.27
ALL	3798.75	3492.50	47.43	7338.68	35.94	100.00	99.99	100.00

Table 3.15. Vertical structure of woody species in the **Xeric Evergreen Forest** vegetation class and associated community types and sub-types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

2. Xeric Evergreen Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	3	2	
FOTHERGILLA MAJOR	1	1			
HAMAMELIS VIRGINIANA	1	1			
KALMIA LATIFOLIA	3	6			
LEUCOTHOE RECURVA	1	1			
NYSSA SYLVATICA	1	3	3	1	
OXYDENDRUM ARBOREUM	1	2	2	1	
PINUS PUNGENS	1	1	3	2	
PINUS RIGIDA	1	1	2	2	
PINUS STROBUS	1	2	2	2	
PINUS VIRGINIANA	1	1	1		
QUERCUS ALBA	1	1	1	1	
QUERCUS COCCINEA VAR COCCINEA	1	1	2	2	
QUERCUS MONTANA	1	1	3	2	
QUERCUS RUBRA	1	1	1		
RHODODENDRON CATAWBIENSE	1	1			
RHODODENDRON MAXIMUM	1	2			
RHODODENDRON MINUS	1	2			
SASSAFRAS ALBIDUM	1	1			
SYMPLOCOS TINCTORIA	1	1			
TSUGA CANADENSIS	1	1			
TSUGA CAROLINIANA	1	1	1		

2.1 Pinus pungens/Gaylussacia baccata-Leiophyllum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1			
AMELANCHIER LAEVIS	1	2			
ARONIA ARBUTIFOLIA	1	1			
FOTHERGILLA MAJOR	1	2			
GAYLUSSACIA BACCATA	1	2			
KALMIA LATIFOLIA	5	5			
LYONIA LIGUSTRINA VAR LIGUSTRINA		1	2		
NYSSA SYLVATICA	1	2			
OXYDENDRUM ARBOREUM	1	1			
PINUS PUNGENS	1	5	1		
PINUS RIGIDA	1	5	1		
PINUS STROBUS	1	1			
PINUS VIRGINIANA	1	1			
QUERCUS COCCINEA VAR COCCINEA	1	1			
RHODODENDRON CATAWBIENSE	1	1			
RHODODENDRON MINUS	2	2			
SMILAX ROTUNDIFOLIA	2	2			
TSUGA CAROLINIANA	1	1			
VACCINIUM CORYMBOSUM	1	1			
VACCINIUM STAMINEUM	1	1			

2.2 Tsuga caroliniana/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	2	1	
BETULA LENTA	1	1	2		
CLETHRA ACUMINATA	1	1			
FOTHERGILLA MAJOR	1	1			
HAMAMELIS VIRGINIANA	1	2	1		
KALMIA LATIFOLIA	3	5	1		
LEUCOTHOE RECURVA	2	2			
NYSSA SYLVATICA	1	2	2	1	
OXYDENDRUM ARBOREUM	1	2	1		
PINUS RIGIDA	1	1	1	1	
PINUS STROBUS	1	1	2	2	
QUERCUS MONTANA	1	1	1		
RHODODENDRON CATAWBIENSE	2	3			
RHODODENDRON MAXIMUM	4	6	2		
RHODODENDRON MINUS	3	4			
SASSAFRAS ALBIDUM	1	1			
SMILAX ROTUNDIFOLIA	2	2			
TSUGA CANADENSIS	1	1			
TSUGA CAROLINIANA	1	3	3	2	
VACCINIUM CORYMBOSUM	1	1			

2.3 Pinus virginiana-Pinus pungens/Kalmia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	2	1	
DIOSPYROS VIRGINIANA	1	1			
HAMAMELIS VIRGINIANA	1	1			
KALMIA LATIFOLIA	4	5			
NYSSA SYLVATICA	1	2	2	1	
OXYDENDRUM ARBOREUM	1	2	1	1	
PINUS PUNGENS	1	2	4	2	
PINUS RIGIDA	1	2	3	2	
PINUS STROBUS	1	1	1		
PINUS VIRGINIANA	1	2	4	2	
QUERCUS COCCINEA VAR COCCINEA	1	1	1		
QUERCUS MONTANA	1	1	3	1	
QUERCUS RUBRA	1	1	1		
RHODODENDRON MINUS	2	2			
SASSAFRAS ALBIDUM	1	1			
SMILAX ROTUNDIFOLIA	1	1			
SYMPLOCOS TINCTORIA	1	1			

2.4 Pinus pungens/Kalmia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	4	3	
AMELANCHIER LAEVIS	1	1	1		
HAMAMELIS VIRGINIANA	1	3			
KALMIA LATIFOLIA	3	7			
LEUCOTHOE RECURVA	1	1			
NYSSA SYLVATICA	1	4	4	2	
OXYDENDRUM ARBOREUM	1	1	2	1	
PINUS PUNGENS	1	2	6	5	
PINUS RIGIDA	1	1	3	3	
PINUS STROBUS	1	2	3	3	
PINUS VIRGINIANA	1	1	1	1	
QUERCUS COCCINEA VAR COCCINEA	1	1	4	3	
QUERCUS MONTANA	1	1	3	3	
RHODODENDRON MAXIMUM	1	2			
RHODODENDRON MINUS	1	2			
SMILAX ROTUNDIFOLIA	1	1			
SYMPLOCOS TINCTORIA	1	3			
TSUGA CANADENSIS	1	1			
TSUGA CAROLINIANA	1	2	1	1	

2.4.1 Pinus pungens-Quercus coccinea/Kalmia sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	3	2	
HAMAMELIS VIRGINIANA	1	2			
KALMIA LATIFOLIA	3	7			
NYSSA SYLVATICA	1	4	4	2	
OXYDENDRUM ARBOREUM	1	1	2	1	
PINUS PUNGENS	1	2	6	6	
PINUS RIGIDA	1	1	3	3	
PINUS STROBUS	1	2	3	2	
PINUS VIRGINIANA	1	1	2	2	
QUERCUS COCCINEA VAR COCCINEA	1	1	4	4	
QUERCUS MONTANA	1	1	3	2	
RHODODENDRON MINUS	1	3			
SYMPLOCOS TINCTORIA	1	3			
TSUGA CAROLINIANA	1	1	1		

2.4.2 Pinus pungens-Pinus strobus/Leucothoe recurva sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	5	4	
AMELANCHIER LAEVIS	1	1	1		
HAMAMELIS VIRGINIANA	1	4			
KALMIA LATIFOLIA	3	6			
LEUCOTHOE RECURVA	1	2			
LIQUIDAMBAR STYRACIFLUA	1	1	1	1	
MAGNOLIA FRASERI	1	1	2	1	
NYSSA SYLVATICA	1	3	4	3	
OXYDENDRUM ARBOREUM	1	1	2	1	
PINUS PUNGENS	1	1	5	4	
PINUS RIGIDA	1	1	3	3	
PINUS STROBUS	1	1	4	4	
QUERCUS ALBA	1	1	1	1	
QUERCUS COCCINEA VAR COCCINEA	1	1	2	2	
QUERCUS MONTANA	1	2	3	3	
RHODODENDRON CATAWBIENSE	1	1			
RHODODENDRON MAXIMUM	1	3			
RHODODENDRON MINUS	1	1			
SASSAFRAS ALBIDUM	1	1			
SMILAX ROTUNDIFOLIA	1	1			
SYMPLOCOS TINCTORIA	1	2			
TSUGA CANADENSIS	1	2	1		
TSUGA CAROLINIANA	1	2	1	1	

2.5 Pinus rigida-Quercus montana/Fothergilla Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	3	3	1	
CASTANEA DENTATA	1	1			
FOTHERGILLA MAJOR	2	4			
KALMIA LATIFOLIA	4	6			
LEUCOTHOE RECURVA	2	4			
LYONIA LIGUSTRINA VAR LIGUSTRINA	1	1			
NYSSA SYLVATICA	1	4	6		
OXYDENDRUM ARBOREUM	1	2	3		
PINUS PUNGENS	1	1	3	1	
PINUS RIGIDA	1	2	5	3	
PINUS STROBUS	1	2	3	2	
QUERCUS COCCINEA VAR COCCINEA	1	1	3	2	
QUERCUS MONTANA	1	3	5	3	
RHODODENDRON CATAWBIENSE	2	3			
RHODODENDRON MAXIMUM	1	1			
RHODODENDRON MINUS	1	1			
SYMPLOCOS TINCTORIA	1	2			
TSUGA CANADENSIS	1	1			
TSUGA CAROLINIANA	1	2	1		
VACCINIUM STAMINEUM	1	1			

2.6 Quercus alba/Kalmia/Galax Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	3	4	1	
AMELANCHIER LAEVIS	1	3	3		
BETULA LENTA	1	1	3		
CASTANEA DENTATA	1	3			
CLETHRA ACUMINATA	1	1			
HAMAMELIS VIRGINIANA	1	2			
KALMIA LATIFOLIA	6	8	1		
LEUCOTHOE RECURVA	2	3			
LYONIA LIGUSTRINA VAR LIGUSTRINA	1	1			
MENZIESIA PILOSA	1	1			
NYSSA SYLVATICA	1	4	3		
OXYDENDRUM ARBOREUM	1	1			
PINUS RIGIDA	1	1	3	1	
PINUS STROBUS	1	1	1		
PRUNUS PENSYLVANICA	1	1			
PYRULARIA PUBERA	1	1			
QUERCUS ALBA	1	2	3	1	
QUERCUS COCCINEA VAR COCCINEA	1	2	1		
QUERCUS RUBRA	1	1	2	1	
RHODODENDRON CATAWBIENSE	4	6			
RHODODENDRON MINUS	2	1			
SASSAFRAS ALBIDUM	1	1			
SMILAX BONA-NOX	1	1			
SYMPLOCOS TINCTORIA	1	1			
TSUGA CANADENSIS	1	1			
TSUGA CAROLINIANA	1	1	1		
VACCINIUM CORYMBOSUM	1	1			

2.7 Quercus alba-Pinus strobus/Kalmia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	3	5	3	
CORNUS FLORIDA	1	1	1		
KALMIA LATIFOLIA	3	4			
LIRIODENDRON TULIPIFERA	1	1	1	1	1
NYSSA SYLVATICA	1	2	4	1	
OXYDENDRUM ARBOREUM	1	2	4	2	
PINUS RIGIDA	1	1	1	1	
PINUS STROBUS	1	1	3	3	1
QUERCUS ALBA	1	1	4	4	1
QUERCUS MONTANA	1	1	3	3	
QUERCUS RUBRA	1	1	3	3	
RHODODENDRON MAXIMUM	1	2			
TSUGA CANADENSIS	2	4	2		

2.8 Quercus montana-Quercus coccinea/Kalmia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	6	5	
CARYA GLABRA	1	1	1	1	
KALMIA LATIFOLIA	3	6			
MAGNOLIA FRASERI	1	1	2	1	
NYSSA SYLVATICA	1	2	3	1	
OXYDENDRUM ARBOREUM	1	4	5	1	
PINUS STROBUS	1	2			
QUERCUS ALBA	1	1	2	2	
QUERCUS COCCINEA VAR COCCINEA	1	1	5	6	
QUERCUS MONTANA	1	1	5	5	1
RHODODENDRON PERICLYMENOIDES	1	1			

2.9 Quercus montana/Galax Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	5	4	
CASTANEA DENTATA	1	1			
HAMAMELIS VIRGINIANA	1	2			
KALMIA LATIFOLIA	3	6			
LEUCOTHOE RECURVA	1	1			
NYSSA SYLVATICA	1	2	2	1	
OXYDENDRUM ARBOREUM	1	3	4	2	
PINUS STROBUS	1	3	2	2	
QUERCUS ALBA	1	1	4	4	
QUERCUS COCCINEA VAR COCCINEA	1	1	2	2	
QUERCUS MONTANA	1	1	4	4	
QUERCUS RUBRA	1	1	3	2	
RHODODENDRON MAXIMUM	1	2			
SASSAFRAS ALBIDUM	1	1	1		
SMILAX ROTUNDIFOLIA	1	1			
SYMPLOCOS TINCTORIA	1	1			
TSUGA CANADENSIS	1	1			
TSUGA CAROLINIANA	1	1			

Table 3.16. Site information for the **<u>Xeric Evergreen Forests</u>** vegetation class. Groups represented by their abbreviation code. For full names see Table 3.1. Average values of site variables are given. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**CL**=lower quartzite, **G**=gneiss, **M**=meta-arkose), Landform types (representing micro-scale topographic units) (**R**=ridge, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**MS**=mid-slopes, **US**=upper-slopes).

2. Xeric Evergreen Forests

	Group											
	2.	2.1	2.2	2.3	2.4	2.4.1	2.4.2	2.5	2.6	2.7	2.8	2.9
Site Characteristics:												
Elevation (m)	880	982	984	690	832	796	894	933	1193	695	802	1059
Slope (o)	19	10	28	27	20	24	13	12	13	13	22	13
Aspect (o)			N-E,W	SE	W-NW	SW-NW	W-NW	SW-NW	W-NW	SE	SE	SW-NE
Parent material	CL	CL	CL	CL	CL,G	CL	CL	CL	CL	CL	CL,G	CL,M
Surface Substrate (%)												
Moss/Lichen	4	5	12	5	3	2	4	1	1	3	4	2
Wood	2	4	2	2	2	1	2	2	2	2	2	2
Rock	8	19	21	16	3	4	2	2	1	4	5	3
Organic Matter	89	78	75	81	93	94	92	96	95	94	92	95
Water	0	0	1	0	1	0	2	0	0	0	0	0
Topographic Characteristics:												
Relative slope (%)	30	26	41	46	32	31	32	8	1	44	37	18
LFI	0.15	0.06	0.17	0.21	0.17	0.20	0.12	0.09	0.05	0.18	0.16	0.10
TSI	-0.04	-0.12	-0.04	-0.03	-0.04	-0.03	-0.04	-0.03	-0.06	-0.01	-0.03	-0.04
Landform type	SS	SS	SS	SS,R	SS	SS	SS	SS	R,SS	R,SS	SS	SS
Topographic pos.n	US	US	US	MS	US,MS	MS	US	US	US	US	US	US

3.5.3 VEGETATION CLASS: 3. Acidic Cove and Slope Forests

The **Acidic Cove and Slope Forests** vegetation class is widespread throughout the Southern Appalachian Mountains, occurring in "narrow gorges, steep ravines and low gentle ridges within coves" at low- and moderate-elevations (Schafale & Weakley 1990).

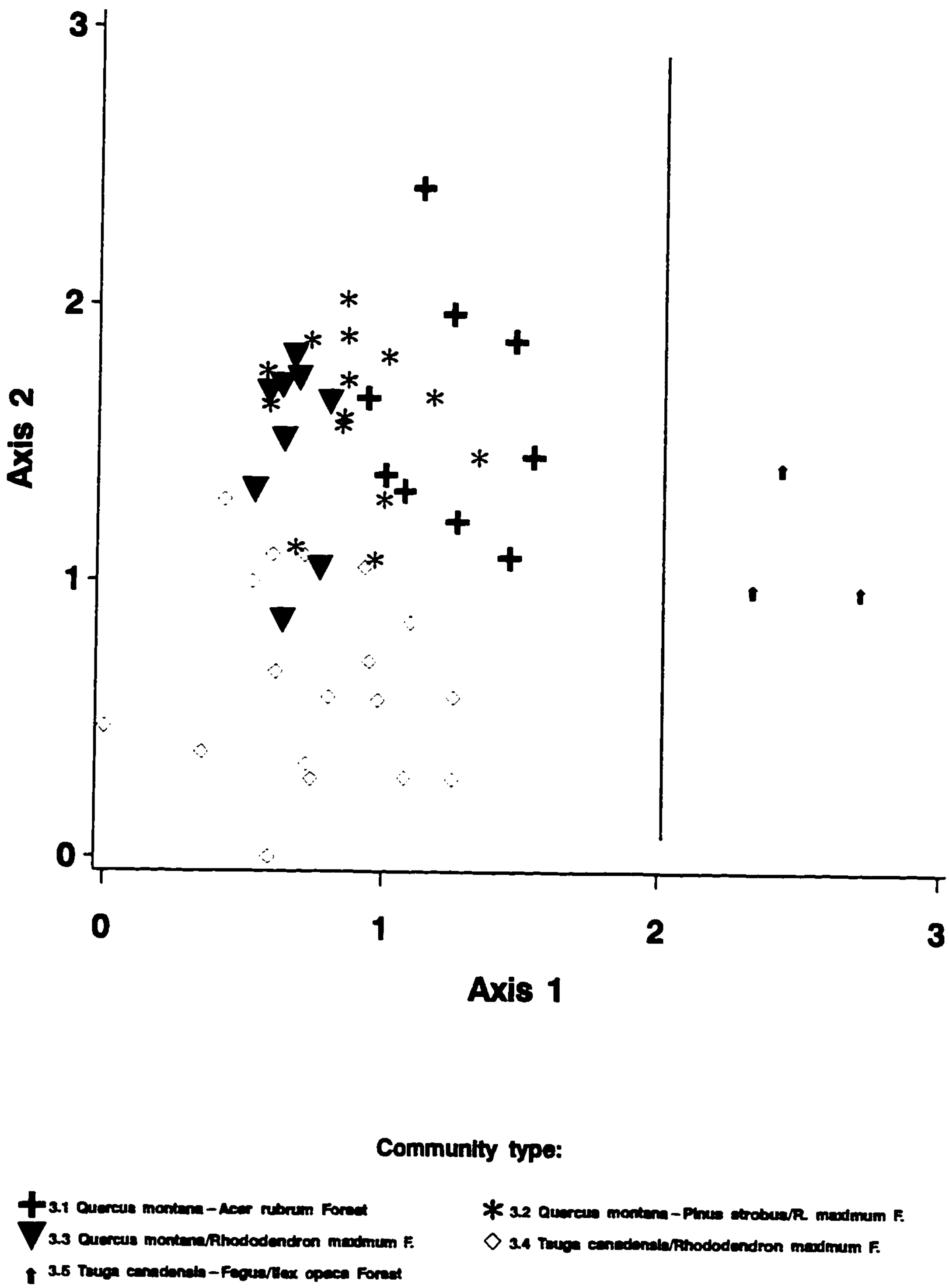
This vegetation class is also widely distributed in sheltered sites throughout Linville Gorge, and is one of the two most widespread vegetation classes identified accounting for 36% of all the sites sampled and 48% of the vegetation mapped (Appendices 1, 4). Sites have typically low species diversity (Table 3.8) and are characterized by the presence of an evergreen shrub layer, either dominated or codominated by *Rhododendron maximum*. Geologic substrate varies with 38% of sites sampled underlain by lower quartzite and approximately 25% on gneiss and 25% on meta-arkose.

The **Acidic Cove and Slope Forests** inhabits sheltered, less fertile, lower-slopes than the **Xeric Evergreen Forests, Montane Oak Forests** and **Rich Cove and Slope Forests** (Figures 3.5, 3.6). Community types in the **Acidic Cove and Slope Forests** class are separated from one another by soil nutrients (Ca, Mn, pH), elevation, slope position and slope angle (Figures 3.13, 3.14). There is marginal correspondence between underlying geology and environmental gradients, with stands underlain by gneiss typically steeper sites with higher slope positions (Figures 3.14, 3.15).

The **Tsuga canadensis-Fagus/Ilex opaca Forest** shows strongest compositional differentiation from the other three community types and is well separated along the soil nutrient-elevation gradient on fertile, low-elevation sites. The extent of the compositional dissimilarities between this community type and the remaining four *Rhododendron*-dominated types may control stand position of these latter types on axis 1. Moreover, the strength of the soil nutrient differences between the **Tsuga canadensis-Fagus/Ilex opaca Forest** and the remaining types may override the significance of other site factors. This community type was eliminated in a subsequent ordination in an attempt to clarify site differences between the remaining four *Rhododendron*-dominated types.

The four *Rhododendron*-dominated types in the **Acidic Cove and Slope Forests** class are separated by topographic characteristics (Figures 3.16, 3.17). The **Tsuga canadensis/Rhododendron maximum Forest** is distributed across a broad range of elevations, inhabiting moist (low solar radiation) lower-slopes. The **Quercus montana/ Rhododendron maximum Forest** is found at higher-elevations. The **Quercus montana-Acer rubrum Forest** and the **Quercus montana-Pinus strobus/Rhododendron maximum Forest** are located on dryer sites with higher slope positions than the two former types. Environmental differences between these two dryer types are indistinct.

Figure 3.13. DCA ordination diagram of the **Acidic Cove and Slope Forests** class showing community types distribution on the two major compositional gradients. The solid line represents separation of stands for a subsequent ordination.



3
2
1
0
Axis 2
0
1
2
3
Axis 1
Community type:
3.1 Quercus montana – Acer rubrum Forest
3.2 Quercus montana – Pinus strobus/R. maximum F.
3.3 Quercus montana/Rhododendron maximum F.
3.4 Tsuga canadensis/Rhododendron maximum F.
3.5 Tsuga canadensis – Fagus/Ilex opaca Forest

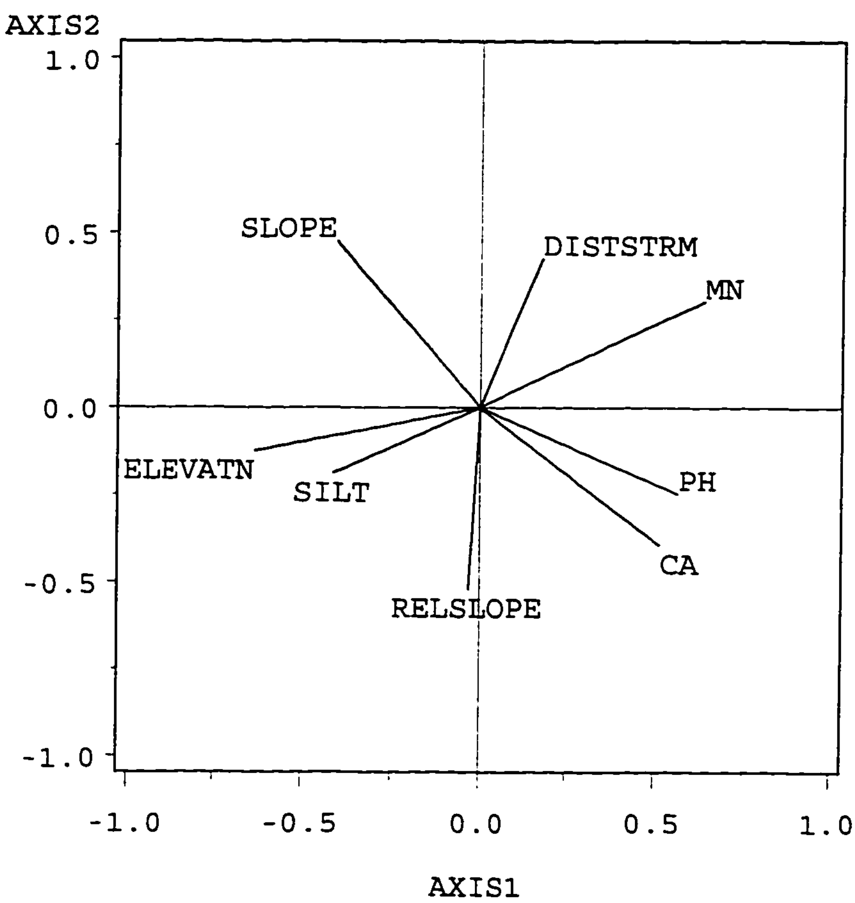
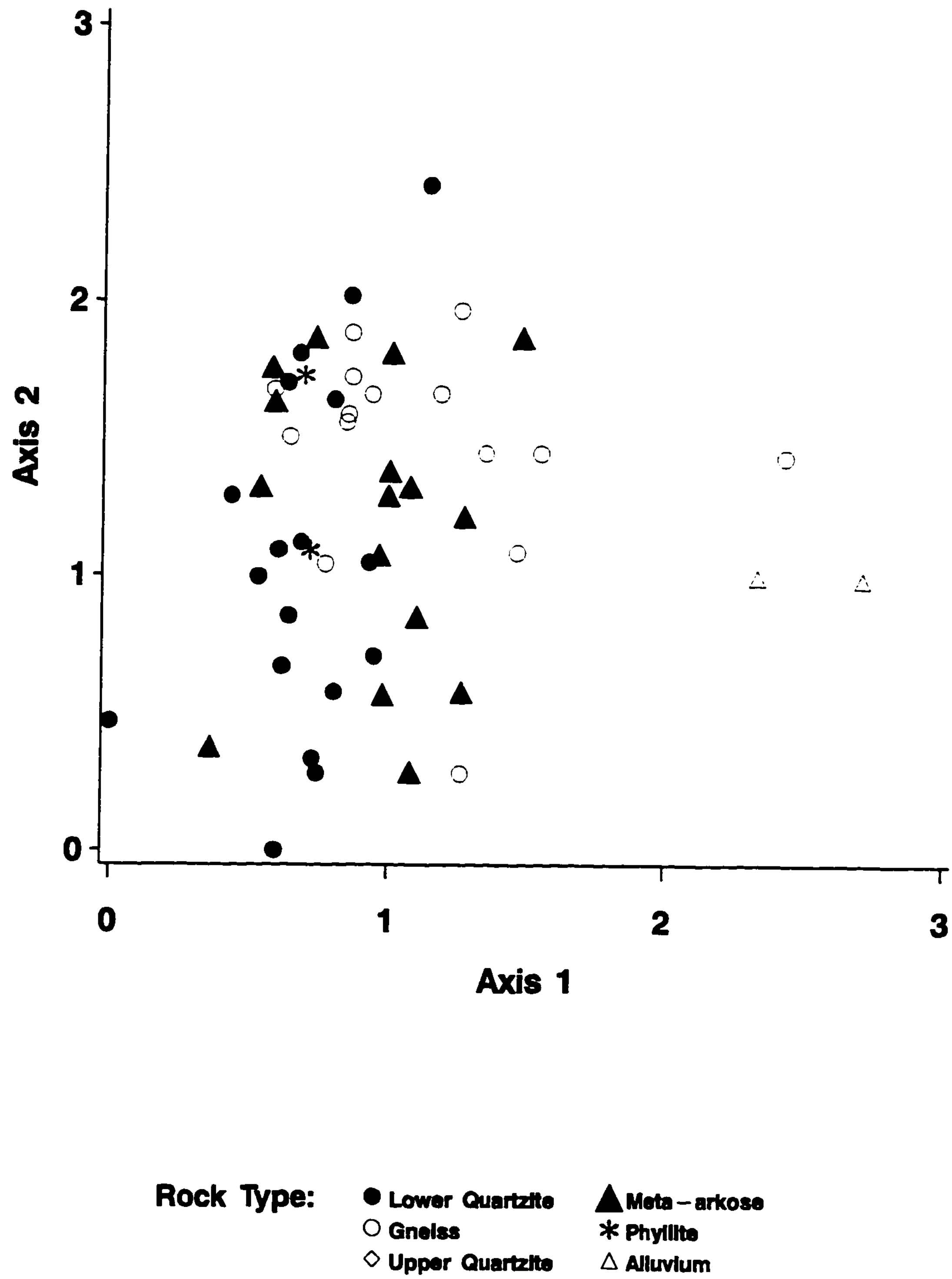


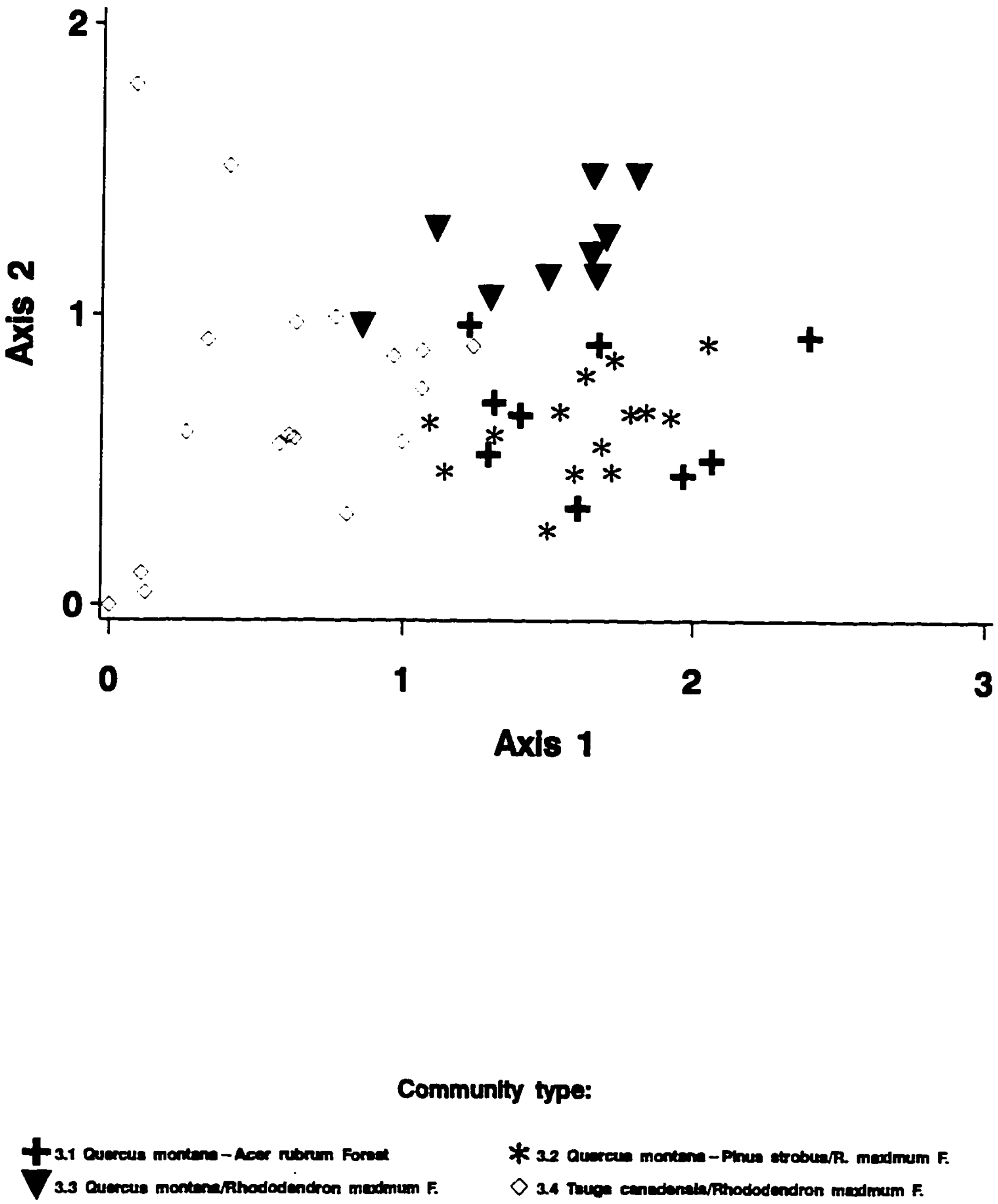
Figure 3.14. Vector diagram for DCA ordination of the **Acidic Cove and Slope Forests** class showing association between species composition and major environmental gradients.

Figure 3.15. DCA ordination diagram of **Acidic Cove and Slope Forests** class showing distribution by parent material type on the two major compositional gradients.



3
2
1
0
Axis 2
0
1
2
3
Axis 1
Rock Type:
Lower Quartzite
Gneiss
Upper Quartzite
Meta – arkose
Phyllite
Alluvium

Figure 3.16. DCA ordination diagram of *Rhododendron*-dominated types in the **Acidic Cove and Slope Forests** showing type distribution on the two major compositional gradients.


Axis 2
2
1
0
0
1
2
3
Axis 1
Community type:
3.1 Quercus montana – Acer rubrum Forest
3.2 Quercus montana – Pinus strobus/R. maximum F.
3.3 Quercus montana/Rhododendron maximum F.
3.4 Tsuga canadensis/Rhododendron maximum F.

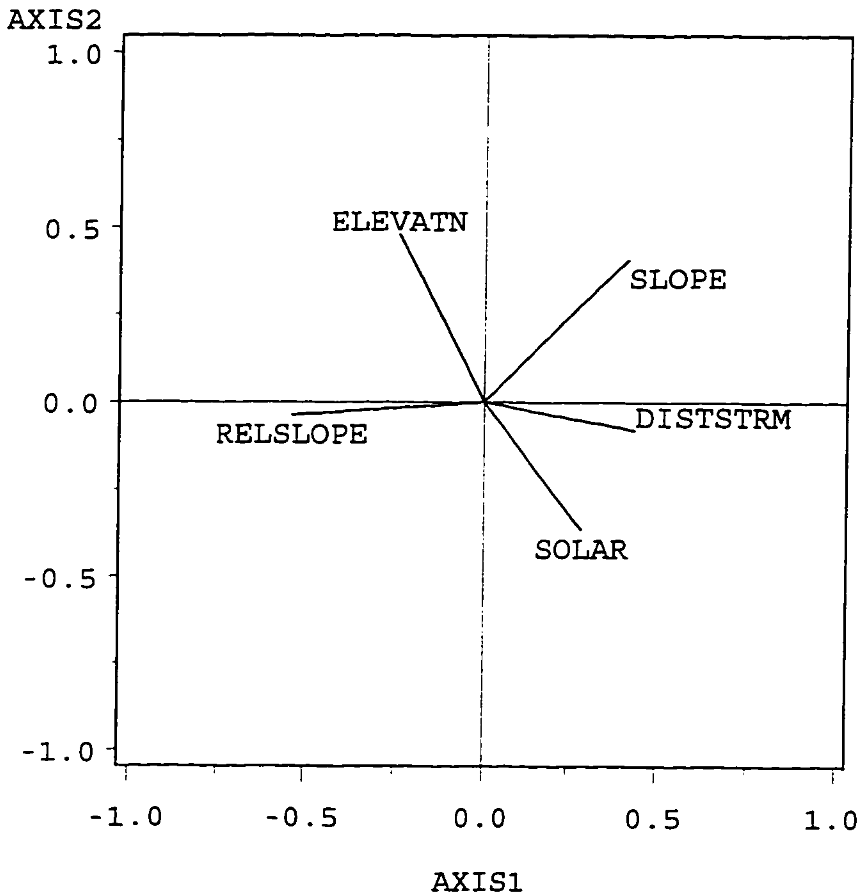


Figure 3.17. Vector diagram for DCA ordination of the *Rhododendron* dominated-types in the **Acidic Cove and Slope Forests** class showing association between species composition and major environmental gradients.

COMMUNITY TYPE: Quercus montana-Acer rubrum Forest (3.1)

Synonymy

Montane Oak--Hickory p.p. (Schafale & Weakley 1990).

Constant species

Acer rubrum var. *rubrum, Chimaphila maculata* var. *maculata, Cornus florida, Kalmia latifolia, Liriodendron tulipifera, Nyssa sylvatica, Oxydendrum arboreum, Pinus strobus, Quercus montana, Quercus rubra, Rhododendron maximum, Smilax glauca* var. *glauca, Smilax rotundifolia, Symplocus tinctoria, Tsuga canadensis, Viola hastata.*

Physiognomy

The rank order by dominance of the major canopy species (large-diameter *Quercus montana* (40 to 91 cm), *Pinus strobus* (40 to 68 cm), and smaller-sized *Acer rubrum*) varies between sites. *Liriodendron tulipifera* and *Quercus rubra* are also scattered throughout the canopy (Tables 3.17, 3.18, 3.19). The subcanopy is typically dominated by *Acer rubrum* and *Oxydendrum arboreum,* but with a distinctive *Tsuga canadensis* understory. The shrub stratum varies in density and species composition. *Rhododendron maximum* forms an open to dense shrub layer on lower-slope sites whereas *Kalmia latifolia* has patchy distribution on dry, mid-to-upper-slope sites. Shrubs are virtually absent on very dry upper-slope sites. In other mid-to-lower-slope sites, *P. strobus* and/or *T. canadensis* form a distinct shrub layer. Forest floor cover contains little more than sparsely scattered *Viola hastata.*

Habitat and Distribution

The **Quercus montana-Acer rubrum Forest** occurs on dry, moderately steep sideslopes on both sides of the valley on gneiss and meta-arkose bedrock (Figures 3.16, 3.17, Table 3.20). Although present across a broad elevational range (457-939 m, average of 714 m), sites typically occur below the bluffs on sideslopes with mid- to lower-slope positions. The **Quercus montana-Acer rubrum Forest** is widely scattered throughout the

Wilderness. Sites on the east side of the valley have southeast- to west-aspects while those on the west are east-facing.

The textural composition of the soils in this community type are similar to the other **Acidic Cove and Slope Forests** types. This type has lower cation exchange capacity, Ca, Mg, Na, S and Zn than other types in this class (Tables 3.4, 3.5).

Distinguishing Features

The **Quercus montana-Acer rubrum Forest** is the major vegetation group inhabiting infertile, dry sideslopes. Site dryness is reflected in part by the southeast-to-westerly site aspect (3.20). All other community types in the **Acidic Cove and Slope Forests** class have cooler, northerly-facing aspects. In comparison to other types, this community type has low species-richness at the 3 smallest spatial scales (Table 3.8).

Succession and Disturbance

There is little evidence of recent fire in this community type, which is reinforced by the presence of *Tsuga canadensis* saplings. Without fire, *Tsuga* dominance is likely to gradually increase and eventually codominate with *Acer rubrum* in the canopy with *Quercus montana* decreasing in abundance (Table 3.18).

COMMUNITY TYPE: Quercus montana-Pinus strobus/Rhododendron maximum Forest (3.2)

Synonymy

White Pine Forest (Schafale & Weakley 1990), White Pine-Chestnut Oak Type (DeYoung 1979), *Pinus strobus-Pinus rigida-Quercus coccinea/Kalmia/Gaylussacia ursina* Forest p.p. (Patterson 1994).

Constant species

Acer rubrum var. *rubrum, Hexastylis virginiana, Kalmia latifolia, Magnolia fraseri, Nyssa sylvatica, Oxydendrum arboreum, Pinus strobus, Quercus montana, Rhododendron maximum, Smilax glauca* var. *glauca, Smilax rotundifolia, Symplocus tinctoris, Tsuga canadensis.*

Physiognomy

Large, mostly 40-80 cm diameter *Quercus montana* stems (largest measuring 103 cm) and 40-55 cm *Pinus strobus* stems (largest 75 cm) codominate the canopy, in conjunction with smaller-diameter *Acer rubrum* (Tables 3.17, 3.18, 3.19). There is a subcanopy of *Nyssa, Oxydendrum* and *Tsuga canadensis. Rhododendron maximum* and *Kalmia latifolia* form an open- to moderately-closed shrub layer. *Smilax glauca* and *S. rotundifolia* are minor components in this stratum. The forest floor is typically dry with a thick layer of litter. A near absence of vascular species accounts for low small-scale richness values (Table 3.8).

Habitat and Distribution

The **Quercus montana-Pinus strobus/Rhododendron maximum Forest** inhabits low- to moderate-elevations (457 to 1059 m) on mostly the east side of the valley. Sites are typically northwest- to north-facing, broad ridgelines and off-ridge slopes below the bluffs (Table 3.20). This type has an equal distribution of sites on gneiss and meta-arkose.

Soils of the **Quercus montana-Pinus strobus/Rhododendron maximum Forest** are similar to average **Acidic Cove and Slope Forests** class values (Tables 3.4, 3.5). This type has lower Fe and higher P and S than other types in this class.

Succession and Disturbance

There is limited evidence for fire in the **Quercus montana-Pinus strobus/ Rhododendron maximum Forest** with charcoal present in only two of the sites.

The future presence of *Quercus montana* is uncertain; few saplings and small trees were present in the understory. *Pinus strobus* saplings assure the continuing presence of this species in this type (Table 3.18).

COMMUNITY TYPE: Quercus montana/Rhododendron maximum Forest (3.3)

Synonymy

Acidic Cove Forest (Schafale & Weakley 1990), Chestnut Oak-Chestnut Heath p.p. (Whittaker 1956), Chestnut Oak Forest (Cooper & Hardin 1970), Chestnut Oak Forest p.p. (McLeod 1988), Chestnut Oak Forest p.p. and Red Oak Slope Forest p.p. (Patterson 1994), *Quercus montana/Rhododendron maximum* Forest (Chapter 5).

Constant species

Acer rubrum var. *rubrum, Betula lenta, Galax urceolata, Hamamelis virginiana, Kalmia latifolia, Magnolia fraseri, Nyssa sylvatica, Oxydendrum arboreum, Pinus strobus, Quercus montana, Rhododendron maximum, Smilax glauca* var. *glauca, Smilax rotundifolia, Tsuga canadensis.*

Physiognomy

Quercus montana and *Acer rubrum* are the major canopy species of this type. Stems of these species are generally large (mostly between 40 and 70 cm), with the largest observed measuring 93 cm. *Betula lenta* and *Magnolia fraseri* are consistent minor components in the canopy. *Q. rubra* abundance varies between sites (Tables 3.17, 3.18, 3.19). The subcanopy is dominated by *Oxydendrum* and *Nyssa*. There is a dense shrub layer of *Rhododendron maximum* and less abundant *Hamamelis virginiana*. The forest floor is dominated by a thick litter layer with virtually no vascular plants present (Table 3.8).

Habitat and Distribution

The **Quercus montana/Rhododendron maximum Forest** occurs on moderately steep, mid-slope positions between 701-1146 m in elevation. On the west side of the Linville valley this type inhabits north-to-east-facing, mid-to-lower sideslopes above the bluffs, whereas it occurs on west-to-north-facing upper-slopes on the east side. Sites are mostly underlain by lower quartzite bedrock, but also occur on meta-arkose, gneiss and phyllite (Table 3.20).

Soils of the **Quercus montana/Rhododendron maximum Forest** are similar to average **Acidic Cove and Slope Forests** class values (Tables 3.4, 3.5).

Succession and Disturbance

A charcoal layer in the soil in of 44% of **Quercus montana/Rhododendron maximum Forest** sites provides evidence for past disturbance by fire. Occasional charred stumps were also recorded.

The long-term prognosis for the present canopy composition is uncertain. Limited *Quercus montana* saplings and small-trees points to a declining presence of this species in the future. Summary information suggests that *Betula lenta* and *Acer rubrum* may replace *Q. montana* in the canopy (Table 3.19).

COMMUNITY TYPE: Tsuga canadensis/Rhododendron maximum Forest (3.4)

Synonymy

Canada Hemlock forest (Schafale & Weakley 1990), Hemlock Forest - Rhododendron type (Oosting & Bourdeau 1955), Eastern Hemlock Forest (Whittaker 1956), Hemlock Forest (Racine & Hardin 1975), High Cove (Rohrer 1983), the Black and Craggy Mountains north-facing slope and gorge variant of Eastern Hemlock forests (McLeod 1988), Hemlock White Pine subtype II (Patterson 1994), *Tsuga canadensis-Betula lenta/Rhododendron maximum* Forest (Chapter 4), *Tsuga canadensis-Quercus rubra/Rhododendron maximum*

Forest p.p. (Chapter 4), *Tsuga canadensis/Rhododendron maximum* Forest (Chapter 5), *Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum* Forest (Chapter 5).

Constant species

Acer rubrum var. *rubrum, Betula lenta, Nyssa sylvatica, Rhododendron maximum, Tsuga canadensis.*

Listed species

Dichanthelium latifolium.

Physiognomy

Tsuga canadensis forms a dense, tall canopy (mean height 30 m). *Tsuga* stems are large, mostly measuring between 40 and 75 cm in diameter, with the largest observed measuring 134 cm. *Acer rubrum, Betula lenta, Magnolia fraseri* and *Nyssa sylvatica* stems are scattered throughout the canopy (Tables 3.17, 3.18, 3.19). Below, *Rhododendron maximum* forms a particularly dense shrub layer with stems mostly in the 1-10 cm size classes. The forest floor is thickly covered with litter.

Tsuga canadensis and *Rhododendron maximum* are the only two species with high cover abundance (7 & 8 respectively). Cover of other species in the canopy varies (Tables 3.17, 3.19). *Acer rubrum, Betula lenta, Nyssa* and *Oxydendrum* have greater cover in the sideslope variant of this community type whereas *Liriodendron tulipifera* and *Magnolia fraseri* are more prevalent in the cove/stream variant. Low-elevation streamside sites (generally at the lower reaches of streams in close proximity to the Linville River) have dense tangles of *Leucothoe axillaris* covering the forest floor. The floristic and structural simplicity of this type is reflected by low species richness at all spatial scales (Table 3.8).

Habitat and Distribution

This community type is widespread throughout Linville Gorge. It dominates the steep slopes in the narrow, northern, gorge-portion of the Wilderness and slopes on adjacent side branches. The **Tsuga canadensis/Rhododendron maximum Forest** also inhabits small, steep, rocky creek gullies leading downslope from the bluffs (Figures 3.16, 3.17).

The **Tsuga canadensis/Rhododendron maximum Forest** occurs across a broad elevational range (537 to 1084 m) and is found on both sides of the Linville River valley (Table 3.20). This type mainly inhabits west and north-facing, moderately steep (6 to 32°, average 18°), sheltered gorge slopes, sideslopes and coves. Sites mostly occur on lower quartzite bedrock, with approximately 20% on meta-arkose.

Soil nutrient levels are similar to average **<u>Acidic</u> <u>Cove</u> and <u>Slope Forests</u>** values, but have lower Al, Mn and higher organic matter (Tables 3.4, 3.5). Higher organic matter levels may reflect the presence, and slow decomposition, of the dense, predominantly *Rhododendron*, litter layer.

Distinguishing Features

This is the only vegetation group where *Tsuga canadensis* alone dominates the canopy, and is also the only group where only two species predominate the vegetation structure and composition. The **Tsuga canadensis/Rhododendron maximum Forest** differs compositionally from the **Quercus montana/Rhododendron maximum Forest** in having generally low abundances of *Quercus montana*, and *Kalmia*, although the latter does occur. The former type inhabits more sheltered, lower-slope positions than the latter.

The predominance of two evergreen species may at least in part account for lowest richness levels at the four largest scales in comparison to other **<u>Acidic</u> <u>Cove</u> and <u>Slope Forests</u>** types (Table 3.8). At the two largest spatial scales (0.1 ha and 0.01 ha) the **Tsuga canadensis/Rhododendron maximum Forest** has the lowest species richness of any forest community type or sub-type recognized in this study. The most depauperate plot contained 7 species in a 0.1 ha area. However, this community type has the highest average basal area (66.12 m^2) of any type in this study.

Succession and Disturbance

Sites in northeastern Linville Gorge and on the northwest slope below Tablerock have been at least partially cut in the past. Charred wood provides evidence of past fire in a small portion of sites. This community type is also subject to human disturbance. Several trails descend to the Linville River through the **Tsuga canadensis/Rhododendron maximum Forest**. In areas where unofficial campsites have been established, the surface substrate of this community type has been disturbed and compacted.

High *Tsuga canadensis* sapling numbers suggests that this community type will be self perpetuating (Table 3.18).

COMMUNITY TYPE: Tsuga canadensis-Fagus/Ilex opaca Forest (3.5)

Synonymy

Acidic Cove Forest p.p., Montane Alluvial Forest p.p., Piedmont/Low Mountain Alluvial Forest p.p. (Schafale & Weakley 1990), Hemlock Forest-herb type p.p. (Oosting & Bourdeau 1955), Disturbed Floodplain Forests p.p. (Cooper & Hardin 1970), Alluvial Forests p.p. (McLeod 1988), Hemlock-White Pine Forest subtype I (Patterson 1994), *Tsuga canadensis-Liriodendron/Mitchella* sub-type p.p. (Chapter 5).

Constant species

Acer rubrum var. *rubrum, Asimina triloba, Aster divaricata, Carex digitalis, Chimaphila maculata* var. *maculata, Cornus florida, Euonymus americana, Fagus grandifolia, Ilex opaca, Liriodendron tulipifera, Mitchella repens, Polystichum acrosticoides, Parthenocissus quinquefolia* var. *quinquefolia, Pinus strobus, Smilax glauca* var. *glauca, Smilax rotundifolia, Tsuga canadensis, Viola hastata, Zizia trifoliata.*

Physiognomy

Tsuga canadensis is the dominant species in the tall (34 m mean height), dense canopy, in association with large-diameter *Fagus grandifolia* (55-79 cm) and *Pinus strobus* (47-62 cm). *Liriodendron tulipifera* is scattered throughout the canopy with low abundance. The understory is dominated by small-diameter *Tsuga* (mostly 2.5 to 20 cm in size) and *Ilex opaca*. The shrub stratum is open, dominated by *Cornus florida* with low, but consistent levels of *Smilax glauca* var. *glauca* and *S. rotundifolia* (Tables 3.17, 3.18, 3.19). *Asimina triloba* is present in some sites. The forest floor is inhabited by *Mitchella repens* and a range of species with limited cover.

Habitat and Distribution

The **Tsuga canadensis-Fagus/Ilex opaca Forest** is restricted to relatively flat (mean slope 7°), low-elevation sites (409-453 m elevational range, 437 m average) (Figures 3.13, 3.14, Table 3.20). This type occurs adjacent to the Linville River in the lower third of the Wilderness, inhabiting a large, non-active alluvial terrace adjacent to the confluence of Cambric Branch and Linville River, the southern most terrace in the Wilderness, and the toeslope at the base of the west-facing slope of Shortoff Mountain.

The soils are high in sand and low in silt content in comparison to other **Acidic Cove and Slope Forests** types, reflecting the composition of the underlying substrate (Tables 3.4, 3.5). The soils are low in K but have higher Al, Ca, Fe, Mn and pH levels than any other **Acidic Cove and Slope Forests** types or sub-types (Figures 3.13, 3.14). These values reflect nutrient input from flood-carried and downslope sediment movement.

Distinguishing Features

This is the only community type in Linville Gorge where *Fagus grandifolia* and *Ilex opaca* are important species. At all spatial scales the **Tsuga canadensis-Fagus/Ilex opaca Forest** has the highest species richness of any **Acidic Cove and Slope Forest** type (Table 3.8), probably owing to the high-nutrient soils and the lack of a dense ericaceous shrub stratum.

The **Tsuga canadensis-Fagus/Ilex opaca Forest** is one of two vegetation groups that inhabit old alluvial surfaces. It contrasts to the other, the **Platanus/Asimina/ Microstegium Forest**, by occupying higher terraces and by having a denser, predominantly evergreen canopy and understory.

Succession and Disturbance

This community type is infiltrated by sediments moving down from the slopes above and by very occasional flooding. The presence of *Tsuga canadensis* in the understory suggests that this species will continue to dominate the canopy. The **Tsuga canadensis-Fagus/Ilex opaca Forest** appears to be a mature, self-maintaining community (Table 3.18).

Table 3.17. Average cover class and constancy of species present in the **Acidic Cove and Slope Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 3.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	3.	3.1	3.2	3.3	3.4	3.5
Number of plots:	53	??	??	9	18	3
Homoteniety:	0.582	0.752	0.700	0.640	0.548	0.756
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species						
ACER PENSYLVANICUM	2 36	1 22	1 36	4 67	2 22	1 67
ACER RUBRUM VAR RUBRUM	5 100	6 100	5 100	5 100	4 100	2 100
AESCULUS FLAVA	1 2					1 33
AGERATINA ALTISSIMA VAR ALTISSIMA	1 4	1 11			1 6	
AGROSTIS CAPILLARIS	1 2	1 11				
AGROSTIS PERENNANS	1 4	1 11			1 6	
AMELANCHIER LAEVIS	2 19			2 44	2 33	
ARALIA NUDICAULIS	1 2			1 11		
ARALIA SPINOSA	1 2			1 11		
ARISTOLOCHIA MACROPHYLLA	1 4			1 11	1 6	
ARISAEMA TRIPHYLLUM	1 17	1 11	1 7	1 11	1 22	1 67
ASIMINA TRILOBA	3 4					3 67
ASPLENIUM MONTANUM	1 4				1 11	
ASPLENIUM PLATYNEURON VAR PLATYNEURON	1 4	1 11				1 33
ASTER DIVARICATUS	1 17	1 22		1 11	1 17	1 100
ASTER MACROPHYLLUS	1 2			1 11		
ATHYRIUM ASPLENIOIDES	2 4				3 6	1 33
BETULA ALLEGHANIENSIS	4 11	1 11			4 28	
BETULA LENTA	3 66	3 44	3 43	3 100	4 78	2 67
CALYCANTHUS FLORIDUS VAR GLAUCUS	1 6	1 11	1 7			1 33
CAMPANULA DIVARICATA	1 2			1 11		
CARDAMINE DIPHYLLA	1 2					1 33
CAREX BLANDA	1 4			1 11		1 33
CAREX COMMUNIS	2 2			2 11		
CAREX DIGITALIS	1 8	1 11				1 100
CAREX PENSYLVANICA	1 4					1 67
CAREX SWANII	1 8	1 22		1 11		1 33
CARYA ALBA	3 9	3 22	3 7			3 67
CARYA GLABRA	2 17	2 67	3 14			3 33
CARYA OVATA	1 4			1 11		1 33
CARYA PALLIDA	1 2					1 33
CASTANEA DENTATA	1 8		2 14	1 22		
CHAMAELIRIUM LUTEUM	1 26	1 11	1 57	1 44	1 6	
CHIMAPHILA MACULATA VAR MACULATA	1 40	1 56	1 57	1 11	1 22	1 100
CHIONANTHUS VIRGINICUS VAR VIRGINICUS	1 2			1 11		
CIRCAEA CANADENSIS	1 2					1 33
CLETHRA ACUMINATA	2 9			1 11	2 22	
CLINTONIA UMBELLULATA	1 8			1 22	1 11	
COLLINSONIA CANADENSIS	1 4				1 11	
CONOPHOLIS AMERICANA	1 2					1 33
CONVALLARIA MONTANA	1 2			1 11		
CORNUS FLORIDA	2 36	2 100	1 29	1 22	2 6	2 100

Group:	3.	3.1	3.2	3.3	3.4	3.5
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
CYPRIPEDIUM ACAULE	1 4					1 67
DANTHONIA SPICATA	1 2	1 11				
DENNSTAEDTIA PUNCTILOBULA	1 13	1 11		1 22	1 22	
DESMODIUM NUDIFLORUM	1 4	1 11				1 33
DICHANTHELIUM SP. #1	1 2		1 7			
DICHANTHELIUM BOSCII	1 2					1 33
DICHANTHELIUM COMMUTATUM	1 4	1 11	1 7			
DICHANTHELIUM DICHOTOMUM VAR 4 (=RAMULOSUM)	1 2	1 11				
DICHANTHELIUM LATIFOLIUM*	1 2				1 6	
DICOT SP. #3	1 2				1 6	
DIOSCOREA QUATERNATA	1 17	1 22	1 7	1 33	1 6	1 67
DIOSPYROS VIRGINIANA	1 2					1 33
DRYOPTERIS INTERMEDIA	1 9			1 11	1 22	
DRYOPTERIS MARGINALIS	1 9	1 22		1 11	1 11	
EPIFAGUS VIRGINIANA	1 2					1 33
EPIGAEA REPENS	1 4		1 7	1 11		
EUONYMUS AMERICANA	1 8				1 6	1 100
FAGUS GRANDIFOLIA	2 11	1 11	1 14			3 100
FRAXINUS AMERICANA	2 4				3 6	1 33
GALAX URCEOLATA	2 55	1 22	2 86	2 78	1 39	1 33
GALIUM CIRCAEZANS VAR CIRCAEZANS	1 2					1 33
GAYLUSSACIA BACCATA	1 2		1 7			
GENTIANA DECORA	1 9	1 11	1 14	1 22		
GOODYERA PUBESCENS	1 38	1 56	1 43	2 44	1 28	
GOODYERA REPENS	1 11	1 11	1 14		1 17	
HALESIA TETRAPTERA VAR MONTICOLA	2 23	2 22	2 14	4 22	3 28	1 33
HAMAMELIS VIRGINIANA	3 51	1 11	3 64	3 100	2 44	
HEUCHERA VILLOSA VAR VILLOSA	1 2			1 11		
HEXASTYLIS SHUTTLEWORTHII VAR SHUTTLEWORTHII	1 21	1 11	1 29	1 22	1 22	
HEXASTYLIS VIRGINICA	1 45	1 33	1 79	2 22	1 39	1 33
HYPERICUM DENSIFLORUM	1 2	1 11				
ILEX MONTANA	2 9			2 33	2 11	
ILEX OPACA VAR OPACA	3 19	1 11	2 14		2 22	5 100
KALMIA LATIFOLIA	4 85	3 100	5 100	4 100	3 67	1 33
LEUCOTHOE FONTANESIANA	7 6				7 17	
LEUCOTHOE RECURVA	1 8		2 14	1 22		
LILIUM MICHAUXII	1 6			1 33		
LIQUIDAMBAR STYRACIFLUA	3 8	4 22				2 67
LIRIODENDRON TULIPIFERA	3 57	3 78	2 43	1 44	3 56	2 100
LISTERA SMALLII	1 17	1 11	1 7	2 22	1 28	
LUZULA MULTIFLORA VAR CONGESTA	1 2	1 11				
LYONIA LIGUSTRINA VAR LIGUSTRINA	1 4		1 7	1 11		
LYSIMACHIA QUADRIFOLIA	1 2			1 11		
LYSIMACHIA TERRESTRIS	1 2				1 6	
MAGNOLIA FRASERI	3 79	2 67	2 93	3 89	3 72	2 67
MAIANTHEMUM CANADENSE	1 4				1 6	1 33
MAIANTHEMUM RACEMOSUM	1 15	1 11		1 56		1 67
MALAXIS UNIFOLIA	1 2		1 7			
MEDEOLA VIRGINIANA	1 19		1 21	1 33	1 22	
MELANTHIUM PARVIFLORUM	1 4				1 11	
MENZIESIA PILOSA	1 2			1 11		
MITCHELLA REPENS	1 53	1 44	1 50	1 44	2 56	2 100
MONOTROPA HYPOPITHYS	1 2	1 11				
MONOTROPA UNIFLORA	1 21	1 22		1 33	1 28	1 33
MUHLENBERGIA TENUIFLORA VAR VARIABILIS	1 2	1 11				
NYSSA SYLVATICA	3 83	2 78	3 100	2 78	3 78	2 67

Group:	3.	3.1	3.2	3.3	3.4	3.5
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	1 2				1 6	
OXYDENDRUM ARBOREUM	4 79	4 100	5 100	3 89	3 50	3 67
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	1 17	1 33	1 7	1 22		1 100
PHACELIA BIPINNATIFIDA	1 2					1 33
PINUS PUNGENS	1 2		1 7			
PINUS RIGIDA	2 2		2 7			
PINUS STROBUS	3 64	2 67	5 100	2 56	2 33	3 100
PINUS VIRGINIANA	2 2		2 7			
PLATANTHERA ORBICULATA VAR ORBICULATA	1 2			1 11		
POLYGONATUM BIFLORUM VAR BIFLORUM	1 15	1 11		1 44	1 6	1 67
POLYPODIUM APPALACHIANUM	1 8				1 22	
POLYPODIUM VIRGINIANUM	1 25	1 22	1 7	1 56	1 28	
POLYSTICHUM ACROSTICHOIDES	1 17	1 22		1 11	1 17	1 100
PRENANTHES ALTISSIMA	1 6		1 7	1 22		
PRENANTHES SERPENTARIA	1 2	1 11				
PRUNUS PENSYLVANICA	1 6			1 11	1 6	1 33
PRUNUS SEROTINA	1 2			1 11		
PYRULARIA PUBERA	1 17	1 11	1 29	3 11	1 17	
QUERCUS ALBA	2 13		3 21	3 22		1 67
QUERCUS COCCINEA VAR COCCINEA	2 15	2 11	3 43	1 11		
QUERCUS MONTANA	5 68	6 100	5 93	4 100	1 22	1 33
QUERCUS RUBRA	3 55	4 100	2 57	4 67	1 28	3 33
QUERCUS VELUTINA	1 4	1 11				1 33
RANUNCULUS REPENS	1 4					1 67
RHODODENDRON MAXIMUM	6 98	5 100	5 100	6 100	8 100	3 67
RHODODENDRON MINUS	2 23	1 11	1 36	4 44	3 11	
ROBINIA PSEUDOACACIA	2 19	2 33	1 21	2 22	2 6	1 33
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1 4	1 11		1 11		
RUBUS CANADENSIS	2 4	1 11			2 6	
SASSAFRAS ALBIDUM	2 38		2 64	2 67	4 28	
SMALLANTHUS UVEDALIA	1 2					1 33
SMILAX GLAUCA VAR GLAUCA	1 74	1 100	1 93	1 89	1 33	1 100
SMILAX ROTUNDIFOLIA	2 92	1 100	2 100	2 89	2 83	1 100
SOLIDAGO ARGUTA SSP. CAROLINIANA	1 8			1 33		1 33
SOLIDAGO CURTISII	1 6	1 11		1 22		
SOLIDAGO PUBERULA	1 2				1 6	
SPIRANTHES SP.	1 4		1 7	1 11		
STELLARIA PUBERA	1 6				1 6	1 67
SYMPLOCOS TINCTORIA	1 53	1 56	2 100	1 33	1 22	1 67
THELYPTERIS NOVEBORACENSIS	2 9	1 33			2 6	3 33
TILIA AMERICANA VAR HETEROPHYLLA	1 4					1 67
TIPULARIA DISCOLOR	1 2	1 11				
TOXICODENDRON RADICANS	1 4					1 67
TRILLIUM UNDULATUM	1 17		1 14	1 33	1 22	
TSUGA CANADENSIS	5 92	4 100	4 100	4 56	7 100	7 100
TSUGA CAROLINIANA	2 32	1 44	1 21	2 67	2 22	
UVULARIA PUBERULA VAR PUBERULA	1 17	1 22	1 29	1 33		
VACCINIUM CORYMBOSUM	1 2			1 11		
VACCINIUM PALLIDUM	1 21	2 11	1 50	1 11	1 11	
VACCINIUM SIMULATUM	1 13		1 7	1 56	1 6	
VACCINIUM STAMINEUM	1 4	1 22				
VIOLA BLANDA	1 8				1 22	
VIOLA CUCULLATA	1 2				1 6	

Group:	3.	3.1	3.2	3.3	3.4	3.5
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
VIOLA HASTATA	1 32	1 78	1 43	1 11		1 100
VIOLA PALMATA VAR PALMATA	1 2	1 11				
VIOLA ROTUNDIFOLIA	1 2				1 6	
VITIS AESTIVALIS	1 15	1 33	1 7	1 11	1 11	1 33
VITIS ROTUNDIFOLIA	2 2					2 33
VITIS VULPINA	1 2	1 11				
XANTHORHIZA SIMPLICISSIMA	3 2				3 6	
XEROPHYLLUM ASPHODELOIDES	1 2		1 7			
ZIZIA TRIFOLIATA	1 13	1 33		1 11		1 100

Table 3.18. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Acidic Cove and Slope Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

3. Acidic Cove and Slope Forests

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	16.59	199.23	7.91	223.73	4.95	5.77	9.99	7.88
KALMIA LATIFOLIA	236.40	318.68	0.00	555.08	0.77	12.51	1.73	7.12
PINUS STROBUS	18.68	68.12	12.28	99.08	5.28	3.55	10.15	6.85
QUERCUS MONTANA	2.39	50.19	22.15	74.73	8.32	2.21	18.74	10.48
RHODODENDRON MAXIMUM	1128.93	1748.18	0.00	2877.11	4.63	42.93	8.55	25.74
TSUGA CANADENSIS	140.35	256.18	31.95	428.48	14.28	10.08	22.26	16.17
ALL	2168.00	3234.91	101.11	5504.03	53.09	99.91	100.00	99.95

3.1 Quercus montana-Acer rubrum Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
ACER RUBRUM VAR RUBRUM	22.02	311.68	4.29	337.99	3.86	9.26	8.64	8.95
KALMIA LATIFOLIA	662.22	680.00	0.00	1342.22	1.09	27.81	2.45	15.13
NYSSA SYLVATICA	10.12	84.34	10.49	104.95	3.37	3.15	7.31	5.23
OXYDENDRUM ARBOREUM	4.29	177.44	0.00	181.72	1.54	5.01	3.40	4.21
PINUS STROBUS	10.24	175.98	32.80	219.02	13.86	8.26	28.36	18.31
QUERCUS MONTANA	1.80	70.35	37.11	109.26	11.63	2.85	25.43	14.14
RHODODENDRON MAXIMUM	384.53	1327.63	0.00	1712.16	3.57	24.19	7.42	15.81
TSUGA CANADENSIS	96.19	217.82	1.43	315.43	2.34	7.87	5.68	6.77
ALL	1609.05	3377.52	95.05	5081.62	46.59	99.92	100.00	99.96

3.2 Quercus montana-Pinus strobus/Rhododendron maximum Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
ACER RUBRUM VAR RUBRUM	5.00	220.65	7.04	232.69	5.55	9.50	12.78	11.14
KALMIA LATIFOLIA	105.28	167.69	0.00	272.96	0.24	10.43	0.60	5.52
LIRIODENDRON TULIPIFERA	0.00	38.24	10.74	48.98	3.72	1.56	9.05	5.30
OXYDENDRUM ARBOREUM	12.04	139.07	0.00	151.11	1.25	5.43	3.14	4.28
PINUS STROBUS	92.22	96.67	0.00	188.89	0.64	6.67	1.55	4.11
QUERCUS MONTANA	6.67	90.19	40.74	137.59	16.69	5.65	34.51	20.07
QUERCUS RUBRA	0.00	35.56	7.78	43.33	5.57	1.60	10.86	6.23
RHODODENDRON MAXIMUM	154.81	1302.78	0.00	1457.59	5.06	40.65	9.36	25.00
TSUGA CANADENSIS	132.59	217.69	7.22	357.50	4.78	10.01	6.21	8.11
ALL	567.59	2494.63	95.46	3157.69	51.20	99.62	99.99	99.81

3.3 Quercus montana/Rhododendron maximum Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	40.37	224.17	1.85	266.39	4.45	6.73	12.90	9.81
BETULA LENTA	27.78	127.13	3.70	158.61	3.16	3.03	8.30	5.67
HAMAMELIS VIRGINIANA	174.63	100.56	0.00	275.19	0.36	7.14	0.96	4.05
KALMIA LATIFOLIA	157.22	396.94	0.00	554.17	1.17	13.99	3.65	8.82
OXYDENDRUM ARBOREUM	13.89	123.06	0.00	136.94	2.08	3.50	5.87	4.69
QUERCUS MONTANA	4.63	87.87	31.94	124.44	13.85	2.80	35.61	19.20
RHODODENDRON MAXIMUM	795.56	1789.54	0.00	2585.09	4.95	38.53	10.34	24.43
ALL	1712.78	3492.04	46.02	5250.83	39.37	100.00	100.00	100.00

3.4 Tsuga canadensis/Rhododendron maximum Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	8.33	116.53	14.95	139.81	6.47	1.36	9.65	5.50
RHODODENDRON MAXIMUM	2542.87	2540.05	0.00	5082.92	5.81	66.36	9.45	37.90
TSUGA CANADENSIS	207.59	284.44	84.21	576.25	33.81	8.69	50.37	29.53
ALL	3913.43	3661.81	133.61	7708.84	66.12	100.00	100.00	100.00

3.5 Tsuga canadensis-Fagus/Ilex opaca Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
FAGUS GRANDIFOLIA	15.00	25.00	24.17	64.17	9.83	3.20	20.29	11.75
ILEX OPACA VAR OPACA	126.67	233.33	0.00	360.00	0.71	17.87	1.36	9.61
LIQUIDAMBAR STYRACIFLUA	4.17	17.50	12.50	34.17	4.78	1.62	8.25	4.93
PINUS STROBUS	0.00	17.50	30.00	47.50	8.08	2.20	14.50	8.35
RHODODENDRON MAXIMUM	41.67	171.67	0.00	213.33	0.35	9.84	0.63	5.24
TSUGA CANADENSIS	240.00	746.67	22.50	1009.17	17.24	49.81	33.09	41.45
ALL	470.83	1457.50	116.67	2045.00	51.99	99.81	100.00	99.90

Table 3.19. Vertical structure of woody species in the **Acidic Cove** and **Slope Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

3. Acidic Cove and Slopes Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	5	4	
BETULA LENTA	1	1	2	2	
HAMAMELIS VIRGINIANA	1	1			
KALMIA LATIFOLIA	1	3			
LIRIODENDRON TULIPIFERA	1	1	1	2	
MAGNOLIA FRASERI	1	1	2	2	
NYSSA SYLVATICA	1	1	2	1	
OXYDENDRUM ARBOREUM	1	2	3	2	
PINUS STROBUS	1	1	2	2	
QUERCUS MONTANA	1	1	3	3	
QUERCUS RUBRA	1	1	1	1	
RHODODENDRON MAXIMUM	3	6	2		
SASSAFRAS ALBIDUM	1	1	1		
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	3	4	3	1

3.1 Quercus montana-Acer rubrum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
SCINAME					
ACER RUBRUM VAR RUBRUM	1	2	5	4	
BETULA LENTA	1	1	1	1	
HAMAMELIS VIRGINIANA	1	1	1		
KALMIA LATIFOLIA	1	4			
LIRIODENDRON TULIPIFERA	1	1	1	1	
MAGNOLIA FRASERI	1	1	3	2	
NYSSA SYLVATICA	1	2	3	3	
OXYDENDRUM ARBOREUM	1	2	4	2	
PINUS STROBUS	1	1	4	4	1
QUERCUS COCCINEA VAR					
COCCINEA	1	1	1	2	
QUERCUS MONTANA	1	1	4	4	
RHODODENDRON MAXIMUM	1	5	1		
SASSAFRAS ALBIDUM	1	1	1		
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	3	3	1	

3.2 Quercus montana-Pinus strobus/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
SCINAME					
ACER RUBRUM VAR RUBRUM	1	3	6	5	
BETULA LENTA	1	1	2	2	
CARYA GLABRA	1	1	2	1	
CORNUS FLORIDA	1	2	2		
KALMIA LATIFOLIA	1	2			
LIQUIDAMBAR STYRACIFLUA	1	1	1	1	
LIRIODENDRON TULIPIFERA	1	1	3	3	
MAGNOLIA FRASERI	1	1	2	2	
NYSSA SYLVATICA	1	2	1		
OXYDENDRUM ARBOREUM	1	2	4	2	
PINUS STROBUS	1	1	1		
QUERCUS MONTANA	1	1	6	7	
QUERCUS RUBRA	1	1	4	4	
RHODODENDRON MAXIMUM	2	5	2		
ROBINIA PSEUDOACACIA	1	1	1	1	
TSUGA CANADENSIS	1	4	2	1	

3.3 Quercus montana/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	2		
ACER RUBRUM VAR RUBRUM	1	2	5	5	
BETULA LENTA	1	1	3	2	
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1		
HAMAMELIS VIRGINIANA	1	2	1		
KALMIA LATIFOLIA	1	4			
MAGNOLIA FRASERI	1	1	3	3	
OXYDENDRUM ARBOREUM	1	2	3	2	
QUERCUS MONTANA	1	1	5	5	
QUERCUS RUBRA	1	1	3	3	
RHODODENDRON MAXIMUM	3	5	1		
RHODODENDRON MINUS	1	1			
SASSAFRAS ALBIDUM	1	1	1	1	
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	1	2	1	
TSUGA CAROLINIANA	1	1	1	1	

3.4 Tsuga canadensis/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	3	3	
BETULA ALLEGHANIENSIS	1	1	1	1	
BETULA LENTA	1	1	3	3	
HALESIA TETRAPTERA VAR					
MONTICOLA	1	1			
HAMAMELIS VIRGINIANA	1	1			
KALMIA LATIFOLIA	1	2	1		
LEUCOTHOE AXILLARIS	1	1			
LIRIODENDRON TULIPIFERA	1	1	2	2	1
MAGNOLIA FRASERI	1	1	2	2	
NYSSA SYLVATICA	1	1	2	2	
OXYDENDRUM ARBOREUM	1	1	2	1	
PINUS STROBUS	1	1	1	2	
RHODODENDRON MAXIMUM	4	7	2		
SASSAFRAS ALBIDUM	1	1	1	1	
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	2	6	6	1

3.5 Tsuga canadensis-Fagus/Ilex opaca Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	3	1	
BETULA LENTA	1	1	2	2	
CARYA GLABRA	1	1	2	2	
CORNUS FLORIDA	1	2	1		
FAGUS GRANDIFOLIA	1	1	3	3	
LIQUIDAMBAR STYRACIFLUA	1	1	3	3	
LIRIODENDRON TULIPIFERA	1	1	2	2	
MAGNOLIA FRASERI	1	1	1	1	
NYSSA SYLVATICA	1	1	1		
OXYDENDRUM ARBOREUM	1	2	3	1	
PINUS STROBUS	1	1	4	4	2
QUERCUS RUBRA	1	1	2	2	
RHODODENDRON MAXIMUM	1	3	1		
TSUGA CANADENSIS	1	3	8	7	2

Table 3.20. Site information for the **Acidic Cove and Slope Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 3.1. Average values of site variables are given. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**A**=alluvium, **CL**=lower quartzite, **G**=gneiss, **M**=meta-arkose), Landform types (representing micro-scale topographic units) (**C**=cove, **RF**=river flat, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**LS**=lower-slopes, **MS**=mid-slopes, **US**=upper-slopes).

3. Acidic Cove and Slope Forests

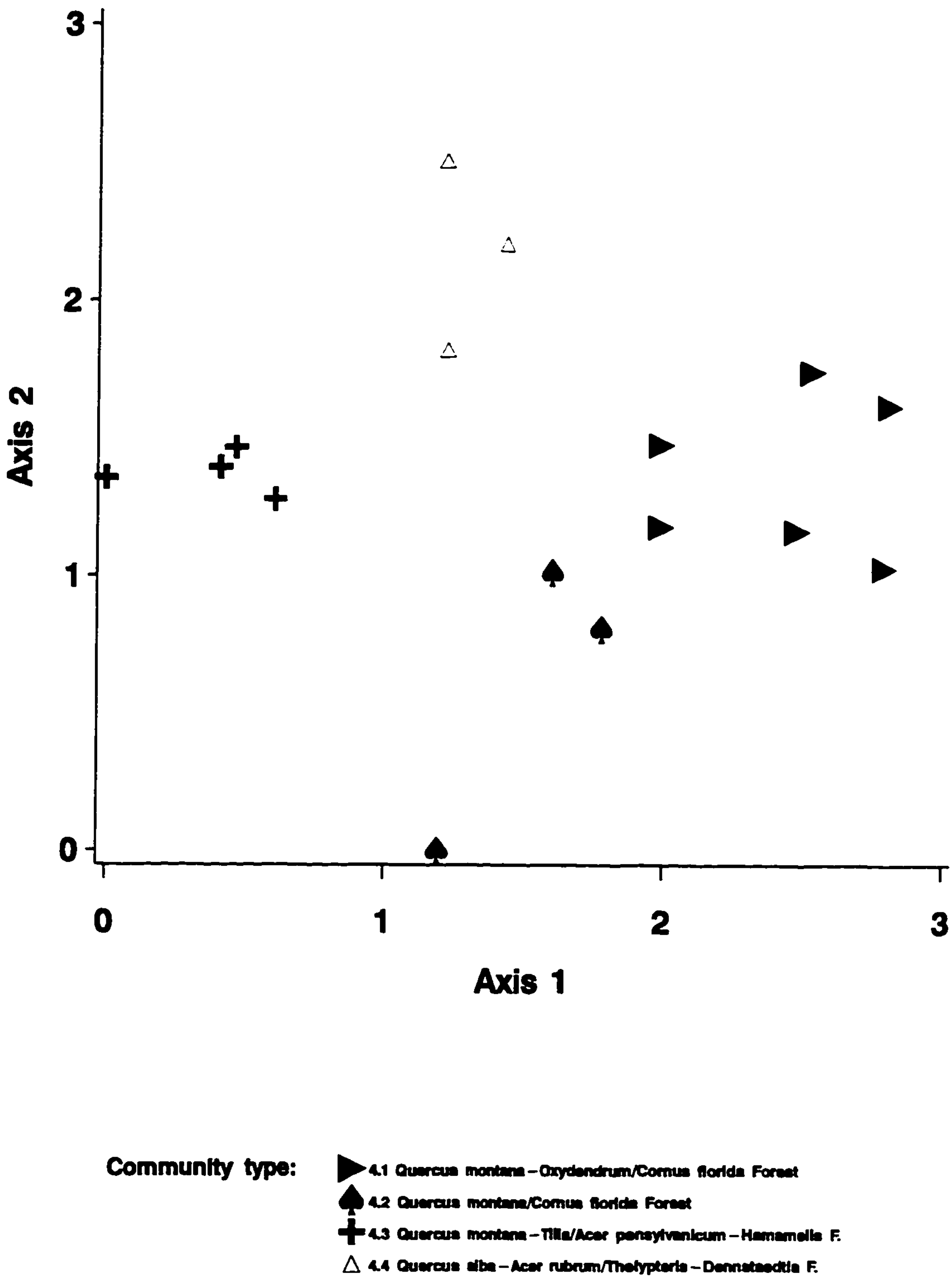
	Group					
	3.	3.1	3.2	3.3	3.4	3.5
Site Characteristics:						
Elevation (m)	833	797	759	965	898	437
Slope (o)	20	20	26	23	18	7
Aspect (o)		SE-W,E	NW-N	N-E	W,N	
Parent material		G,M	G,M	CL	CL	A
Surface Substrate (%)						
Moss/Lichen	6	3	6	9	8	3
Wood	3	4	2	3	3	1
Rock	11	2	13	18	15	2
Organic Matter	83	93	80	75	78	94
Water	2	1	1	0	4	0
Topographic Characteristics:						
Relative slope (%)	55	55	50	40	60	93
LFI	0.22	0.20	0.25	0.18	0.23	0.25
TSI	0.01	-0.01	0.01	-0.01	0.05	-0.00
Landform type	SS	SS	R	SS	C,SS	RF
Topographic position	MS	MS	MS	MS	LS,MS	

3.5.4 VEGETATION CLASS: 4. Montane Oak Forests

Montane Oak Forests are widespread in the Southern Appalachian Mountains in general. However, in Linville Gorge they represent only a small area of the landscape (8% of the area mapped; Appendices 1,4). This vegetation class, unlike all others in Linville Gorge, occurs predominantly over gneiss bedrock. This group also has the largest deciduous component of any vegetation class identified in this study. Canopies are dominated by *Quercus* species, typically *Quercus montana*.

Montane Oak Forests typically inhabit more fertile sites with finer-textured soils than the **Xeric Evergreen Forests** and the **Acidic Cove and Slope Forests** (Figures 3.3, 3.6). The four **Montane Oak Forests** separate from one another by site moisture (solar radiation, TMI), elevation and soil nutrients (Ca) (Figures 3.18, 3.19). A scatterplot showing stands classified by geologic type was not included as most stands are underlain by gneiss. The **Quercus montana/Cornus florida Forest** and the **Quercus montana/ Oxydendrum/Cornus florida Forest** are situated on dryer (high solar radiation, low TMI), lower-elevation sites, with sites in the latter type steeper and more fertile. The two high-elevation types are separated by slope angle and fertility, with the **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest** occurring on more fertile, steeper sites than the **Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest**.

Figure 3.18. DCA ordination diagram of the **Montane Oak Forests** class showing community types distribution on the two major compositional gradients. The solid line represents separation of stands for a subsequent ordination.


3
2
1
0
Axis 2
0
1
2
3
Axis 1
Community type:
4.1 Quercus montana – Oxydendrum/Cornus florida Forest
4.2 Quercus montana/Cornus florida Forest
4.3 Quercus montana – Tilia/Acer pensylvanicum – Hamamelis F.
4.4 Quercus alba – Acer rubrum/Thelypteris – Dennstaedtia F.

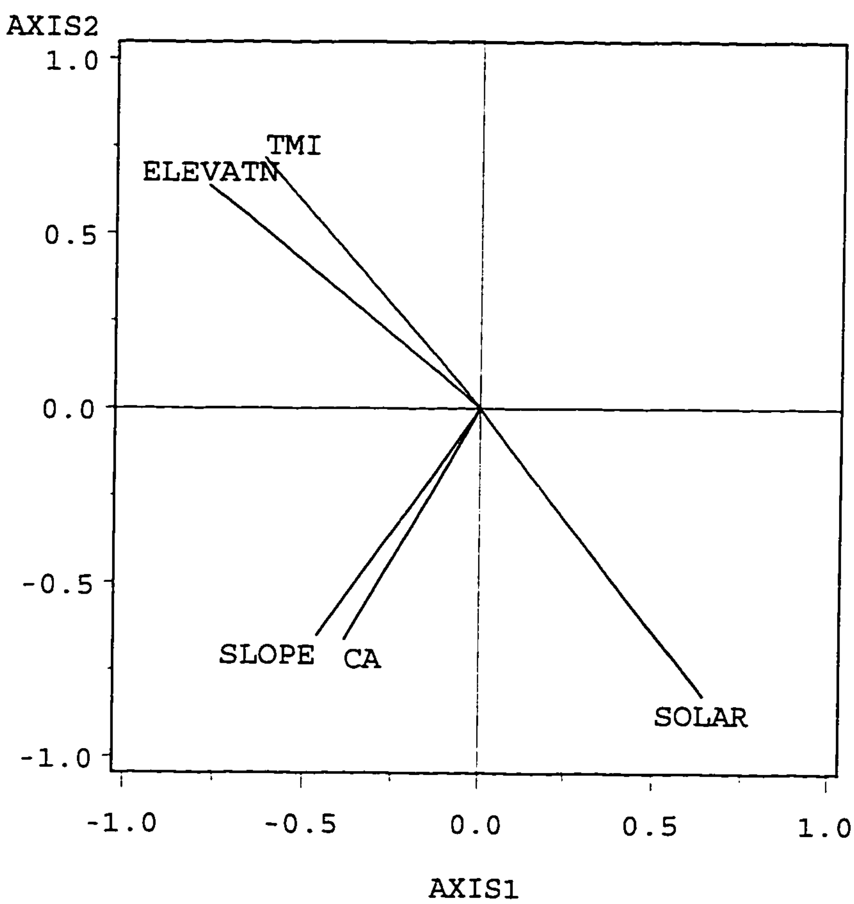


Figure 3.19. Vector diagram for DCA ordination of the **Montane Oak Forests** class showing association between species composition and major environmental gradients. Small TMI values represent low site moisture potential whereas large values represent high moisture.

COMMUNITY TYPE: Quercus montana/Oxydendrum/Cornus florida Forests (4.1.)

Synonymy

Montane Oak--Hickory (Schafale & Weakley 1990), Chestnut Oak-Chestnut Forest p.p. (Whittaker 1956), Chestnut Oak Forest p.p., Red Oak, Yellow Popular, Chestnut Oak Forest p.p. (McLeod 1988).

Constant species

Acer rubrum var. *rubrum, Carya glabra, Chimaphila maculata* var. *maculata, Cornus florida, Dichanthelium dichotomum* var. *dichotomum, Kalmia latifolia, Liriodendron tulipifera, Nyssa sylvatica, Oxydendrum arboreum, Parthenocissus quinquifolia* var. *quinquifolia, Pinus strobus, Quercus montana, Quercus rubra, Smilax glauca* var. *glauca, Smilax rotundifolia, Symplocus tinctoria, Tsuga canadensis, Vaccinium stamineum.*

Listed species

Thermopsis fraxinifolia.

Physiognomy

Large-diameter *Quercus montana* (40 to 73 cm, largest 93 cm) dominate the canopy of this community type (mean height 29 m) in conjunction with less abundant *Quercus rubra* (41 to 59 cm) and *Liriodendron tulipifera* (40 to 83 cm, largest 116 cm) (Tables 3.21, 3.22, 3.23). *Oxydendrum arboreum* and *Acer rubrum* are the major subcanopy species. *Cornus florida* forms a distinctive, but open shrub and sapling stratum with more scattered *Kalmia latifolia* present. The forest floor is dry and sparsely covered by a variable assemblage of low-cover species. *Dichanthelium dichotomum* var. *dichotomum* is the only species present throughout all sites.

Habitat and Distribution

The **Quercus montana/Oxydendrum/Cornus florida Forest** is restricted to the southern third of Linville Gorge. This type occurs on dry, low-elevation (elevational range 598-872 m), moderately steep, southeast-facing slopes. Sites underlain by gneiss (Table 3.24).

Soil texture and nutrient levels are similar to **Montane Oak Forests** class averages (Tables 3.4, 3.5).

Distinguishing Features

The **Quercus montana/Oxydendrum/Cornus florida Forest** is one of two **Montane Oak Forests** types inhabiting dry sideslopes in Linville Gorge. This type is distributed on dryer, lower-elevation slopes in the southern third of the Wilderness, whereas the **Quercus montana/Cornus florida Forest** inhabits dry, but more fertile slopes at higher elevations further north (Figures 3.18, 3.19).

The canopy of the **Quercus montana/Oxydendrum/Cornus florida Forest** is typically taller, with large-diameter stems and higher basal area than other **Montane Oak Forests** types. Species richness, however, is lowest at all spatial scales in comparison to other types within this vegetation class (Table 3.8) reflecting in part the dryness of the sites inhabited by this type.

Succession and Disturbance

The presence of the shade intolerant *Liriodendron tulipifera* in the canopy suggests past disturbances (Lorimer 1980, Schafale & Weakley 1990) at a scale larger than small-scale gaps. An absence of *Quercus montana*, *Q. rubra* and *Liriodendron* regeneration points to a change in the future composition of the canopy (Table 3.22). Current subcanopy species in the **Quercus montana/Oxydendrum/Cornus florida Forest** may become more important, although none of these have high regeneration.

COMMUNITY TYPE: Quercus montana/Cornus florida Forest (4.2)

Synonymy

Montane Oak--Hickory Forests p.p. (Schafale & Weakley 1990), Chestnut Oak Forest p.p. (McLeod 1988).

Constant species

Acer rubrum var. *rubrum*, *Arabis laevigata* var. *laevigata*, *Asplenium platyneuron* var. *platyneuron*, *Campanula divaricata*, *Cornus florida*, *Dioscorea quaternata*, *Hamamelis virginiana*, *Heuchera americana*, *Kalmia latifolia*, *Liriodendron tulipifera*, *Muhlenbergia tenuiflora* var. *variabilis*, *Oxydendrum arboreum*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Poa cuspidata*, *Prunella vulgaris*, *Quercus montana*, *Rhododendron minus*, *Robinia pseudo-acacia*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Solidago curtisii*, *Tsuga canadensis*, *Vaccinium staminium*, *Zizia trifoliata*.

Physiognomy

Large-diameter *Quercus montana* (40 to 79 cm) dominate the canopy (mean height 26 m) of this community type (Tables 3.21, 3.22, 3.23). There are smaller diameter *Q. rubra* scattered throughout. Below the open mid-strata *Cornus florida* forms a distinctive shrub stratum. *Hamamelis virginiana* is also present in this stratum. The predominantly rocky ground surface (40%; Table 3.24) is inhabited by a wide variety of species are sparsely distributed species. This is reflected by the high species richness of this community type (Table 3.8). All species in this stratum have low cover except for *Carex pensylvanica* which has high cover in two of the three sites.

Habitat

This community type occurs on gneiss bedrock on mid-to-upper sideslopes below the bluffs (774 to 854 m elevation range) on the east side of Linville Gorge (Table 3.24). Sites are steep (all 38° slope angle) and south-to-southwest-facing.

The soils have high Al and Ca in comparison to average <u>**Montane Oak Forests**</u> values. The **Quercus montana/Cornus florida Forest** has highest percent base saturation and pH values of any type in this class (Tables 3.4, 3.5).

Distinguishing Features

In comparison to other <u>**Montane Oak Forests**</u> types the **Quercus montana/ Cornus florida Forest** has highest species richness levels at the four largest scales (Table 3.8). Values at these scales are comparable to types in the <u>**Rich Cove**</u> **and** <u>**Slopes Forests**</u> class. High pH and base saturation levels may partly account for richness in the **Quercus montana/Cornus florida Forest.**

Succession and Disturbance

The lack of *Quercus montana* saplings suggests the canopy of this community type may change toward increased dominance of *Acer rubrum* as the older canopy trees die (Table 3.22).

COMMUNITY TYPE: Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest (4.3)

Synonymy

Dry-Mesic Oak--Hickory Forest p.p. (Schafale & Weakley 1990)

Constant species

Acer pensylvanicum, Acer rubrum var. *rubrum, Aster divaricata, Aster macrophyllus, Cardamine diphylla, Clintonia umbellata, Dioscorea villosa, Dryopteris marginalis, Hamamelis virginiana, Houstonia purpurea* var. *purpurea, Iris cristata, Lysimachia quadrifolia, Maianthemum racemosum, Melampyrum lineare, Parthenocissus quinquefolia* var. *quinquefolia, Pinus strobus, Polygonatum biflorum, Polypodium virginianum,* *Polystichum acrosticoides* var. *acrosticoides, Prenanthes altissima, Quercus montana, Quercus rubra, Rhododendron minus, Rhododendron maximum, Smilax rotundifolia, Solidago arguta, Tilia americana* var. *heterophylla, Tsuga canadensis, Viola rotundifolia, Zizia trifoliata.*

Listed species

Amelanchier sanguinaria var. *sanguinaria.*

Physiognomy

The somewhat stunted canopy (17.5 m average height) has variable dominance by three species. Overall, *Quercus montana* dominates the canopy, but in some sites, *Betula lenta* and *Tilia americana* var. *heterophylla* have higher abundance. *Acer rubrum* is the predominant subcanopy species (Tables 3.21, 3.22, 3.23). Stem density is high, particularly in the shrub stratum where stems are mostly <2.5 cm in diameter. Shrub dominance varies with *Rhododendron minus* more abundant on rocky or shallow soils and *R. maximum* on deeper soils. *Hamamelis virginiana* and *A. pensylvanicum* are subdominant shrubs throughout most sites.

The ground is particularly rocky (39% surface substrate average), and moist with high bryophytic cover (18 % surface substrate) generally covering the rocks (Table 3.24). Vascular ground cover is patchy. A diverse assemblage of mostly low cover, but highly constant species are present; *Iris cristata* is the most abundant of these. *Toxicodendron radicans*, a species generally unknown in Linville Gorge, dominates the floor of one site.

Habitat and Distribution

The **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest** inhabits steep (30 to 44°), high elevation (902 to 1173 m) sites on both sides of the gorge (Table 3.24). On the east side this community type occurs in mid-slope, northwest-facing small, damp, rocky gullies underlain by gneiss and below upper-slope bluffs between Tablerock Mountain and The Chimneys. On the west side a site on the east side of Laurel Knob inhabits a southeast-facing moist slope underlain by lower quartzite at the top of a small escarpment.

The soils are thin and coarse-textured (Tables 3.4, 3.5). The **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest** soils have the highest Ca, Fe, K, Mn and Cation exchange capacity levels of any **Montane Oak Forests** type.

Distinguishing Features

The **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest** is set apart from other vegetation groups by the presence of *Tilia* and *Acer pensylvanicum*. The calciphile *Tilia americana* var. *heterophylla* occurs with highest abundance in this community type, occurring on the 3 sites underlain by gneiss. The presence of *Amelanchier sanguinaria* var. *sanguinaria* and the occurrence of this community type on rocky, seepage areas also distinguishes it from other types in this study.

The **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest** is one of two types inhabiting rocky substrates. However, the **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest** occupies moist areas and does not contain the range of graminoids present on the dry, rocky slopes inhabited by the **Quercus montana/ Cornus florida Forest** (Figures 3.18, 3.19, Table 3.21). This may part explain the higher species richness levels in the latter group (Table 3.8).

Succession and Disturbance

A layer of charcoal in the soil of 75% of the plots provides evidence of past fire. The ground surface of some of the plots is also unstable due to a loose, rocky surface, suggesting that ground species may be subject to frequent, small-scale disturbance. The lack of *Quercus montana* saplings in this community type suggests that the canopy may change with *Acer rubrum* increasing in dominance (Table 3.22).

COMMUNITY TYPE: Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest (4.4)

Synonymy

Dry-Mesic Oak--Hickory Forest p.p. (Schafale & Weakley 1990), White Oak-Chestnut Oak Forest p.p. (Whittaker 1956), White Oak Forest (McLeod 1988).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Arisaema triphylla*, *Betula lenta*, *Castanea dentata*, *Chamaelirium luteum*, *Clintonia umbellulata*, *Dennstaedtia punctilobula*, *Dioscorea villosa*, *Goodyera pubescens*, *Kalmia latifolia*, *Magnolia fraseri*, *Medeola virginiana*, *Nyssa sylvatica*, *Oxydendrum arboreum*, *Pinus strobus*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrosticoides*, *Quercus rubra*, *Robinia pseudo-acacia*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Solidago curtisii*, *Tsuga canadensis*, *Zizia trifoliata*.

Physiognomy

Species dominance in the canopy (mean height 25.3 m) of this community type varies considerably. Summary table results indicate that *Acer rubrum* dominates the canopy, but this merely reflects its consistent subdominance throughout (Tables 3.21, 3.22, 3.23). Between-site variation in the canopy suggests the possibility of further subdivision at some future time when more data are available. Large-diameter *Quercus alba* (40 to 65 cm) and *Carya glabra* dominate one site while *Betula lenta*, in conjunction with *Q. alba* dominate a second site. *A. rubrum* and *Q. montana* form the canopy of the third site. *Oxydendrum arboreum* is a consistent canopy subdominant in all sites. *Hamamelis virginiana* dominates the shrub stratum which is generally open, although density varies between sites. The composition and abundance of ground species is consistent throughout and holds these sites together as a distinct community type. Two fern species, *Thelypteris noveboracensis* and *Dennstaedtia punctilobula*, essentially carpet the ground at all three sites. Species richness is high in this community, mainly consisting of a diverse group of low-abundance species scattered amongst the ferns (Tables 3.8, 3.21).

Habitat and Distribution

This community type inhabits moderately steep (23 to 25°), high-elevation (927 to 1183 m), east-facing sites (Figures 3.18, 3.19, Table 3.24). The community type is confined to the ridge and associated upper-slopes on the western border of Linville Gorge, along the ridge north of Dogback Mountain, and the slopes at the northern end of Laurel Knob. There is also a lower-elevation site below the bluffs on a sideslope north of Sandy Flats Trail. Geologic substrate varies. The two sites above the bluffs are underlain by upper and lower quartzite while the remaining site, on gneiss bedrock, occurs below the bluffs. All three sites occur on upper-slopes in close proximity to either major or minor ridgelines.

The **Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest** has high Al levels and low Ca, Mg, P and cation exchange capacity in comparison to other **Montane Oak Forests** types (Tables 3.4, 3.5). The soils also have higher organic content. However, although low in nutrients in comparison to other types within this vegetation class, the **Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest** has higher nutrient status than types in the **Acidic Cove and Slope Forests** class, which may account for the lack of ericad cover. The near ridgeline position of this type may also allow nutrients to leach down-slope from sites inhabited by this community type.

Distinguishing Features

Canopy species cover varies highly, but the ground species are uniformly dominant throughout. The presence of the lush fern cover in all three sites and dominance of largely herbaceous constant species in this community type reflects the compositional and structural similarity within this group and emphasizes the differences to other vegetation groups identified in Linville. The **Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest** has higher species richness at most scales in comparison to other **Montane Oak Forests** community types (Table 3.8).

Succession and Disturbance

The variability of canopy species and consistent abundance of *Acer rubrum* suggests that this community type may be recovering from disturbance (M. Schafale *pers. comm.*). The variability may be artificially large, due to the limited sample size. These forests may have been burnt, logged or opened up by chestnut death. Charcoal on the ground and in the soil A horizon provides evidence of fire in one of the three sites. However, there is no evidence to validate either of the other two hypotheses. Similar vegetation in the Virginia section of the Southern Appalachian Mountains occurs in areas that previously had been heavily logged (P. Coulling *pers. comm.*). Similarly, in Pennsylvania dense *Dennstaedtia* ground cover in *Acer saccharum-Prunus serotina* forests have been attributed to both logging and browsing by deer (Horsley 1993).

Woody stem summary information points to the future decline in *Quercus alba* dominance of the canopy and a rise in the presence of *Acer rubrum* in this stratum (Table 3.22). It is possible that dense cover by *Dennstaedtia* has inhabited *Quercus* regeneration (P. Coulling *pers. comm.*). Research in Pennsylvania has shown that *Prunus serotina* establishment and growth was significantly lower in forests with a dense *Dennstaedtia* ground cover. *Dennstaedtia* was shown to cause a reduction in the ratio of red to far-red light on the forest floor beneath the fern canopy (Horsley 1993).

Table 3.21. Average cover class and constancy of species present in the **Montane Oak Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 3.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	4.	4.1	4.2	4.3	4.4
Number of plots:	16	6	3	4	3
Homoteneity:	0.593	0.681	0.776	0.720	0.780
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species					
ACER PENSYLVANICUM	3 63	2 33	3 33	4 100	2 100
ACER RUBRUM VAR RUBRUM	4 100	4 100	4 100	4 100	6 100
AESCULUS FLAVA	1 6	1 17			
AGERATINA ALTISSIMA VAR ALTISSIMA	1 44	1 33	2 67	2 25	1 67
AGROSTIS PERENNANS	2 19	1 17		2 50	
ALLIUM CERNUUM VAR CERNUUM	1 6			1 25	
AMELANCHIER LAEVIS	2 19		1 33	2 50	
AMELANCHIER SANGUINEA VAR SANGUINEA	2 6			2 25	
AMPHICARPAEA BRACTEATA	1 13		1 33		1 33
ANDROPOGON VIRGINICUS	1 6	1 17			
ANTENNARIA PLANTAGINIFOLIA	2 19	2 33	3 33		
ARABIS LAEVIGATA VAR LAEVIGATA	1 25		1 100	1 25	
ARALIA NUDICAULIS	1 13			1 25	1 33
ARISTOLOCHIA MACROPHYLLA	1 19	1 17		1 50	
ARISTOLOCHIA SERPENTARIA	1 6	1 17			
ARISAEMA TRIPHYLLUM	1 38	1 17	1 33	1 25	1 100
ARUNDINARIA GIGANTEA	1 6	1 17			
ASPLENIUM PLATYNEURON VAR PLATYNEURON	1 38	1 50	1 100		
ASTER DIVARICATUS	2 50	1 17	2 67	2 100	1 33
ASTER MACROPHYLLUS	2 38	1 17	1 33	2 75	2 33
ASTER UNDULATUS	1 44	1 33	2 67	1 50	1 33
ATHYRIUM ASPLENIOIDES	3 13				3 67
AUREOLARIA LAEVIGATA	1 6		1 33		
BETULA LENTA	3 63	2 50	1 67	5 50	3 100
CAMPANULA DIVARICATA	1 56	1 67	1 100	3 50	
CARDAMINE DIPHYLLA	1 19			1 75	
CARDAMINE FLAGELLIFERA	1 6		1 33		
CAREX BLANDA	1 31	1 33	1 67	2 25	
CAREX CEPHALOPHORA	1 6	1 17			
CAREX COMMUNIS	1 19		2 67		1 33
CAREX DIGITALIS	2 25	2 17			2 100
CAREX FLEXUOSA	1 13			1 25	1 33
CAREX LUCORUM VAR AUSTROLUCORUM	4 6			4 25	
CAREX LAXIFLORA VAR LAXIFLORA	2 13			2 50	
CAREX PENSYLVANICA	3 19		5 67		1 33
CAREX SWANII	2 13	2 33			
CAREX UMBELLATA	2 25	2 67			
CAREX VIRESCENS	2 25	1 17		3 50	1 33
CARYA ALBA	2 31	2 67	1 33		
CARYA GLABRA	2 63	2 83	1 67	2 25	4 67
CARYA OVATA	2 25		1 33	1 50	3 33
CARYA PALLIDA	2 19	3 33	1 33		

Group:	4.	4.1	4.2	4.3	4.4
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
CASTANEA DENTATA	2 25			1 25	2 100
CHAMAELIRIUM LUTEUM	1 50	1 67	1 33		1 100
CHIMAPHILA MACULATA VAR MACULATA	1 56	1 83	1 67		1 67
CHIONANTHUS VIRGINICUS VAR VIRGINICUS	2 13		1 33	2 25	
CIMICIFUGA AMERICANA	1 6			1 25	
CLINTONIA UMBELLULATA	1 44			1 100	1 100
CLITORIA MARIANA	1 13	1 33			
COLLINSONIA CANADENSIS	2 25		1 33	2 50	2 33
COREOPSIS MAJOR VAR RIGIDA	2 19			2 50	2 33
CORNUS FLORIDA	4 75	4 100	5 100	1 50	2 33
CRATAEGUS MACROSPERMA	2 6			2 25	
CYPRIPEDIUM PARVIFLORUM VAR PUBESCENS	1 6				1 33
DANTHONIA SPICATA	1 31	1 33	1 67	1 25	
DENNSTAEDTIA PUNCTILOBULA	3 38	1 50			4 100
DESMODIUM NUDIFLORUM	1 31	1 33	1 33		2 67
DICHANTHELIUM BOSCII	1 56	2 50	2 67	2 50	1 67
DICHANTHELIUM COMMUTATUM	2 31	2 67	1 33		
DICHANTHELIUM DICHOTOMUM VAR DICHOTOMUM	1 38	1 83	1 33		
DIOSCOREA QUATERNATA	2 75	1 33	2 100	1 100	2 100
DRYOPTERIS INTERMEDIA	3 6			3 25	
DRYOPTERIS MARGINALIS	2 44		1 67	2 100	1 33
EPIGAEA REPENS	1 6	1 17			
ERECHTITES HIERACIIFOLIA VAR HIERACIIFOLIA	1 19	1 50			
ERIGERON PULCHELLUS VAR PULCHELLUS	1 19	1 33	1 33		
FRAXINUS AMERICANA	4 6		4 33		
GALAX URCEOLATA	2 25	1 33		3 50	
GALIUM CIRCAEZANS VAR CIRCAEZANS	1 13	1 17	1 33		
GAMOCHAETA PURPUREA	1 6		1 33		
GENTIANA DECORA	1 6			1 25	
GOODYERA PUBESCENS	1 38	1 33		1 25	1 100
HALESIA TETRAPTERA VAR MONTICOLA	2 31	2 50	1 33		3 33
HAMAMELIS VIRGINIANA	3 69	1 33	3 100	4 100	4 67
HEUCHERA AMERICANA	1 19		1 100		
HEUCHERA VILLOSA VAR VILLOSA	2 19			2 75	
HEXASTYLIS SHUTTLEWORTHII VAR SHUTTLEWORTHII	1 6				1 33
HEXASTYLIS VIRGINICA	1 6				1 33
HIERACIUM PANICULATUM	1 25	1 33	1 33		1 33
HIERACIUM VENOSUM	1 19	1 17	1 67		
HOUSTONIA PURPUREA VAR PURPUREA	2 50	1 33	2 67	2 75	2 33
HYDRANGEA ARBORESCENS	1 6			1 25	
HYPOXIS HIRSUTA	1 13	1 33			
ILEX MONTANA	1 19	1 17		2 25	1 33
ILEX OPACA VAR OPACA	1 13	1 33			
IRIS CRISTATA	2 31		1 33	3 75	1 33
IRIS VERNA	1 6	1 17			
KALMIA LATIFOLIA	2 81	3 100	2 67	3 50	1 100
LACTUCA BIENNIS	1 6				1 33
LAPORTEA CANADENSIS	1 6			1 25	
LESPEDEZA REPENS	1 19	1 50			
LEUCOTHOE RECURVA	1 13			1 25	1 33
LIATRIS GRAMINIFOLIA	1 6			1 25	
LILIUM MICHAUXII	1 6	1 17			
LIRIODENDRON TULIPIFERA	2 56	3 83	1 100		1 33

Group:	4.	4.1	4.2	4.3	4.4
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
LUZULA MULTIFLORA VAR CONGESTA	1 6	1 17			
LYONIA LIGUSTRINA VAR LIGUSTRINA	1 13	1 17			1 33
LYSIMACHIA QUADRIFOLIA	2 31			2 100	2 33
LYSIMACHIA TERRESTRIS	1 6			1 25	
MAGNOLIA FRASERI	2 38	1 17		3 50	3 100
MAIANTHEMUM CANADENSE	2 13			1 25	2 33
MAIANTHEMUM RACEMOSUM	1 38	1 17		1 75	1 67
MALUS CORONARIA	1 6			1 25	
MEDEOLA VIRGINIANA	1 44		1 67	1 50	1 100
MELAMPYRUM LINEARE	1 13	1 17			1 33
MELANTHIUM PARVIFLORUM	2 25			2 75	2 33
MITCHELLA REPENS	1 6			1 25	
MONOTROPA UNIFLORA	1 6				1 33
MUHLENBERGIA TENUIFLORA VAR VARIABILIS	1 31	1 17	1 100	2 25	
NYSSA SYLVATICA	2 69	3 100	1 67		1 100
OSTRYA VIRGINIANA VAR VIRGINIANA	1 6		1 33		
OXYDENDRUM ARBOREUM	4 75	4 100	2 100		4 100
OXYPOLIS RIGIDIOR	1 6			1 25	
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	2 81	1 100	2 100	2 75	1 33
PENSTEMON SMALLII	1 13		1 67		
PINUS RIGIDA	1 13	1 33			
PINUS STROBUS	2 88	2 100	2 67	1 75	1 100
PINUS VIRGINIANA	4 13	4 33			
PIPTOCHAETIUM AVENACEUM	1 6	1 17			
POA ALSODES	3 6				3 33
POA CUSPIDATA	2 38	1 17	2 100		1 67
POLYGONATUM BIFLORUM VAR BIFLORUM	1 75	1 67	2 67	2 75	1 100
POLYGONUM CONVOLVULUS VAR CONVOLVULUS	2 13		2 67		
POLYPODIUM VIRGINIANUM	2 31			2 75	1 67
POLYSTICHUM ACROSTICHOIDES	1 81	1 67	1 67	2 100	1 100
POTENTILLA CANADENSIS VAR CANADENSIS	1 50	1 67	2 67		1 67
PRENANTHES ALTISSIMA	2 44	1 17	1 33	2 75	2 67
PRENANTHES SERPENTARIA	1 6				1 33
PROSARTES LANUGINOSA	1 13			1 50	
PRUNELLA VULGARIS	1 19		1 100		
PYCNANTHEMUM MONTANUM	1 13		1 33		1 33
PYCNANTHEMUM PYCNANTHEMOIDES VAR PYCNANTHEMOIDES	1 6		1 33		
PYRULARIA PUBERA	3 25		1 33	3 25	3 67
QUERCUS ALBA	4 25	4 33			5 67
QUERCUS MONTANA	5 94	5 100	6 100	5 100	2 67
QUERCUS RUBRA	3 100	4 100	4 100	2 100	3 100
RHODODENDRON CALENDULACEUM	2 13	1 17			3 33
RHODODENDRON MAXIMUM	3 63	1 50	1 33	4 100	4 67
RHODODENDRON MINUS	3 44	1 17	2 100	4 75	
ROBINIA PSEUDOACACIA	2 69	2 50	1 100	2 50	2 100
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1 50	1 50	2 33	1 75	1 33
RUBUS ARGUTUS	1 6		1 33		
SASSAFRAS ALBIDUM	1 25	1 33			2 67
SAXIFRAGA MICHAUXII	1 6			1 25	
SCHIZACHYRIUM SCOPARIUM	1 13	1 33			
SELAGINELLA TORTIPILA	1 6			1 25	
SILENE STELLATA	1 13	1 17	1 33		
SILENE VIRGINICA VAR VIRGINICA	1 25	1 17	1 67		1 33
SMILAX GLAUCA VAR GLAUCA	1 75	2 100	1 100		1 100

Group:	4.	4.1	4.2	4.3	4.4
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
SMILAX HERBACEA	1 6			1 25	
SMILAX ROTUNDIFOLIA	1 100	1 100	2 100	2 100	2 100
SOLANUM AMERICANUM VAR AMERICANUM	1 6	1 17			
SOLIDAGO ARGUTA SSP CAROLINIANA	1 44	1 17	1 67	1 75	2 33
SOLIDAGO CURTISII	1 56	1 17	2 100	1 50	1 100
SPIRANTHES SP.	1 6	1 17			
STELLARIA PUBERA	1 38	1 33	2 67		1 67
SYMPLOCOS TINCTORIA	1 50	2 100			1 67
THALICTRUM CLAVATUM	1 6			1 25	
THELYPTERIS NOVEBORACENSIS	5 19	1 17			7 67
THERMOPSIS FRAXINIFOLIA*	1 6	1 17			
TIARELLA CORDIFOLIA VAR COLLINA	1 13	1 33			
TILIA AMERICANA VAR HETEROPHYLLA	3 19			3 75	
TIPULARIA DISCOLOR	1 6	1 17			
TOXICODENDRON RADICANS	3 19		2 67	4 25	
TRADESCANTIA SUBASPERA	1 13	1 17	1 33		
TRAUTVETTERIA CAROLINIENSIS VAR CAROLINIENSIS	2 6			2 25	
TRILLIUM UNDULATUM	1 6			1 25	
TSUGA CANADENSIS	2 88	2 83	2 100	2 75	2 100
TSUGA CAROLINIANA	1 56	1 67	1 33	1 50	3 67
UVULARIA PUBERULA VAR PUBERULA	1 25	1 17	1 33		2 67
VACCINIUM CORYMBOSUM	2 25	2 33	2 33	2 25	
VACCINIUM PALLIDUM	1 25	1 50			1 33
VACCINIUM SIMULATUM	2 13	2 17		1 25	
VACCINIUM STAMINEUM	1 56	1 83	1 100	1 25	
VIBURNUM ACERIFOLIUM	1 31	1 17	2 67	2 50	
VICIA CAROLINIANA	1 6				1 33
VIOLA AFFINIS	2 25	1 17	1 33	2 25	2 33
VIOLA BLANDA	2 13		2 33	2 25	
VIOLA CUCULLATA	1 6			1 25	
VIOLA HASTATA	1 31	1 50			2 67
VIOLA PALMATA VAR PALMATA	1 19	1 50			
VIOLA ROTUNDIFOLIA	2 25			1 75	2 33
VIOLA SORORIA	1 6		1 33		
VITIS AESTIVALIS	1 44	1 67	1 67		1 33
VITIS CINEREA	2 13	1 17	2 33		
VITIS VULPINA	1 6				1 33
ZIZIA TRIFOLIATA	1 81	1 67	2 100	1 75	1 100

Table 3.22. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Montane Oak Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

4. Montane Oak Forests

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	45.42	177.86	0.63	223.90	2.61	9.09	7.05	8.07
CORNUS FLORIDA	48.63	138.36	0.00	186.98	0.69	11.97	1.72	6.85
HAMAMELIS VIRGINIANA	307.62	199.01	0.00	506.63	0.42	13.14	1.05	7.10
KALMIA LATIFOLIA	69.53	96.77	0.00	166.30	0.18	7.50	0.53	4.01
OXYDENDRUM ARBOREUM	13.89	95.76	0.00	109.65	1.82	6.46	4.76	5.61
QUERCUS MONTANA	0.00	83.04	44.77	127.81	16.18	5.66	40.44	23.05
QUERCUS RUBRA	4.69	45.90	8.75	59.33	3.52	2.75	9.03	5.89
RHODODENDRON MINUS	600.31	248.97	0.00	849.29	0.39	7.57	1.85	4.71
ALL	1581.32	1694.44	80.60	3356.36	39.66	99.88	99.95	99.92

4.1 Quercus montana-Oxydendrum/Cornus florida Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
CORNUS FLORIDA	24.17	227.78	0.00	251.94	1.14	19.29	2.59	10.94
KALMIA LATIFOLIA	143.75	163.89	0.00	307.64	0.31	16.58	0.90	8.73
LIRIODENDRON TULIPIFERA	0.00	1.67	10.83	12.50	5.67	1.10	11.30	6.20
NYSSA SYLVATICA	5.00	110.97	0.00	115.97	0.50	7.70	1.28	4.49
OXYDENDRUM ARBOREUM	7.78	137.78	0.00	145.56	2.01	11.89	4.51	8.20
QUERCUS MONTANA	0.00	62.64	42.50	105.14	17.71	7.11	42.65	24.88
QUERCUS RUBRA	0.00	36.67	14.17	50.83	5.09	3.68	12.12	7.90
ALL	300.83	1095.56	84.17	1480.56	42.55	100.01	100.00	100.00

4.2 Quercus montana/Cornus florida Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	13.33	135.17	0.00	148.50	1.30	7.04	3.62	5.33
CORNUS FLORIDA	211.01	259.01	0.00	470.02	1.24	24.29	3.49	13.89
HAMAMELIS VIRGINIANA	308.42	103.59	0.00	412.00	0.16	19.10	0.45	9.78
QUERCUS MONTANA	0.00	115.76	97.09	212.85	30.00	11.79	70.67	41.23
QUERCUS RUBRA	8.33	93.67	3.33	105.34	3.97	5.38	11.02	8.21
ALL	930.19	966.28	108.75	2005.22	40.63	99.99	99.99	100.01

4.3 Quercus montana-Tilia/Acer pensylvanicum Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	434.72	206.94	0.00	641.67	0.67	15.80	1.94	8.87
ACER RUBRUM VAR RUBRUM	16.67	123.61	0.00	140.28	2.43	3.33	5.48	4.40
BETULA LENTA	0.00	28.47	11.11	39.58	6.29	1.50	14.67	8.09
HAMAMELIS VIRGINIANA	591.67	279.17	0.00	870.83	0.68	20.37	1.81	11.09
QUERCUS MONTANA	0.00	126.39	37.50	163.89	13.66	2.14	38.84	20.49
RHODODENDRON MAXIMUM	255.56	691.67	0.00	947.22	1.57	14.91	4.48	9.69
RHODODENDRON MINUS	2375.00	975.00	0.00	3350.00	1.54	27.78	7.34	17.56
TILIA AMERICANA VAR HETEROPHYLLA	0.00	43.06	16.67	59.72	4.93	1.83	10.21	6.02
ALL	4188.89	2834.72	77.08	7100.69	37.95	99.52	99.82	99.67

4.4 Quercus alba-Acer rubum/Thelypteris-Dennstaedtia Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	203.33	30.00	0.00	233.33	0.11	8.48	0.27	4.38
ACER RUBRUM VAR RUBRUM	203.33	503.33	3.33	710.00	7.19	26.82	21.41	24.12
BETULA LENTA	0.00	73.33	3.33	76.67	2.11	3.22	6.68	4.95
HAMAMELIS VIRGINIANA	513.33	560.00	0.00	1073.33	1.12	19.90	2.65	11.28
MAGNOLIA FRASERI	46.67	66.67	0.00	113.33	1.41	4.36	4.20	4.28
OXYDENDRUM ARBOREUM	20.00	203.33	0.00	223.33	5.39	6.88	15.58	11.23
QUERCUS ALBA	0.00	53.33	16.67	70.00	5.85	2.39	15.21	8.80
QUERCUS MONTANA	0.00	33.33	6.67	40.00	2.67	1.36	7.93	4.65
ALL	1316.67	2100.00	50.00	3466.67	35.20	99.98	100.00	100.00

Table 3.23. Vertical structure of woody species in the **Montane Oak Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

4. Montane Oak Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1		
ACER RUBRUM VAR RUBRUM	1	1	4	3	
BETULA LENTA	1	1	1	2	
CARYA GLABRA	1	1	2	1	
CORNUS FLORIDA	1	3	2		
HAMAMELIS VIRGINIANA	1	2			
KALMIA LATIFOLIA	1	1			
MAGNOLIA FRASERI	1	1	1		
NYSSA SYLVATICA	1	1	1		
OXYDENDRUM ARBOREUM	1	2	3	2	
PINUS STROBUS	1	1			
QUERCUS ALBA	1	1	1	1	
QUERCUS MONTANA	1	1	4	4	
QUERCUS RUBRA	1	1	3	3	
RHODODENDRON MINUS	1	1			
ROBINIA PSEUDOACACIA	1	1	1	1	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1		
TSUGA CANADENSIS	1	1			

4.1 Quercus montana-Oxydendrum/Cornus florida Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	4	3	
BETULA LENTA	1	1	2	2	
CARYA GLABRA	1	1	3	2	
CARYA PALLIDA	1	1	1	1	
CORNUS FLORIDA	1	5	3		
HALESIA TETRAPTERA VAR MONTICOLA	1	1		1	
HAMAMELIS VIRGINIANA	1	1			
KALMIA LATIFOLIA	1	3			
LIRIODENDRON TULIPIFERA	1	1	3	3	1
NYSSA SYLVATICA	1	4	2	1	
OXYDENDRUM ARBOREUM	1	3	5	3	
PINUS STROBUS	1	2	1		
QUERCUS ALBA	1	1	2	2	
QUERCUS MONTANA	1	1	4	6	1
QUERCUS RUBRA	1	1	5	5	
ROBINIA PSEUDOACACIA	1	1	2	2	
SYMPLOCOS TINCTORIA	1	1			
TSUGA CANADENSIS	1	1			

4.2 Quercus montana/Cornus florida Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
SCINAME					
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	2	4	2	
BETULA LENTA	1	1			
CORNUS FLORIDA	1	5	2		
FRAXINUS AMERICANA	1	1	1		
HALESIA TETRAPTERA VAR MONTICOLA	1	1			
HAMAMELIS VIRGINIANA	1	3	1		
KALMIA LATIFOLIA	1	1			
OXYDENDRUM ARBOREUM	1	1			
PINUS STROBUS	1	1	1		
QUERCUS MONTANA	1	1	6	7	
QUERCUS RUBRA	1	1	5	5	
RHODODENDRON MINUS	1	1			
TSUGA CANADENSIS	1	2	1		
VITIS AESTIVALIS	1	1			

4.3 Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	3		
ACER RUBRUM VAR RUBRUM	1	1	3	1	
BETULA LENTA	1	1	2	2	
HAMAMELIS VIRGINIANA	1	3			
KALMIA LATIFOLIA	1	1			
MAGNOLIA FRASERI	1	1	2		
PINUS STROBUS	1	1			
QUERCUS MONTANA	1	2	3	2	
QUERCUS RUBRA	1	1	1		
RHODODENDRON MAXIMUM	1	3			
RHODODENDRON MINUS	1	3			
ROBINIA PSEUDOACACIA	1	1			
TILIA AMERICANA VAR HETEROPHYLLA	1	1	3	3	
TOXICODENDRON RADICANS	1				
TSUGA CANADENSIS	1	1			

4.4 Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	6	5	
BETULA LENTA	1	1	2	2	
CARYA GLABRA	1	1	2	2	
CARYA OVATA	1	1	1	1	
CASTANEA DENTATA	1	2			
CORNUS FLORIDA	1	1			
HAMAMELIS VIRGINIANA	1	3	1		
KALMIA LATIFOLIA	1	1			
MAGNOLIA FRASERI	1	1	3	2	
OXYDENDRUM ARBOREUM	1	1	4	4	
PYRULARIA PUBERA	1	1			
QUERCUS ALBA	1	1	3	3	
QUERCUS MONTANA	1	1	1	1	
QUERCUS RUBRA	1	1	2	2	
RHODODENDRON CALENDULACEUM	1	1			
RHODODENDRON MAXIMUM	1	2	1		
ROBINIA PSEUDOACACIA	1	1			
TSUGA CANADENSIS	1	1			
TSUGA CAROLINIANA	1	2			

Table 3.24. Site information for the **Montane Oak Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 3.1. Average values of site variables are given. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**CL**=lower quartzite, **CP**=upper quartzite, **G**=gneiss), Landform types (representing micro-scale topographic units) (**C**=cove, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**MS**=mid-slopes, **US**=upper-slopes).

4. Montane Oak Forests

	Group				
	4.	4.1	4.2	4.3	4.4
Site Characteristics:					
Elevation (m)	850	680	802	1000	1040
Slope (o)	31	28	38	35	24
Aspect (o)		SE	S-SW	NW	E
Parent material	G	G	G	G	CL,CP,G
Surface Substrate (%)					
Moss/Lichen	9	4	17	18	1
Wood	2	3	2	2	1
rock	24	16	40	38	3
Organic Matter	70	76	52	55	94
Water	0.13	0	0	1	0
Topographic Characteristics:					
Relative slope (%)	35	49	51	18	13
LFI	0.26	0.25	0.37	0.24	0.21
TSI	0.01	0.01	0.05	-0.01	0.01
Landform type	SS	SS	SS	C	SS
Topographic position	MS	MS	MS,US	US	MS

3.5.5 VEGETATION CLASS: 5. **Rich Cove and Slope Forests**

The **Rich Cove and Slope Forests** vegetation class is well known throughout the Southern Appalachian Mountains for its diverse range of tree species and rich herbaceous flora (Schafale & Weakley 1990). In Linville Gorge this class is the most species-rich vegetation class present (Table 3.8), and it occupies the nutrient-rich soils (Figures 3.2, 3.3, 3.5, 2.6). Although widespread elsewhere in the Southern Appalachian Mountains (Schafale & Weakley 1990), **Rich Cove and Cove Forests** have very limited distribution in Linville Gorge representing 2% of the vegetation mapped in this Wilderness (Appendices 1, 4).

COMMUNITY TYPE: Carya glabra/Ageratina Forest (5.1)

Synonymy

Basic-Oak Hickory Forests (Schafale & Weakley 1990), Mesic Oak-Hickory Forest p.p. (Patterson 1994).

Constant species

Acer rubrum var. *rubrum, Ageratina altissima* var. *altissima, Amphicarpaea bracteata, Arisaema triphylla, Betula lenta, Carya glabra, Dennstaedtia punctilobula, Dioscorea quaternata, Polygonatum biflorum* var. *biflorum, Polystichum acrosticoides, Prenanthes altissima, Pycnanthemum montanum, Quercus rubra, Robinia pseudo-acacia, Rubus allegheniensis* var. *allegheniensis, Smilax glauca* var. *glauca, Smilax rotundifolia, Solidago curtisii.*

Physiognomy

The low average basal area (29.7m^2/ha) reflects the simple woody structure of this forest. *Carya glabra* forms a closed, tall (27 m mean height) canopy (cover 7) in conjunction with *Quercus rubra* (Tables 3.25, 3.26, 3.27). The lower stories are virtually non-existent apart from a few scattered individuals of *Carya glabra* and *Halesia tetraptera* in one site. The ground stratum is tall and dense, dominated by *Ageratina altissima* var. *altissima* (cover 6) with lower cover from *Amphicarpaea bracteata, Dennstaedtia punctilobula, Solidago curtisii* and a diverse assemblage of other species.

Habitat and Distribution

This community type occurs between 1070 and 1189 m on upper sideslopes and ridge-crests on both sides of the gorge (Table 3.28). The **Carya glabra/Ageratina Forest** probably contains two quite different sub-types, separated by habitat and geologic type. However, the distribution of these sub-types is so restricted that the data are too limited to show this separation. The meta-arkose sub-type occurs on the east side of Linville Gorge, where it inhabits the southeast-facing upper slopes of Gingercake Mountain distributed above the road into Tablerock Mountain from the northern boundary of the Wilderness, south to the knob north of Hawksbill. The phyllite sub-type is found on the western side of the gorge and is restricted to the narrow band of phyllite outcrops along the ridgeline in the vicinity of Dogback Mountain and area immediately north of Babel Tower Trail.

Soils of the **Carya glabra/Ageratina Forest** have highest sand and lowest silt content of any non-alluvial forest community type in this study (Tables 3.4, 3.5). The soils of this community type have higher B, Ca, K, Mg and organic matter levels than the **[Liriodendron-Carya glabra Forest]** soils.

Distinguishing Features

The codominance of *Carya glabra* and *Ageratina* in this community type sets this group apart from all others in Linville Gorge. The **Carya glabra/Ageratina Forests** have the second highest elevation position in Linville, which is made all the more unusual by the high fertility soils; most high-elevation sites being underlain by highly leached, nutrient-deficient soils. This group has the highest species diversity of all community types and sub-types recognized in this study at all spatial scales from 1 m^2 - 1000 m^2 (Table 3.8). The two most diverse plots both contained 84 species per 0.1 ha area.

Succession and Disturbance

Sites on the southeast slopes of Gingercake Mountain have been logged. (Cut stumps are only visible during winter months when the tall dense herbaceous layer has died down).

The structure of this community type, characterized by a few large and presumably older *Quercus rubra* and *Q. alba* scattered amongst a matrix of smaller-diameter and probably younger *Carya glabra* (Table 3.26), suggests that *Carya* have grown up to replace canopy gaps formed by removal of *Quercus* during past logging. Schafale & Weakley (1990) describe these forests as unevenaged under natural conditions with regeneration reliant on canopy gap disturbances. The absence of saplings in most sites, perpetuated by the density of the herbaceous layer and the canopy, suggests that *Carya glabra* will continue to dominate this canopy until fire or small scale patch dynamics open the canopy and the herbaceous layer enabling other woody species to invade (see Graves 1995).

COMMUNITY TYPE: [Liriodendron-Carya glabra Forest] (5.2)

Synonymy

Rich Cove Forest (Schafale & Weakley 1990), Cove Hardwood Forest (Whittaker 1956), Mixed Mesophytic Forest - Cove Segregate (Cooper & Hardin 1970), Cove Hardwood Forest (Racine & Hardin 1975), Cove Hardwoods, Oak, Mixed Mesic Forest p.p. (McLeod 1988), Cove Forest (Patterson 1994), *Liriodendron/Halesia* Forest (Chapter 4).

Constant species

Acer rubrum var. *rubrum, Aralia nudicaulis, Arisaema triphyllum, Aster divaricatus, Athyrium asplenioides, Betula lenta, Botrychium virginianum, Carya glabra, Cimicifuga racemosa, Cornus florida, Dioscorea quaternata, Eupatorium purpureum* var. *purpureum, Euonymus americana, Halesia tetraptera* var. *monticola, Laportea canadensis, Liriodendron tulipifera, Lysimachia quadrifolia, Maianthemum racemosum, Medeola* *virginiana, Mitchella repens, Osmorhiza claytonii, Oxydendrum arboreum, Parthenocissus quinquefolia* var. *quinquefolia, Polygonatum biflorum* var. *biflorum, Polystichum acrosticoides, Prenanthes altissima, Prosartes lanuginosum, Quercus rubra, Rhododendron maximum, Robinia pseudo-acacia, Sanguinaria canadensis, Smilax glauca* var. *glauca, Smilax rotundifolia, Solidago curtisii, Stellaria pubera, Thelypteris noveboracensis, Tipularia discolor, Tilia americana* var. *heterophylla, Tsuga canadensis, Viburnum acerifolium, Viola affinis, Viola blanda.*

Physiognomy

The canopy of this community type is tall (mean height 38 m), dense (basal area 61.5 m^2/ha), and dominated by large-diameter trees (Table 3.36). Canopy dominance varies between large *Liriodendron tulipifera* (90 to 150 cm diameter) and *Carya glabra* (41-50 cm in dbh) (Tables 3.25, 3.26, 3.27). The lower stories are open with *Tsuga canadensis* (5 to 20 cm in diameter) dominating the subcanopy and *Halesia tetraptera* most abundant in the shrub stratum. The forest floor is rocky (19% rock substrate), with dense and diverse patches of herbaceous vegetation (Table 3.28). *Thelypteris noveboracensis*, *Laportea canadensis* and *Viola blanda* are the most prominent herbaceous species. *Aster divaricatus*, *Cimicifuga racemosa*, *Eupatorium purpureum*, *Euonymus americana*, *Mitchella repens*, *Parthenocissus quinquefolia*, *Polystichum acrosticoides*, *Solidago curtisii*, *Stellaria pubera*, *Prosartes lanuginosum*, and *Viola affinis* occur with low abundance at both sites.

Habitat and Distribution

The **[Liriodendron-Carya glabra Forest]** is restricted to sheltered east-to-southeast-facing cove slopes adjacent to water courses on the western side of the Linville valley (elevational range of 598-744 m). The two sites vary in slope (13 and 27°) and geology (gneiss and meta-arkose; Table 3.28).

The soil is second only to the **Carya glabra/Ageratina Forest** of all non-alluvial forest types in having high sand and second lowest silt content (Tables 3.4, 3.5). The **[Liriodendron-Carya glabra Forest]** soils are also rich in Ca, Cu, Mn, P and S with high

CEC and base saturation levels and low Na and K values. This reflects continual nutrient input from downslope water movement.

Distinguishing Features

This community type occurs in the most species-rich vegetation class identified in this study (Table 3.8). Species diversity is second only to the **Carya glabra/Ageratina Forest** at the largest two spatial scales (100 m^2 and 1000 m^2), but is lower than many of the **Montane Oak Forests** types at smaller spatial scales. This is probably due to the dominance of large-sized species such as *Thelypteris* and *Laportea*. Herbaceous species on the forest floor account for most of the diversity in both community types. High diversity reflects the nutrient-rich soils present throughout the **Rich Cove and Slope Forests** vegetation class (Figures 3.2, 3.3, 3.5, 3.6).

The **[Liriodendron-Carya glabra Forest]** also contains the largest diameter tree recorded in this study (a *Liriodendron tulipifera* of 148 cm) and has the second highest total average basal area of any community type in this study. This community type has very limited distribution in Linville Gorge.

Succession and Disturbance

The presence of *Tsuga canadensis* in the lower stories suggests that canopy dominance may gradually shift, with *Liriodendron tulipifera* and *Carya glabra* being partially replaced by *Tsuga canadensis* (Table 3.26).

Table 3.25. Average cover class and constancy of species present in the **Rich Cove and Slope Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 3.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	5.	5.1	5.2
Number of plots:	8	6	2
Homoteneity:	0.614	0.824	0.637
	Cov/Con	Cov/Con	Cov/Con
Species			
ACER PENSYLVANICUM	3 25	3 17	3 50
ACER RUBRUM VAR RUBRUM	4 88	4 83	4 100
ACHILLEA MILLEFOLIUM	1 13	1 17	
ADIANTUM PEDATUM VAR PEDATUM	1 13		1 50
AGERATINA ALTISSIMA VAR ALTISSIMA	5 88	6 100	1 50
AGROSTIS HYEMALIS	1 13	1 17	
AGROSTIS PERENNANS	1 38	1 50	
AMELANCHIER LAEVIS	2 25	2 33	
AMPHICARPAEA BRACTEATA	2 88	3 100	2 50
APOCYNUM ANDROSAEMIFOLIUM	2 13	2 17	
AQUILEGIA CANADENSIS	1 13	1 17	
ARABIS CANADENSIS	1 25	1 33	
ARABIS LAEVIGATA VAR LAEVIGATA	1 50	1 50	1 50
ARALIA NUDICAULIS	1 63	2 50	1 100
ARALIA RACEMOSA VAR RACEMOSA	1 13	1 17	
ARISTOLOCHIA MACROPHYLLA	1 25	1 17	1 50
ARISAEMA TRIPHYLLUM	2 100	2 100	2 100
ARNOGLOSSUM ATRIPLICIFOLIA	1 63	1 67	1 50
ARNOGLOSSUM MUHLENBERGII	2 13	2 17	
ARUNCUS DIOICUS VAR DIOICUS	1 13	1 17	
ASCLEPIAS VARIEGATA	1 38	2 33	1 50
ASPLENIUM PLATYNEURON VAR PLATYNEURON	1 50	1 50	1 50
ASTER CORDIFOLIUS	1 38	1 50	
ASTER DIVARICATUS	2 50	2 33	2 100
ASTER MACROPHYLLUS	1 38	1 50	
ASTER PRENANTHOIDES	2 13	2 17	
ASTER UNDULATUS	1 25	1 33	
ATHYRIUM ASPLENIOIDES	1 63	1 50	1 100
BETULA LENTA	2 88	2 83	3 100
BOEHMERIA CYLINDRICA	1 13	1 17	
BOTRYCHIUM VIRGINIANUM	1 63	1 50	1 100
BRACHYELYTRUM ERECTUM	1 13	1 17	
CALYCANTHUS FLORIDUS VAR GLAUCUS	1 13		1 50
CALYSTEGIA SPITHAMAEA VAR PURSHIANA	1 25	1 33	
CAMPANULASTRUM AMERICANUM	1 25	1 33	
CAMPANULA DIVARICATA	1 13	1 17	
CARDAMINE FLAGELLIFERA	1 13	1 17	
CAREX APPALACHICA	2 13	2 17	
CAREX BLANDA	2 25	2 17	1 50

Group:	5.	5.1	5.2
	Cov/Con	Cov/Con	Cov/Con
CAREX DIGITALIS	1 63	1 67	1 50
CAREX LAXIFLORA VAR LAXIFLORA	2 13	2 17	
CAREX VIRESCENS	1 25	1 17	1 50
CARPINUS CAROLINIANA	2 13	2 17	
CARYA ALBA	2 38	2 33	3 50
CARYA CORDIFORMIS	1 13	1 17	
CARYA GLABRA	6 100	7 100	5 100
CARYA OVATA	1 25	1 33	
CASTANEA DENTATA	1 50	1 50	1 50
CAULOPHYLLUM THALICTROIDES	1 13	1 17	
CHIMAPHILA MACULATA VAR MACULATA	1 13	1 17	
CIMICIFUGA AMERICANA	1 13		1 50
CIMICIFUGA RACEMOSA	2 75	2 67	2 100
CIRCAEA CANADENSIS	1 13		1 50
CIRSIUM DISCOLOR	1 13	1 17	
CLEMATIS VIRGINIANA	1 38	1 50	
CLINTONIA UMBELLULATA	1 38	1 33	2 50
COLLINSONIA CANADENSIS	2 50	2 50	1 50
COREOPSIS MAJOR VAR RIGIDA	1 50	1 67	
CORNUS FLORIDA	2 50	2 33	1 100
CORYDALIS SEMPERVIRENS	1 13	1 17	
CRYPTOTAENIA CANADENSIS	1 38	1 17	1 100
CUSCUTA SP. #1	2 13	2 17	
CYPRIPEDIUM PARVIFLORUM VAR PUBESCENS	1 13		1 50
DANTHONIA SPICATA	1 13	1 17	
DENNSTAEDTIA PUNCTILOBULA	3 63	3 83	
DEPARIA ACROSTICHOIDES	1 13	1 17	
DESCHAMPSIA FLEXUOSA VAR FLEXUOSA	1 13	1 17	
DESMODIUM NUDIFLORUM	1 50	1 67	
DESMODIUM PANICULATUM	1 13	1 17	
DICHANTHELIUM BOSCII	2 25	2 33	
DICHANTHELIUM CLANDESTINUM	1 13		1 50
DICHANTHELIUM COMMUTATUM	1 13	1 17	
DICHANTHELIUM LATIFOLIUM*	1 38	1 50	
DIOSCOREA QUATERNATA	2 88	2 83	1 100
DRYOPTERIS MARGINALIS	1 63	2 67	1 50
EPIGAEA REPENS	1 13	1 17	
ERECHTITES HIERACIIFOLIA VAR HIERACIIFOLIA	1 13	1 17	
ERIGERON PULCHELLUS VAR PULCHELLUS	1 38	1 50	
EUONYMUS AMERICANA	2 25		2 100
EUPATORIUM PURPUREUM VAR PURPUREUM	2 75	2 67	2 100
FESTUCA SUBVERTICILLATA	2 25	2 33	
FRAXINUS AMERICANA	2 38	3 33	2 50
GALEARIS SPECTABILIS	1 25		1 100
GALIUM CIRCAEZANS VAR CIRCAEZANS	2 50	2 67	
GALIUM LATIFOLIUM	1 25	1 33	
GALIUM TRIFLORUM	1 25	1 17	1 50
GERANIUM MACULATUM	1 13	1 17	
GLECHOMA HEDERACEA VAR MICRANTHA	1 13	1 17	
GOODYERA PUBESCENS	1 38	1 33	1 50
HALESIA TETRAPTERA VAR MONTICOLA	5 38	5 17	6 100
HAMAMELIS VIRGINIANA	1 50	1 50	1 50

Group:	5.		5.1		5.2	
	Cov/Con		Cov/Con		Cov/Con	
HELIOPSIS HELIANTHOIDES VAR HELIANTHOIDES	1	25	1	33		
HEUCHERA VILLOSA VAR VILLOSA	2	25	2	33		
HIERACIUM CAESPITOSUM	1	13	1	17		
HIERACIUM PANICULATUM	1	13	1	17		
HOUSTONIA PURPUREA VAR PURPUREA	1	50	1	67		
HYDRANGEA ARBORESCENS	1	13	1	17		
HYPERICUM MITCHELLIANUM	1	38	1	50		
ILEX MONTANA	1	25	1	33		
ILEX OPACA VAR OPACA	3	13			3	50
ILEX VERTICILLATA	1	13			1	50
IMPATIENS PALLIDA	3	25	3	33		
JUGLANS NIGRA	1	13	1	17		
KALMIA LATIFOLIA	1	38	1	50		
LACTUCA BIENNIS	1	13	1	17		
LAPORTEA CANADENSIS	4	38	6	17	3	100
LEUCOTHOE FONTANESIANA	1	13			1	50
LIGUSTICUM CANADENSE	1	13	1	17		
LILIUM MICHAUXII	1	38	1	50		
LIPARIS LILIIFOLIA	1	13	1	17		
LIRIODENDRON TULIPIFERA	5	63	4	50	5	100
LUZULA MULTIFLORA VAR CONGESTA	1	13	1	17		
LYONIA LIGUSTRINA VAR LIGUSTRINA	1	13	1	17		
LYSIMACHIA QUADRIFOLIA	2	75	2	67	2	100
LYSIMACHIA TERRESTRIS	1	13	1	17		
MAGNOLIA FRASERI	1	25	1	17	1	50
MAIANTHEMUM RACEMOSUM	1	88	1	83	1	100
MEDEOLA VIRGINIANA	1	50	1	33	1	100
MELAMPYRUM LINEARE	1	13	1	17		
MELANTHIUM PARVIFLORUM	1	50	1	50	1	50
MITCHELLA REPENS	2	25			2	100
MONARDA CLINOPODIA	1	25	1	33		
MONARDA DIDYMA	1	50	1	67		
MUHLENBERGIA TENUIFLORA VAR VARIABILIS	1	25	1	33		
NYSSA SYLVATICA	1	25	1	17	1	50
OSMORHIZA CLAYTONII	1	25			1	100
OSMUNDA CLAYTONIANA	6	13	6	17		
OXALIS STRICTA	1	25	1	33		
OXYDENDRUM ARBOREUM	2	75	2	67	2	100
PANAX QUINQUEFOLIUS*	1	13			1	50
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	2	75	2	67	2	100
PHACELIA BIPINNATIFIDA	1	13	1	17		
PHEGOPTERIS HEXAGONOPTERA	1	25	1	17	1	50
PHYTOLACCA AMERICANA	1	13	1	17		
PINUS STROBUS	2	25	2	33		
POA COMPRESSA	1	13	1	17		
POA CUSPIDATA	1	63	2	67	1	50
PODOPHYLLUM PELTATUM	2	13	2	17		
POLYGONATUM BIFLORUM	1	100	1	100	1	100
POLYGONUM CONVOLVULUS VAR CONVOLVULUS	2	50	2	67		
POLYPODIUM APPALACHIANUM	1	13			1	50
POLYPODIUM VIRGINIANUM	2	25	2	33		
POLYSTICHUM ACROSTICHOIDES	2	88	2	83	2	100
PORTERANTHUS TRIFOLIATUS	1	13	1	17		
POTENTILLA CANADENSIS VAR CANADENSIS	1	50	1	67		
POTENTILLA SIMPLEX	1	13	1	17		

Group:	5.	5.1	5.2
	Cov/Con	Cov/Con	Cov/Con
PRENANTHES ALTISSIMA	1 88	1 83	1 100
PRENANTHES SERPENTARIA	1 38	1 33	1 50
PROSARTES LANUGINOSUM	2 38	2 17	2 100
PRUNUS PENSYLVANICA	1 25	1 33	
PRUNUS SEROTINA	3 38	3 50	
PTERIDIUM AQUILINUM VAR LATIUSCULUM	1 13	1 17	
PYCNANTHEMUM MONTANUM	2 75	2 83	1 50
PYCNANTHEMUM PYCNANTHEMOIDES VAR PYCNANTHEMOIDES	2 13	2 17	
PYCNANTHEMUM PYCNANTHEMOIDES VAR VIRIDIFOLIUM	1 13	1 17	
QUERCUS ALBA	3 25	3 33	
QUERCUS MONTANA	1 25	1 33	
QUERCUS RUBRA	4 100	5 100	3 100
RANUNCULUS HISPIDUS	1 13	1 17	
RANUNCULUS RECURVATUS	1 25	1 33	
RHODODENDRON CATAWBIENSE	1 13	1 17	
RHODODENDRON MAXIMUM	2 75	1 67	3 100
RHODODENDRON PERICLYMENOIDES	2 13	2 17	
ROBINIA PSEUDOACACIA	3 88	3 83	2 100
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	2 75	2 100	
RUBUS CANADENSIS	1 13		1 50
RUDBECKIA LACINIATA	1 13	1 17	
RUMEX ACETOSELLA	1 13	1 17	
RUMEX OBTUSIFOLIUS	1 13	1 17	
SANGUINARIA CANADENSIS	1 50	1 33	2 100
SANICULA CANADENSIS VAR CANADENSIS	2 25	2 33	
SASSAFRAS ALBIDUM	2 50	2 67	
SCHIZACHYRIUM SCOPARIUM	1 13	1 17	
SILENE STELLATA	2 13	2 17	
SILENE VIRGINICA VAR VIRGINICA	1 25	1 33	
SMILAX GLAUCA VAR GLAUCA	1 88	1 83	1 100
SMILAX HERBACEA	1 38	2 33	1 50
SMILAX ROTUNDIFOLIA	2 88	2 83	2 100
SOLIDAGO ARGUTA SSP CAROLINIANA	1 38	1 50	
SOLIDAGO CURTISII	2 100	3 100	2 100
STACHYS LATIDENS	2 50	2 67	
STELLARIA PUBERA	1 75	1 67	2 100
SYMPLOCOS TINCTORIA	1 25	1 17	1 50
THALICTRUM CORIACEUM	1 13	1 17	
THALICTRUM DIOICUM	1 13	1 17	
THALICTRUM PUBESCENS	2 25	2 33	
THALICTRUM REVOLUTUM	1 13	1 17	
THASPIUM BARBINODE	1 25	1 33	
THELYPTERIS NOVEBORACENSIS	3 75	3 67	4 100
TILIA AMERICANA VAR HETEROPHYLLA	2 25		2 100
TIPULARIA DISCOLOR	1 25		1 100
TOXICODENDRON RADICANS	2 38	3 33	1 50
TRADESCANTIA SUBASPERA	2 50	2 67	
TRILLIUM ERECTUM	1 13	1 17	
TRILLIUM UNDULATUM	1 13		1 50
TSUGA CANADENSIS	3 50	1 33	5 100
TSUGA CAROLINIANA	1 25	1 33	
UVULARIA PUBERULA VAR PUBERULA	1 13	1 17	
VACCINIUM SIMULATUM	1 13	1 17	
VACCINIUM STAMINEUM	1 13	1 17	
VIBURNUM ACERIFOLIUM	1 38	2 17	1 100

Group:	5.		5.1		5.2	
	Cov/Con		Cov/Con		Cov/Con	
VICIA CAROLINIANA	1	25	1	33		
VIOLA AFFINIS	2	75	2	67	2	100
VIOLA BLANDA	2	50	2	33	3	100
VIOLA CANADENSIS VAR CANADENSIS	1	13	1	17		
VIOLA HASTATA	2	38	2	50		
VIOLA PUBESCENS VAR PUBESCENS	1	13			1	50
VIOLA ROTUNDIFOLIA	1	13			1	50
VITIS AESTIVALIS	1	53	1	66	2	50
VITIS ROTUNDIFOLIA	1	13			1	50
ZIZIA TRIFOLIATA	2	50	2	50	2	50

Table 3.26. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Rich Cove and Slope Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

5. Rich Cove and Slope Forests

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
CARYA GLABRA	20.63	193.44	17.19	231.25	8.58	19.69	25.85	22.77
FRAXINUS AMERICANA	59.38	32.08	0.83	92.29	0.61	5.89	2.60	4.24
HALESIA TETRAPTERA VAR MONTICOLA	122.81	98.75	0.00	221.56	0.49	9.93	1.26	5.60
LIRIODENDRON TULIPIFERA	11.25	41.56	15.00	67.81	9.67	6.29	18.16	12.23
QUERCUS RUBRA	15.94	56.15	15.94	88.02	7.66	6.18	22.71	14.45
ROBINIA PSEUDOACACIA	43.75	38.44	4.06	86.25	2.09	5.68	5.64	5.66
SASSAFRAS ALBIDUM	96.25	27.50	0.00	123.75	0.46	7.31	1.62	4.46
TSUGA CANADENSIS	8.13	151.88	0.00	160.00	1.87	7.71	4.34	6.03
ALL	628.75	965.10	63.85	1657.71	37.63	99.58	99.99	99.78

5.1 Carya glabra/Ageratina Forest

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
CARYA GLABRA	27.50	226.67	10.00	264.17	8.58	24.16	28.95	26.55
FRAXINUS AMERICANA	77.08	38.61	1.11	116.81	0.81	7.56	3.46	5.51
HALESIA TETRAPTERA VAR MONTICOLA	105.00	61.67	0.00	166.67	0.23	7.22	0.96	4.09
LIRIODENDRON TULIPIFERA	15.00	43.33	10.00	68.33	3.29	7.34	10.88	9.11
QUERCUS RUBRA	21.25	73.19	19.17	113.61	7.67	8.07	26.94	17.50
ROBINIA PSEUDOACACIA	50.00	49.58	2.08	101.67	2.18	6.95	6.05	6.50
SASSAFRAS ALBIDUM	128.33	36.67	0.00	165.00	0.61	9.75	2.15	5.95
ALL	697.08	757.22	56.81	1511.11	29.69	99.73	99.98	99.86

5.2 [Liriodendron-Carya glabra Forest]

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
CARYA GLABRA	0.00	93.75	38.75	132.50	8.58	6.27	16.56	11.42
HALESIA TETRAPTERA VAR MONTICOLA	176.25	210.00	0.00	386.25	1.28	18.08	2.16	10.12
LIRIODENDRON TULIPIFERA	0.00	36.25	30.00	66.25	28.80	3.14	40.02	21.58
QUERCUS RUBRA	0.00	5.00	6.25	11.25	7.62	0.53	10.02	5.28
RHODODENDRON MAXIMUM	30.00	221.25	0.00	251.25	0.79	11.76	1.24	6.50
TSUGA CANADENSIS	27.50	591.25	0.00	618.75	7.44	29.70	17.19	23.45
ALL	423.75	1588.75	85.00	2097.50	61.47	99.11	100.01	99.56

Table 3.27. Vertical structure of woody species in the **Rich Cove** and **Slope Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

5. Rich Cove and Slope Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1		
ACER RUBRUM VAR RUBRUM	1	3	3		
BETULA LENTA	1	1	3	3	
CARYA GLABRA	1	2	6	6	1
CORNUS FLORIDA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	2	2		
LIRIODENDRON TULIPIFERA	1	1	3	3	1
OXYDENDRUM ARBOREUM	1	1	1	1	
PRUNUS SEROTINA	1	1	2	1	
QUERCUS ALBA	1	1	1	1	
QUERCUS RUBRA	1	1	4	5	
RHODODENDRON MAXIMUM	1	1			
ROBINIA PSEUDOACACIA	1	2	2	1	
TSUGA CANADENSIS	1	1	1	1	

5.1 Carya glabra/Ageratina Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1		
ACER RUBRUM VAR RUBRUM	1	2	3		
AMELANCHIER LAEVIS	1	1	1		
BETULA LENTA	1	1	3	3	
CARPINUS CAROLINIANA	1	1	1		
CARYA GLABRA	1	2	6	7	
CORNUS FLORIDA	1	1			
FRAXINUS AMERICANA	1	1	1	1	
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1		
LIRIODENDRON TULIPIFERA	1	1	2	2	
PRUNUS SEROTINA	1	1	2	1	
QUERCUS ALBA	1	1	2	2	
QUERCUS RUBRA	1	1	5	5	
ROBINIA PSEUDOACACIA	1	2	2	2	
SASSAFRAS ALBIDUM	1	1	1		
TOXICODENDRON RADICANS	1	1	1		

5.2 [Liriodendron-Carya glabra Forest]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	1		
ACER RUBRUM VAR RUBRUM	1	4	3		
BETULA LENTA	1	3	4	3	
CARYA GLABRA	1	2	6	6	3
FRAXINUS AMERICANA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	5	4		
HAMAMELIS VIRGINIANA	1	1			
LIRIODENDRON TULIPIFERA	1	1	7	7	4
MAGNOLIA FRASERI	1	1			
OXYDENDRUM ARBOREUM	1	1	2	2	
QUERCUS RUBRA	1	1	3	3	
RHODODENDRON MAXIMUM	1	4	2		
ROBINIA PSEUDOACACIA	1	2			
TILIA AMERICANA VAR HETEROPHYLLA	1	1	3	2	
TSUGA CANADENSIS	1	4	5	4	

Table 3.28. Site information for the **Rich Cove and Slope Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 3.1. Average values of site variables are given. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**G**=gneiss, **M**=meta-arkose), Landform types (representing micro-scale topographic units) (**C**=cove, **R**=ridge, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**LS**=lower-slopes, **T**=toeslope, **US**=upper-slopes).

5. Rich Cove and Slope Forests

	Group		
	5.	5.1	5.2
Site Characteristics:			
Elevation (m)	1009	1122	671
Slope (o)	23	24	20
Aspect (o)		E,SE	SE,E
Parent material	M	G,M	M
Surface Substrate (%):			
Moss/Lichen	5	5	5
Wood	2	2	2
Rock	16	15	19
Organic matter	81	82	78
Water	0	0	0
Topographic Characteristics:			
Relative slope (%)	23	3	84
LFI	0.18	0.14	0.31
TSI	0.02	0.02	0.02
Landform	SS	SS,R	C,SS
Topographic position	US	US	LS,T

3.5.6 VEGETATION CLASS: 6. Alluvial Wetlands

Alluvial Wetlands are distributed throughout the Southern Appalachian Mountains along stream and river floodplains (Schafale & Weakley 1990). In Linville Gorge this vegetation class is limited in distribution to alluvial flats and broad stream margin areas adjacent to the Linville River.

COMMUNITY TYPE: [Liquidambar Rocky Streambed Forest] (6.1)

Synonymy

Piedmont/Mountain Levee Forest (Schafale & Weakley 1990), Riverbank Shrub Thicket Community (Cooper & Hardin 1970).

Physiognomy

Liquidambar styraciflua, in association with *Platanus occidentalis* and *Betula lenta*, dominate the canopy of this forest (mean height 12 m) (Tables 3.29, 3.30, 3.31). *Toxicodendron radicans* densely covers many tree trunks. The trees are all <40 cm in diameter. There is little understory owing to stream scour. The ground is dominated by a bouldery surface substrate (60%; Table 3.32) matrix of 10 to 30 cm diameter boulders intermixed with sand and gravel. Vegetation is very sparse, restricted to sandy crevices.

Habitat and Distribution

This community type inhabits the Linville River margins. The **[Liquidambar Rocky Streambed Forest]** sample plot is situated on the margin of the Linville River (440 m), adjacent to the Cambric Branch confluence. This group inhabits frequently flooded areas. The soils are exceptionally sandy textured with highest sand content, soil density and lowest silt content of any community type in this study (Table 3.5).

The **[Liquidambar Rocky Streambed Forest]** soils are fertile as indicated by high pH and base saturation values (Tan 1993), probably due to frequent sediment inflow

(Tables 3.4, 3.5). Like the other community type in this vegetation class, the soil is low in K and high in Fe. Both community types have the highest pH levels of any group identified in Linville Gorge.

Distinguishing Features

Apart from the **Rocky Streamside Shrublands** vegetation class, this community type is subject to a more frequent and intense disturbance regime than any vegetation group recognized in Linville Gorge. The soils are the sandiest and densest identified of any type in this study. Both community types in this vegetation class are floristically very different from other Linville vegetation groups. *Liquidambar styraciflua* and *Platanus occidentalis* are not only widespread in this class, but are also both restricted to this vegetation class.

Succession and Disturbance

This community type is subject to frequent flooding. The periodicity and intensity of flooding will determine the longevity and sustainability of this community type. Under the present flooding regime, this community type will be maintained. However, unusually high, fast-flowing floods could severely alter the community composition.

COMMUNITY TYPE: [Platanus/Asimina/Microstegium Alluvial Forest] (6.2)

Synonymy

Piedmont/Mountain Bottomland Forest p.p. (Schafale & Weakley 1990).

Physiognomy

Liquidambar styraciflua dominates the tall (39 m canopy height), dense canopy in association with large-diameter *Liriodendron tulipifera* (40 to 70 cm diameter) and *Platanus occidentalis* (45 to 60 cm). The understory is open with *Asimina triloba* forming a patchy shrub stratum (Tables 3.29, 3.30, 3.31). The ground is densely covered by the introduced species *Microstegium vimineum* (cover 8), as well as *Ageratina altissima* var. *altissima* (cover 5) and a variety of other herbaceous species.

The simple structure of this community type and high species richness recorded at all spatial scales indicates the degree of ground species diversity present (Table 3.8). The extent of species micro-scale diversity is reflected by the fact that this group has highest species richness at the two smallest spatial scales (0.01 m^2 and 0.1 m^2).

Habitat and Distribution

This community type dominates a large, high alluvial flat on the western side of the Linville River in the lower reaches of the Wilderness (409 m elevation; Table 3.32). The area is subject to periodic flooding and accumulates water and sediments from the slopes above. The soils have a high sand and clay content (Table 3.5). They are fertile and nutrient rich, with high levels of Al, cation exchange capacity, K, Cu, Mg, Mn, P and S and low B, Fe, soil density, organic matter and base saturation in comparison to the **[Liquidambar Rocky Streambed Forest]** (Table 3.4). This can be explained by the finer soil texture at this site, and lower-frequency, less-intense flooding.

Distinguishing Features

This community type is 1 of 2 where *Platanus* is dominant and the only group where an introduced species (*Microstegium*) is an important floristic component. This community type is restricted to one alluvial terrace in the lower third of Linville Gorge. The **[Platanus/Asimina/Microstegium Alluvial Forest]** has the finest textured soils of any vegetation group identified in Linville (Table 3.4), resulting in part from downslope sediment accumulation.

Succession and Disturbance

The **[Platanus/Asimina/Microstegium Alluvial Forest]** is subject to downslope sediment movement and periodic flooding. Infrequent flooding probably maintains the dominance of *Microstegium* and *Platanus*. A reduction in the flooding regime could gradually lower soil fertility and allow the invasion of evergreen species such as *Tsuga canadensis* and *Rhododendron maximum* which are present on nearby sites. Summary data suggests that the present canopy species will not be maintained in the future (Table 3.30).

Table 3.29. Average cover class and constancy of species present in the **Alluvial Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 3.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. Homoteneity is the mean constancy of the prevalent species.

Group:	6.	6.1	6.2
Number of plots:	2	1	1
Homoteneity:	0.667	1.00	1.00
	Cov/Con	Cov/Con	Cov/Con
Species			
ACER RUBRUM VAR RUBRUM	3 100	4 100	1 100
AGERATINA ALTISSIMA VAR ALTISSIMA	3 100	1 100	5 100
AGROSTIS PERENNANS	2 50	2 100	
ALBIZIA JULIBRISSIN	3 50		3 100
AMPHICARPAEA BRACTEATA	2 50		2 100
ARABIS LAEVIGATA VAR LAEVIGATA	1 50	1 100	
ARISAEMA TRIPHYLLUM	1 50		1 100
ASIMINA TRILOBA	6 50		6 100
ASTER PRENANTHOIDES	2 50	2 100	
ATHYRIUM ASPLENIOIDES	1 50		1 100
BETULA ALLEGHANIENSIS	4 50	4 100	
BETULA LENTA	6 50	6 100	
BOTRYCHIUM BITERNATUM	1 50		1 100
CAMPANULA DIVARICATA	2 50	2 100	
CAREX BLANDA	1 50		1 100
CAREX LAXIFLORA VAR LAXIFLORA	1 50		1 100
CAREX SWANII	2 50		2 100
CAREX TORTA	2 50	2 100	
CARPINUS CAROLINIANA	3 50	3 100	
CIRCAEA CANADENSIS	1 50		1 100
CORNUS FLORIDA	3 100	3 100	2 100
CRYPTOTAENIA CANADENSIS	2 50		2 100
DICHANTHELIUM CLANDESTINUM	2 100	1 100	2 100
DICHANTHELIUM DICHOTOMUM V.=RAMULOSUM	3 50	3 100	
ELEPHANTOPUS CAROLINIANUS	1 50		1 100
ERIGERON PULCHELLUS VAR PULCHELLUS	1 50		1 100
EUONYMUS AMERICANA	1 50		1 100
GALEARIS SPECTABILIS	1 50		1 100
GALIUM TRIFLORUM	1 50		1 100
GOODYERA PUBESCENS	1 50		1 100
ILEX OPACA VAR OPACA	1 50		1 100
IRIS VERNA	1 50		1 100
LEERSIA VIRGINICA	2 50		2 100
LIQUIDAMBAR STYRACIFLUA	8 100	8 100	8 100
LIRIODENDRON TULIPIFERA	5 50		5 100
LOBELIA SPICATA	1 50		1 100
LONICERA SEMPERVIRENS	1 100	1 100	1 100
LUZULA MULTIFLORA VAR CONGESTA	2 100	2 100	1 100
LYCOPUS VIRGINICUS	1 50		1 100
MICROSTEGIUM VIMINEUM	5 100	1 100	8 100
MUHLENBERGIA TENUIFLORA VAR VARIABILIS	1 100	1 100	1 100
NYSSA SYLVATICA	1 50		1 100

Group:	6.	6.1	6.2
	Cov/Con	Cov/Con	Cov/Con
OXALIS STRICTA	1 100	1 100	1 100
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	3 100	3 100	2 100
PHACELIA BIPINNATIFIDA	1 50		1 100
PINUS STROBUS	3 100	4 100	1 100
PLATANUS OCCIDENTALIS	6 100	6 100	5 100
POA CUSPIDATA	1 50		1 100
POLYGONUM VIRGINIANA	1 50		1 100
POTENTILLA CANADENSIS VAR CANADENSIS	1 50	1 100	
RANUNCULUS RECURVATUS	1 100	1 100	1 100
ROBINIA PSEUDOACACIA	3 50		3 100
ROSA MULTIFLORA	1 50	1 100	
SANICULA CANADENSIS VAR CANADENSIS	2 50		2 100
SISYRINCHIUM ANGUSTIFOLIUM	1 50		1 100
SMILAX GLAUCA VAR GLAUCA	1 50		1 100
SMILAX ROTUNDIFOLIA	1 50		1 100
SOLANUM AMERICANUM VAR AMERICANUM	1 50		1 100
SOLANUM CAROLINENSE VAR CAROLINENSE	1 50		1 100
SOLIDAGO ARGUTA SSP CAROLINIANA	1 100	1 100	1 100
TIPULARIA DISCOLOR	1 50		1 100
TOXICODENDRON RADICANS	5 100	6 100	3 100
TRIFOLIUM INCARNATUM	1 50	1 100	
TSUGA CANADENSIS	4 50	4 100	
VIOLA CUCULLATA	2 100	2 100	2 100
VIOLA PALMATA VAR PALMATA	1 50		1 100
VITIS AESTIVALIS	2 100	1 100	2 100

Table 3.30. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Alluvial Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

6. Alluvial Forests

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ASIMINA TRILOBA	320.00	5.00	0.00	325.00	0.02	23.05	0.05	11.55
BETULA LENTA	0.00	100.00	0.00	100.00	2.01	5.27	6.99	6.13
LIQUIDAMBAR STYRACIFLUA	15.00	640.00	5.00	660.00	14.72	38.58	38.79	38.68
LIRIODENDRON TULIPIFERA	0.00	35.00	40.00	75.00	11.85	5.32	22.69	14.01
PLATANUS OCCIDENTALIS	0.00	100.00	25.00	125.00	8.85	7.04	22.54	14.79
ALL	415.00	1165.00	75.00	1655.00	40.51	100.00	99.99	99.99

6.1 [Liquidambar Rocky Streambed Forest]

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	0.00	100.00	0.00	100.00	0.83	5.26	2.90	4.08
BETULA LENTA	0.00	200.00	0.00	200.00	4.03	10.53	13.98	12.25
LIQUIDAMBAR STYRACIFLUA	0.00	900.00	0.00	900.00	13.60	47.37	47.23	47.30
PLATANUS OCCIDENTALIS	0.00	200.00	0.00	200.00	7.17	10.53	24.89	17.71
ALL	100.00	1800.00	0.00	1900.00	28.79	99.99	99.99	99.99

6.2 [Platanus/Asimina/Microstegium Alluvial Forest]

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ASIMINA TRILOBA	640.00	10.00	0.00	650.00	0.05	46.10	0.09	23.09
LIQUIDAMBAR STYRACIFLUA	30.00	380.00	10.00	420.00	15.84	29.79	30.34	30.06
LIRIODENDRON TULIPIFERA	0.00	70.00	80.00	150.00	23.70	10.64	45.38	28.01
PLATANUS OCCIDENTALIS	0.00	0.00	50.00	50.00	10.54	3.55	20.18	11.86
ALL	730.00	530.00	150.00	1410.00	52.22	100.01	99.99	99.98

Table 3.31. Vertical structure of woody species in the **Alluvial Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

6. Alluvial Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	3	3		
ASIMINA TRILOBA	3	3			
BETULA ALLEGHANIENSIS	1	3	3		
BETULA LENTA	1	3	3		
CARPINUS CAROLINIANA	1	2	2		
CORNUS FLORIDA	1	5	4		
LIQUIDAMBAR STYRACIFLUA	1	4	8	4	4
LIRIODENDRON TULIPIFERA	1	1	3	3	3
PINUS STROBUS	1	2	2		
PLATANUS OCCIDENTALIS	1	3	6	3	3
ROBINIA PSEUDOACACIA	1	1	3	3	3
TOXICODENDRON RADICANS	1	3	4		
TSUGA CANADENSIS	1	2	1		

6.1 [Liquidambar Rocky Streambed Forest]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	5	5		
BETULA ALLEGHANIENSIS	1	6	6		
BETULA LENTA	1	5	6		
CARPINUS CAROLINIANA	1	4	3		
CORNUS FLORIDA	1	4	3		
LIQUIDAMBAR STYRACIFLUA	1	7	8		
PINUS STROBUS	1	4	3		
PLATANUS OCCIDENTALIS	1	4	6		
TOXICODENDRON RADICANS	1	5	4		
TSUGA CANADENSIS	1	4	2		

6.2 [Platanus/Asimina/Microstegium Alluvial forest]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ASIMINA TRILOBA	5	6			
CORNUS FLORIDA	1	5	5		
LIQUIDAMBAR STYRACIFLUA	1	1	8	8	7
LIRIODENDRON TULIPIFERA	1	1	6	6	6
PLATANUS OCCIDENTALIS	1	1	5	6	5
ROBINIA PSEUDOACACIA	1	1	5	5	5
TOXICODENDRON RADICANS	1	1	4	1	
VITIS AESTIVALIS	1	1	1		

Table 3.32. Site information for the **Alluvial Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 3.1. Average values of site variables are given. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**A**=alluvium), Landform types (representing micro-scale topographic units) (**RF**=river flat, **RM**=river margin) and Topographic position (representing macro-scale topographic units) (**P**=plain/level).

6. Alluvial Forests

	Group		
	6.	6.1	6.2
Site Characteristics:			
Elevation (m)	425	440	409
Slope (o)	1	1	1
Aspect (o)	flat	flat	flat
Parent material	A	A	A
Surface Substrate (%):			
Moss/Lichen	3	4	1
Wood	1	1	1
Rock	31	60	1
Organic matter	56	15	97
Water	2	3	0
Topographic Characteristics:			
Slope position	100	100	99
LFI	0.26	0.25	0.28
TSI	0.03	0.03	0.03
Landform		RM	RF
Topographic position	P	P	P

3.5.7 VEGETATION CLASS: 7. <u>Rocky</u> <u>Streamside</u> <u>Shrublands</u>

<u>Rocky</u> <u>Streamside</u> <u>Shrublands</u> distribution is limited throughout the Southern Appalachian Mountains to open areas adjacent to and often scoured by streams or rivers (Schafale & Weakley 1990). In Linville Gorge the distribution of this vegetation class is restricted to the narrow, open banks of the Linville River.

COMMUNITY TYPE: [Alnus/Xanthorhiza Rocky Streamside Shrubland] (8.1.1)

Synonymy

Sand and Mud Bar p.p., Rocky Bar & Sand Shore (Schafale & Weakley 1990), "Shifting sand bars" (Cooper & Hardin 1970).

Constant species

Agrostis perennans, Alnus serrulata, Anthoxanthum odoratum var. *odoratum, Aster prenanthoides, Boykinia acontifolia, Carex torta, Holcus lanatus, Juncus coriaceus, Leucothoe axillaris, Luzula multiflora* ssp. *congesta, Lycopus virginicus, Trautvetteria caroliniensis, Xanthorhiza simplicissima.*

Physiognomy

Ground-layer vegetation is patchy in distribution and restricted to clumps between rocks and more open sandy areas (Tables 3.33, 3.34, 3.35). *Xanthorhiza simplicissima* (cover 5) is the dominant species in this community type (mean height 0.3 m), with *Aster prenanthoides* and *Carex torta* somewhat less abundant (cover of 3). There is a diverse assemblage of many herbaceous species also present. Scattered *Alnus serrulata* shrubs provide the only woody vegetation present. Foliage from nearby forest overhangs one of the sample sites.

Habitat and Distribution

The **[Alnus/Xanthorhiza Rocky Streamside Shrubland]** inhabits the Linville River margins. Although both plots in this group were sampled in the upper half of the Wilderness (911 to 926 m elevation range; Table 3.36), this community type occurs along the length of the river. This type is restricted to narrow, open areas flanking the river. Sites are subject to frequent, fast-flowing flood waters. The surface is made up of large, exposed rock slabs with soil restricted to protected areas between the rocks. The soils are silty with the highest silt content, base saturation, Fe and pH levels and lowest cation exchange capacity, Mg and N of any type or sub-type in this study (Tables 3.4, 3.5).

Distinguishing Features

This vegetation class is subject to the most frequent and most intense disturbance regime of any vegetation type recognized in Linville Gorge. This community type has little floristic affinity with other community types in this study.

Succession and Disturbance

This community type is subject to frequent, high-intensity flooding. The periodicity and intensity of flooding determine the longevity and sustainability of the **[Alnus/ Xanthorhiza Rocky Streamside Shrubland]**. This type can be maintained in its present form under the present flooding regime. However, changes in the flooding dynamics could alter this community type, either eliminating it or enabling woody species to gradually invade.

Table 3.33. Average cover class and constancy of species present in the **Rocky Streamside Shrublands** vegetation class. Values are given for the vegetation class. The class is represented by its abbreviation code. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. Homoteneity is the mean constancy of the prevalent species.

Group:	7.
Number of plots:	2
Homoteneity:	0.681
	Cov/Con
Species	
AGROSTIS PERENNANS	2 100
AGROSTIS STOLONIFERA	1 50
ALNUS SERRULATA	3 100
ANTHOXANTHUM ODORATUM VAR ODORATUM	2 100
ARONIA ARBUTIFOLIA	1 50
ARONIA MELANOCARPA	2 50
ASTER DIVARICATUS	2 50
ASTER PRENANTHOIDES	3 100
BETULA ALLEGHANIENSIS	7 50
BIDENS FRONDOSA	1 50
BOYKINIA ACONITIFOLIA	2 100
CAREX FLEXUOSA	1 50
CAREX TORTA	3 100
DICHANTHELIUM ACUMINATUM VAR ACUMINATUM	1 50
DICHANTHELIUM ACUMINATUM VAR FASCICULATUM	1 50
DICHANTHELIUM DICHOTOMUM V.=RAMULOSUM	1 50
DRYOPTERIS INTERMEDIA	2 50
ELEOCHARIS OBTUSA	1 50
FRAXINUS AMERICANA	2 50
GALAX URCEOLATA	1 50
GLYCERIA STRIATA VAR STRIATA	1 50
HAMAMELIS VIRGINIANA	3 50
HOLCUS LANATUS	1 100
HOUSTONIA SERPYLLIFOLIA	1 50
HYPERICUM DENSIFLORUM	2 50
IMPATIENS CAPENSIS	1 50
JUNCUS ACUMINATUS	1 50
JUNCUS CORIACEUS	2 100
JUNCUS MARGINATUS VAR MARGINATUS	1 50
LEUCOTHOE FONTANESIANA	2 100
LOBELIA CARDINALIS	1 50
LUZULA MULTIFLORA VAR CONGESTA	2 100
LYCOPUS VIRGINICUS	1 100
MITCHELLA REPENS	1 50
MONARDA DIDYMA	1 50
MYOSOTIS LAXA	1 50
NYSSA SYLVATICA	1 50
OXALIS STRICTA	1 50
PINUS STROBUS	2 50
POACEAE SP. #1	1 50
POA TRIVIALIS	1 50
RANUNCULUS RECURVATUS	1 50

Group:	7.	
	Cov/	Con
RANUNCULUS REPENS	1	50
RHODODENDRON MAXIMUM	2	50
RHODODENDRON MINUS	1	50
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1	50
RUDBECKIA LACINIATA	2	50
SALIX NIGRA	2	50
SCUTELLARIA SP. #1	2	50
SELAGINELLA TORTIPILA	1	50
SENECIO VULGARIS	1	50
SOLIDAGO PUBERULA	1	50
SYMPLOCOS TINCTORIA	2	50
THASPIUM BARBINODE	1	50
TRAUTVETTERIA CAROLINIENSIS VAR CAROLINIENSIS	2	100
TSUGA CANADENSIS	2	50
VACCINIUM PALLIDUM	1	50
VIOLA BLANDA	1	50
VIOLA CUCULLATA	3	50
XANTHORHIZA SIMPLICISSIMA	5	100

Table 3.34. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Rocky Streamside Shrublands** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

7. Rocky Streamside Shrublands

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ALNUS SERRULATA	75.00	0.00	0.00	75.00	0.01	30.00	2.41	16.21
BETULA ALLEGHANIENSIS	0.00	25.00	0.00	25.00	0.11	10.00	38.07	24.04
FRAXINUS AMERICANA	0.00	25.00	0.00	25.00	0.99	25.00	38.21	31.61
PINUS STROBUS	0.00	25.00	0.00	25.00	0.31	25.00	11.79	18.40
RHODODENDRON MAXIMUM	0.00	25.00	0.00	25.00	0.03	10.00	9.52	9.76
ALL	75.00	100.00	0.00	175.00	1.45	100.00	100.00	100.00

Table 3.35. Vertical structure of woody species in the **Rocky Streamside Shrublands** vegetation class. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

7. Rocky Streamside Shrublands

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ALNUS SERRULATA	1	2			
BETULA ALLEGHANIENSIS	1	1	3		
FRAXINUS AMERICANA	1	1			
HAMAMELIS VIRGINIANA	1	2			
PINUS STROBUS	1	1			
TSUGA CANADENSIS	1	1			

Table 3.36. Site information for the **Rocky Streamside Shrublands** vegetation class. The class is represented by its abbreviation code. Average values of site variables are given. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**A**=alluvium), Landform types (representing micro-scale topographic units) (**RM**=river margin) and Topographic position (representing macro-scale topographic units) (**P**=plain/level, **T**=toeslope).

7. Rocky Streamside Shrublands

	Group
	7.
Site Characteristics:	
Elevation (m)	919
Slope (o)	9
Aspect (o)	flat
Parent material	A
Surface Substrate (%):	
Moss/Lichen	18
Wood	6
Rock	63
Organic matter	5
Water	19
Topographic Characteristics:	
Relative position (5)	100
LFI	0.32
TSI	0.15
Landform	RM
Topographic position	P,T

3.5.8 VEGETATION CLASS: 8. Non-Alluvial Wetlands

Non-Alluvial Wetlands have extremely limited distribution within the Southern Appalachians (Schafale & Weakley 1990) and are represented within Linville Gorge by two small temporary ponds.

COMMUNITY TYPE: [Scirpus cyperinus-Dulichium Temporary Pond] (8.1)

Synonymy

Upland Pools (Schafale & Weakley 1990).

Physiognomy

The sampled pond is approximately 15 x 20 m in size. *Scirpus cyperinus*, *Dulichium arundinaceum*, and *Osmunda regalis* var. *spectabilis* (cover 5) are the most abundant vascular species, occurring as emergent, monospecific clumps. *Juncus effusus* is also present, with *Bartonia virginica* and *Liquidambar styraciflua* sparsely distributed along the pond margin (Table 3.37). Two *Sphagnum* species are abundant on the hard pond base. Of the 6 vascular plant species present in this pond (Table 3.8), all except *L. styraciflua*, are restricted in Linville Gorge to this community type. The pond is surrounded by the ***Pinus pungens-Pinus strobus/Leucothoe recurva sub-type***.

Habitat and Distribution

The soils of this community type have the highest silt and lowest sand components of any group recognized in Linville Gorge (Tables 3.4, 3.5). In comparison to other vegetation classes associated with wet conditions (i.e. **Rocky Streamside Shrublands** and **Alluvial Forests**), soils of the **[Scirpus cyperinus-Dulichium Temporary Pond]** community type are high in Na, P, S and organic matter and low in Ca, Cu, Fe, Mn, Zn, pH, soil density and base saturation. In relation to all the vegetation groups in Linville Gorge, the **[Scirpus cyperinus-Dulichium Temporary Pond]** soils have highest Na, P, S and organic content and as well as generally high Al and low values of Ca, Cu, K, Mn and CEC.

This sample plot is situated on the shallow slopes above the western bluffs (995 m) near Conley Cove Trail (Table 3.38). The underlying geologic substrate is lower quartzite. Another pond on the summit of Shortoff Mountain appears to be similar in plant composition but was not sampled. The rare *Sphagnum pylaesii* inhabits the edge of this pond (Weakley 1992).

Succession and Disturbance

The pond appears to be spring fed. It may have been formed, or increased in depth, by an artificial dam on the northern edge. With time, this pond may gradually infill, but the process would be extremely slow.

Table 3.37. Average cover class and constancy of species present in the **Non-Alluvial Wetlands** vegetation class. Values are given for the vegetation class. The class is represented by its abbreviation code. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species.

Group:	8.
Number of plots:	1
Homoteneity:	1.00
	Cov/Con
Species	
BARTONIA VIRGINICA	1 100
DULICHIUM ARUNDINACEUM	5 100
JUNCUS EFFUSUS VAR SOLUTUS	4 100
LIQUIDAMBAR STYRACIFLUA	1 100
OSMUNDA REGALIS VAR SPECTABILIS	5 100
SCIRPUS CYPERINUS	5 100

Table 3.38. Site information for the **Non-Alluvial Wetlands** vegetation class. The class is represented by its abbreviation code. Average values of site variables are given. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**CL**=lower quartzite), Landform types (representing micro-scale topographic units) (**SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**US**=upper-slopes).

8. Non-Alluvial Wetlands

	Group
	8.
Site Characteristics:	
Elev	907
Slope (o)	0
Aspect (o)	flat
Parent material	CL
Surface Substrate (%):	
Moss/Lichen	12
Wood	90
Rock	1
Organic matter	0
Water	100
Topographic Characteristics:	
Relative position (%)	23.00
LFI	0.08
TSI	-0.01
Landform	SS
Topographic position	US

3. 6 Discussion

3.6.1 Comparisons with other studies

3.6.1.1 *Southern Appalachian Mountains*

In their classification of North Carolina vegetation, Schafale & Weakley (1990) indicated the occurrence of 9 natural communities in Linville Gorge. These range from Canadian Hemlock and Carolina Hemlock Bluff Forest, to White Pine Forest, Chestnut Oak Forest, Pine--Oak/Heath and Heath Balds. A quartzite variant of the High Elevation Rocky Summit community, containing several rare species and some endemic to this area was also recognized along with Montane Acidic Cliff and Upland Pool communities (Schafale & Weakley 1990). In this present study 8 of the communities identified by Schafale & Weakley (1990) have been recognized as distinct groups. The ninth group, Heath Balds, overlaps with the **Tsuga caroliniana/Rhododendron maximum** community type and the ***Rhododendron minus-Fothergilla/Leiophyllum/Selaginella tortipila sub-type***. Differences between the 2 classifications may relate to the fact that present study is based on quantitative information whereas the Schafale & Weakley descriptions were not. The current study differs in its treatment of the rock outcrops, and provides greater differentiation within the Pine--Oak/Heath and Chestnut Oak Forests. This study also documents the presence of several additional broad vegetation groups; the **Alluvial Wetlands** , **Rich Cove and Slope Forests** and **Rocky Streamside Shrublands** vegetation classes, as well as additional **Montane Oak Forests** community types dominated by *Quercus alba* and the **Tsuga canadensis-Fagus/Ilex opaca Forest** in the **Acidic Cove and Slope Forests** vegetation class.

Forests in the Southern Appalachian Mountains dominated by *Quercus montana* in association with a dense shrub understory of *Kalmia latifolia* and/or *Rhododendron maximum* have been described extensively in the past (e.g., Whittaker 1956, Cooper & Hardin 1970, Stamper 1976, McLeod 1988). Such forests correspond to the **Quercus montana-Quercus coccinea/Kalmia Forest**, the **Quercus montana/Galax Forest**, the **Quercus montana/Rhododendron maximum Forest** and the **Quercus montana-Acer**

rubrum Forest recognized in this study. Both Whittaker (1956) and Stamper (1976) list *Rhododendron calendulaceum* as one of the major shrub species, however this species has very low abundance in ericaceous-dominated *Q. montana* types at Linville Gorge. A lack of *R. calendulaceum* has also been noted in similar forests in the Chattooga River watershed (C. Zartman *pers. comm.*). Similarly, Whittaker (1956) and McLeod (1988) noted the presence of *Cornus florida* in these forests. Low abundance of both deciduous species at Linville Gorge probably relates to the generally dry and infertile conditions in this landscape. Such conditions would favor greater dominance of ericaceous shrub species. Indeed, ericaceous-dominated *Q. montana* types at Linville Gorge have closest association with Whittaker's (1956) Chestnut Oak-Chestnut Heath. However, the Linville Gorge types are distributed across a much broader range of slope positions and corresponding site conditions than Whittaker's type which is restricted to xeric upper-slopes. Dominance by ericaceous-*Quercus montana* types across a range of site conditions illustrates the widespread infertility of sites at Linville Gorge.

The occurrence of distinct *Quercus montana* communities with a non-ericaceous shrub stratum classified in this study have not been previously described in any Southern Appalachian study. Of the three non-ericaceous types identified, the **Quercus montana/ Oxydendrum/Cornus florida Forest**, and the **Quercus montana/Cornus florida Forest**, inhabit dry, mid- to upper- southeast- to southwest-facing slopes. The slope orientation of these types contrasts particularly with the *Rhododendron maximum* ericad-dominated *Quercus montana* forests in this study and in the Smoky Mountains (Whittaker 1956), which generally have cooler, northerly-facing aspects. The two essentially ericad-free Linville Gorge community types have some resemblance to one of the *Quercus montana* variants of Scarlet Oak-Chestnut Oak Oak-Hickory forest type in the Chattooga River (DuMond 1970) and Mixed Oak, Yellow Popular, Hickory Forest in the Black and Craggy Mountains (McLeod 1988), although forests in the latter region the canopy contains three *Quercus* species. The **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest,** the third non-ericaceous *Quercus montana* community type has closest floristic affinity with Red Oak, Yellow Popular, Chestnut Oak described by McLeod (1988), with *Hamamelis* *virginiana* and *Acer pensylcanicum* dominating the shrub stratum. However, McLeod's community occurs on open-slopes, whereas in Linville Gorge the **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest** inhabits moister, small, damp, rocky gullies and seepage areas in close proximity to mid-slope escarpments. The presence of these three community types in Linville Gorge suggests that *Quercus montana* dominates a broader range of site conditions and compositional groups than has been documented elsewhere in the Southern Appalachian Mountains.

The overriding dominance of *Quercus montana* across Linville Gorge contrasts to most descriptions of Southern Appalachian landscapes. McLeod (1988) described the dominance of *Q. montana* in forests on south, southwest-facing mid- to upper-slopes and narrow ridges of most aspects. His descriptions follow the general pattern found throughout the Southern Appalachians (e.g., Whittaker 1956). However, at Linville Gorge, this species also dominates north-facing sites and is the major species across a broader range of slope positions and moisture regimes. Low-rainfall and infertile soils, associated with highly acidic underlying bedrock, probably at least partly account for the preponderance of *Q. montana* across the Linville landscape. Moreover, overwhelming *Q. montana* canopy dominance may partly reflect an absence of canopy disturbance by logging and chestnut death. Canopies opened by both disturbance types are more likely to be inhabited by fast-growing, shade-tolerant species such as *Betula lenta* and *Acer rubrum*.

The role of chestnut, *Castanea dentata*, in Linville community types is difficult to ascertain. This species has widespread distribution throughout the Southern Appalachian Mountains (Braun 1950). In the Smoky Mountains chestnut was codominant in *Q. montana* communities (Whittaker 1956). However, at Linville Gorge virtually no *Castanea* logs were encountered during field work, although low levels of chestnut sprouts were recorded throughout most types dominated by *Q. montana*. The fact that chestnut logs were regularly encountered during field work in the higher-rainfall Shining Rock and Joyce Kilmer landscapes (Chapters 4 & 5) discounts the possibilities of chestnut logs decomposing beyond recognition in the dry conditions at Linville Gorge. The preponderance of old (>200 years), large-diameter *Q. montana* in most Linville community types suggests that chestnut may have been only a minor canopy component. However, Reed (1905) documented the presence of chestnut forest on the slopes of Grandfather Mountain, approximately 15 kilometers north of Linville Gorge. Although Grandfather Mountain is underlain by similar rock types (quartzite and sandstone) to those within Linville Gorge, there are significant areas of more base-rich rock, which perhaps explains the presence of chestnut in this region.

In Linville Gorge, communities dominated by *Quercus alba* inhabit exposed, shallow-sloping, southwest-facing upper-slopes and comparatively flat, broad ridgetops, corresponding to patterns documented elsewhere in the Southern Appalachians (Whittaker 1956, Baranski 1975, Patterson 1994). In the Smoky Mountains, Whittaker (1956) noted the absence of definable *Q. alba* communities below 1360 m, with this species a component of *Q. rubra* and *Q. montana* forests. However, in Linville Gorge *Q. alba* forests are well-differentiated above 1060 m. This may relate to the general infertility of Linville soils, which perhaps have conditions comparable to sites at higher-elevations in other landscapes. The **Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest** corresponds with Whittaker's (1956) open White Oak Forest with a "fairly rich herb layer" (Whittaker 1956, p. 51). This type floristically resembles the White Oak Forest described by McLeod (1988), although his group occurs on well-drained valley flats and terraces. The site conditions of the low-elevation variant of the **Quercus alba-Pinus strobus/Kalmia Forest** correspond most closely with McLeod's type. Baranski (1975) and Whittaker (1956) also document the presence of *Q. alba* forests on low-elevation flats and sheltered lower-slopes. The **Quercus alba/Kalmia/Galax Forest** and high-elevation stands in the **Quercus alba-Pinus strobus/ Kalmia Forest** are similar to Whittaker's lower-elevation *Kalmia* variant of the White Oak Forest, although in Linville Gorge these community types have high-elevation positions on the landscape.

Community types in this study dominated by the xeric *Pinus* species correspond closely with previous Southern Appalachian descriptions. However, the distinct elevational separation of the pines described by Whittaker (1956), with *Pinus pungens* at highest elevation and *P. rigida* below, was not observed at Linville Gorge. My results corroborate those of Racine & Hardin (1975) which document the abundance of *P. pungens* on the most highly exposed sites with thinnest soils. These sites perhaps mirror conditions associated with higher-elevation areas, although Zobel (1969) associates this species with "thin, rocky soil" rather than factors associated with elevation. In Linville Gorge, *P. rigida* has higher abundance on more sheltered sites, increasing in abundance with increasing distance from rock bluffs and summits. A similar pattern was observed by Racine & Hardin (1975) in the Green River Gorge. At Linville Gorge the concentration of *Pinus virginiana* on south-facing, lower-elevation slopes is indicative of the typically low-elevation, piedmont distribution of this species (Whittaker 1956, Racine 1966).

The classification of the **Quercus montana-Pinus strobus/Rhododendron maximum Forest** in this study verifies the presence and provides further information on the little-known White Pine Forest described by Schafale & Weakley (1990). This type have some resemblance to White Pine-Chestnut Oak described by DeYoung (1979) in the Smoky Mountains, but his community inhabits areas previously logged and farmed. Fire is the only known disturbance for the Linville type. This type also has some loose similarities with the *Pinus strobus-Pinus rigida/Quercus coccinea/Kalmia latifolia/Gaylussacia ursina* Subtype II described by Patterson (1994), although *Pinus rigida* is not present in the **Quercus montana-Pinus strobus/Rhododendron maximum Forest**. The dynamics of this community type are not well understood. In most landscapes *Pinus strobus* is considered a successional species, often present as the result of clearing and other disturbances. However, in the comparatively undisturbed old-growth **Quercus montana-Pinus strobus/Rhododendron maximum Forest** at Linville Gorge *P. strobus* may be maintained by the infertile site conditions and possibly fire (Schafale & Weakley 1990).

Although widespread throughout the Southern Appalachian Mountains, the **Rich Cove and Slope Forests** class has limited distribution in Linville Gorge, where it is restricted to a few lower- and upper-slopes. In the Southern Appalachian region, this class is typically found on lower-slopes across a broad elevational range (Whittaker 1956, McLeod 1988). The unusual upper-slope distribution of this class at Linville Gorge is associated with the presence of a band of nutrient-rich bedrock. The limited abundance of the **Rich Cove and Slope Forests** on lower-slopes is probably explained by the lack of suitable sites where lower-slopes are typically steep and highly dissected.

The composition of **Rich Cove and Slope Forests** loosely resembles descriptions by Schafale & Weakley (1990), and Whittaker (1956). Lack of similarity may, in part, reflect the limited sample size, or, as suggested by Schafale & Weakley (1990), verify the presence of a low-elevation variant of this vegetation class. Indeed, in Linville Gorge the **[Liriodendron-Carya glabra Forest]**, has closest affinities with the group described by Patterson (1994) in Ellicott Rock Wilderness, another low-elevation area in the Southern Appalachian Mountains.

The **Rock Outcrops** vegetation class in Linville Gorge separates by bedrock type, corresponding to patterns described by Wiser *et al.* (1996) in their analysis of high-elevation rock outcrops of the Southern Appalachian Mountains. However, their 1200 m elevation limit restricted sampling in Linville Gorge to the summits of Tablerock and Hawksbill Mountains. These two sites both classified into the *Aronia arbutifolia/Kalmia latifolia* outcrop community. Their community has some resemblance to the ***Rhododendron minus-Fothergilla/Leiophyllum/Selaginella tortipila*** and the ***Rhododendron minus/ Leiophyllum/Selaginella tortipila-Hypericum densiflorum sub-types*** identified in this study. The ***[Selaginella tortipila-Carex umbellata sub-type]*** and the **Selaginella tortipila Outcrops** type corresponds with the *Selaginella tortipila/Carex umbellata* Outcrop community described by Wiser *et al.* (1996) and the brief descriptions of rock outcrops in the Southern Escarpment gorges by DuMond (1970), Racine & Hardin (1975) and Larson & Batson (1978).

Community types within the **Rock Outcrops** class also separate by elevation and valley position. The **[Cheilanthes tomentosa-Danthonia spicata Outcrops]** are limited to the southern, low-elevation end of Linville Gorge and mostly lack rare species associated with high-elevations (e.g., *Liatris helleri*, *Scirpus cespitosus*, *Sibbaldiopsis tridentatus*), although *Minuartia groenlandica*, also associated with such elevations (Wiser 1994), is present. The two higher-elevation types are distributed on different sides of the Linville valley. The **Rhododendron minus/Selaginella Outcrops** are restricted to bluffs on the east side of the valley, whereas the **Selaginella tortipila Outcrops** only inhabit bluffs on the west side. The mid-slope position of the latter type protects it from the adverse climatic conditions associated with the former type. Higher heating potential of these sites may account for the lack of rare high-elevation species in the **Selaginella tortipila Outcrops**.

The two *Tsuga-Rhododendron*-dominated community types in this study correspond well to communities described elsewhere in the Southern Appalachian Mountains. The **Tsuga canadensis/Rhododendron maximum Forest** has close association with previous descriptions (e.g., Whittaker 1956, Schafale & Weakley 1990, Chapters 4 & 5). Further, as described by McLeod (1988), *Tsuga canadensis* canopy cover increases with slope steepness and, as observed here, with proximity to streams. The **Tsuga caroliniana/ Rhododendron maximum Forest**, a community with limited distribution in the Southern Appalachian Mountains, corresponds closely to the Carolina Hemlock Bluff community (Schafale & Weakley 1990), bluff stands of Carolina Hemlock (McLeod 1988) and stands at Bluff Mountain described by Humphrey (1989). As McLeod (1988) observed in the Black Mountains, this group has closest floristic association with heath vegetation in Linville Gorge. This study provides more quantitative information on a little known type.

The **Tsuga canadensis-Fagus/Ilex opaca Forest** does not fall neatly into any community previously described, possibly due to the fact that it inhabits sites that are lower in elevation than have been included in previous studies and that have mostly been destroyed for cultivation and farming. This type has closest association with Acidic Cove Forest described by Schafale & Weakley (1990), but lacks the *Rhododendron* shrub element described. It has loose resemblance to the Herb type of Hemlock Forest documented by Oosting & Bourdeau (1955), but does not contain the diversity of herbaceous species described in the latter study. The **Tsuga canadensis-Fagus/Ilex opaca Forest** have very general affiliations with the Alluvial Forest (McLeod 1988) and Disturbed Floodplain Forests of Cooper & Hardin (1970).

The three smallest vegetation classes in Linville Gorge, the **Non-Alluvial Wetlands**, **Alluvial Wetlands** and **Rocky Streamside Shrublands**, have close association with highly disturbed and particularly heterogeneous palustrine communities described by Schafale &

Weakley (1990). This study provides quantitative information on a group which in the past, because of restricted spatial distribution, has seldom been described, let alone quantified in detail (Schafale & Weakley 1990).

Quantification of species richness at 7 scales provides a means of comparing compositional differences between different vegetation classes and community types. This information has not been documented in previous studies. In general, richness in lower in ericaceous-dominated community types, with the **Acidic Cove and Slope Forests** having lowest richness at most spatial scales (Table 3.8). The trend of increasing richness from the infertile **Acidic Cove and Slope Forests** class to the nutrient-rich **Rich Cove and Slope Forests** corresponds with patterns described in other forested landscapes in the Southern Appalachian Mountains (e.g., Whittaker 1956, Graves & Monk 1985, McLeod 1988, Graves 1995, Chapters 4 & 5) and piedmont of North Carolina (e.g., Peet & Christensen 1988). Species richness is generally lower at Linville Gorge than in similar community types and vegetation classes in other Southern Appalachian landscapes (Newell & Peet 1996, Chapters 4 & 5). This is probably a consequence of the dry climate and infertile conditions at Linville Gorge.

3.6.1.2 *The Southern Blue Ridge Escarpment Gorges*

The southeastern Escarpment region of the Blue Ridge contains a series of gorges that have been compared to and contrasted with Linville Gorge, which carves through the Escarpment further north (e.g., Billings & Anderson 1966, Cooper & Hardin 1970). During the mid 1960's and early 1970's, a series of studies was undertaken to characterize the vegetation of that region; (Rodgers 1965, Rodgers & Shake 1965, Mowbray 1966, Racine 1966, Rodgers 1969, DuMond 1970, Racine 1971, Ware 1973, Racine & Hardin 1975). This work has been supplemented by more recent studies (Wentworth 1980, Tobe *et al.* 1992, Patterson 1994, Chattooga Ecological Classification Team 1995, Wiser *et al.* 1996, Zartman 1996). The article by Cooper & Hardin (1970) summarizes the vegetation communities identified in this region. Linville Gorge spans a broader elevational range than all Southern Escarpment Gorge study sites (484 to 1155 m with elevational ranges of between 500 and 700 m). Most major rivers in the Southern Escarpment have a steeper vertical descent than Linville Gorge (see DuMond 1970, p. 204). This study area has a much drier climate than the Southern gorges, where the rainfall of between 1750 mm and 2300 mm per year, is only comparable to levels measured at the summits of Mount Mitchell and the Great Smoky Mountains (Billings & Anderson 1966, Cooper & Hardin 1970, Earthinfo Inc. 1989).

All 8 Southern gorge communities recognized by Cooper & Hardin (1970) are present in Linville Gorge. The Pine Type (dominated by xeric pines) and Chestnut Oak Type are the most widespread Southern Escarpment vegetation groups. Similarly, xeric *Pinus*- and *Quercus*- dominated forests are 2 of the 3 most widely distributed vegetation groups in Linville Gorge (the **Tsuga canadensis/Rhododendron maximum Forest** is the third dominant group). At Linville Gorge, xeric *Pinus* types typically are restricted to xeric, infertile sites dominating major and minor ridgelines and slopes immediately above the bluffs. However, in the Southern Escarpment region this genus is widely distributed across a broader range of topographic and soil nutrient conditions. Differences in distribution may relate to the more dissected, highly leached Linville Gorge landscape, and possibly an absence of past logging and associated catastrophic fires in this landscape (Newell *et al.* (*in press*)). The widespread abundance of *Pinus strobus* in Ellicott Rock Wilderness may reflect the high degree of past logging and subsequent burning in this landscape. However, the absence of *Pinus echinata* at Linville Gorge and its relative abundance in Southern gorges, probably relates to the lower-elevation position of the latter region and its closer floristic association with piedmont vegetation. The presence of a series of rolling foot hills adjacent to the Southern Escarpment region perhaps allows a broader transition between piedmont and mountain species than the comparatively abrupt topographic rise from the piedmont to the eastern ridgeline of Linville Gorge.

Differences in rainfall and soil fertility probably account to some extent for differences in the presence and composition of *Quercus*-dominated forests in the 2 gorge regions. Forests dominated by *Quercus alba* inhabit similar high-elevation, upper-slope sites in both gorge regions. Descriptions by the Chattooga Ecological Classification Team

(1995), Patterson (1994) and Tobe *et al.* (1992) suggest that some Escarpment *Quercus alba* types are dominated by a higher diversity of canopy and shrub species. *Q. rubra* is locally dominant in the Southern Escarpment at high elevations (Cooper & Hardin 1970) and on steep rocky slopes (Racine & Hardin 1975), and is sufficiently distinctive in Ellicott Rock Wilderness for Patterson (1994) to describe a Red Oak Slope Forest. In contrast, in Linville Gorge this species has limited distribution throughout most *Quercus montana* community types and reaches highest abundance in the high-elevation, ridge **Carya glabra/Ageratina Forest**. Generally low *Q. rubra* abundance is probably a consequence of the infertile, dry conditions of this landscape.

The Linville Gorge study identifies a larger number of *Quercus montana*- dominated forests than the Chestnut Oak Type described by Cooper & Hardin (1970) and more recent authors. Southern Escarpment forests dominated by *Q. montana* are similar to ericaceous-dominated types in Linville Gorge by mostly having a dense ericaceous shrub stratum of either *Kalmia latifolia* or *Rhododendron maximum*. However, *Gaylussacia ursina* is also an important shrub species in the Southern region. The absence of this species at Linville Gorge is perhaps an artifact of post-Pleistocene warming, which isolated individual species and species groups within subsections of the Southern Appalachians (Ramseur 1960, Wiser 1994), rather than differences in site conditions. *Gaylussacia ursina* is restricted to 12 counties south of the Asheville Basin (Weakley 1997). Patterson (1994) also documents a similar, but *Q. rubra* ericaceous-dominated type. However, Southern Escarpment research to date has not identified the non-ericaceous-dominated *Q. montana* forests that are a striking feature of Linville Gorge. Similar open-slope sites in Southern gorges are dominated by a mix of *Quercus* and *Carya* species (DuMond 1970, Patterson 1994, Chattooga Ecological Classification Team 1995). Broader *Q. montana* distribution in Linville Gorge may be a consequence of lower rainfall, more widespread infertility, and lack of anthropogenic disturbance.

The **Tsuga canadensis/Rhododendron maximum Forest**, a widespread community type in Linville Gorge, is also a component of the Southern gorges (DuMond 1970, Anderson & Zander 1973, Racine & Hardin 1975, Patterson 1994, Chattooga

Ecological Classification Team 1995), although descriptions suggest it is less widespread in the latter area. Differences in watershed orientation might account for limited distribution in the Southern Escarpment region. Racine & Hardin (1975) suggest that most Southern gorges lack north-south orientations, which produce the cool microclimate suitable for this community type. In general, Southern Escarpment forests dominated by *Tsuga* are more species-rich, mesic communities that lack a dense ericaceous understory (Cooper & Hardin 1970, Chattooga Ecological Classification Team 1995). It should be noted that limited quantitative information from the Southern Escarpment make comparisons with Linville Gorge difficult. Most Southern gorge authors describe a continuum between ericaceous- and herbaceous-*Tsuga* forests and do not provide differentiating site characteristics.

By contrast, *Tsuga*- and *Liriodendron*-dominated **Rich Cove and Slope Forests**, represented by the Cove segregate of Mixed Mesophytic forest (Cooper & Hardin 1970; also see DuMond 1970), Cove Hardwood Forest (Racine & Hardin 1975), Mixed mesophytic type (Wentworth 1980) and Cove Forest (Patterson 1994), have much wider distribution in Southern gorges than Linville Gorge. This probably is attributable to generally dry conditions, low-nutrient soils and the lack of suitable habitat in the latter landscape. In Southern gorge sites the **Rich Cove and Slope Forests** inhabit shallow lower-slopes of predominantly north-south flowing tributaries. By contrast, most tributaries in Linville Gorge have an east-west orientation and the sites are steep. These sites at Linville are infertile and inhabited by the **Acidic Cove and Slope Forests** vegetation class.

Rock Outcrops vegetation has been documented in the Chattooga and Green Rivers and granite domes throughout the area (DuMond 1970, Racine & Hardin 1975, Wiser *et al.* 1996, Zartman 1996). Dry rock surfaces are inhabited by vegetation similar to the ***[Selaginella tortipila-Carex umbellata sub-type]***. In contrast to Linville Gorge, there are extensive mats of bryophytes, wetland vascular species and ferns on moist rocks in the forest or at the base of waterfalls (Billings & Anderson 1966, Racine & Hardin 1975, Zartman 1996). Linville Gorge does not have extensive areas of moist rock faces to support such a vegetation group (Anderson & Zander 1973), although *Asplenium montanum* is sparsely distributed in small crevices of isolated, moist bluffs in steep forested slopes on the west side of the valley.

In both gorge areas, the **Rock Outcrops** have special significance with nationally and regionally listed species, Pleistocene relicts, pre-Pleistocene tropical relicts and Southern Appalachian endemics present in this habitat. In Linville Gorge, alpine relicts (e.g. *Scirpus caespitosa*; Wiser 1994), inhabit dry, highly exposed outcrops. In the Southern gorges the moist, sheltered gorge walls and spray cliffs harbor relict mesic disjunct or endemic species (e.g. *Asplenium monanthes, Plagiomnum carolinianum*; Billings & Anderson 1966,), including vascular and bryophytic species with tropical affinities (e.g., *Vittaria appalachiana*; Farrar & Mickel 1991, *Trichomanes boschianum*; Zartman 1996) and northern Pleistocene relicts reaching their southern limits (e.g., *Fontinalis sphagnifolia, Huperzia porophila*; Zartman 1996).

Of the remaining communities, Cooper & Hardin (1970) and Tobe *et al.* (1992) document alluvial and stream communities similar to some of those identified in Linville Gorge. Although stands dominated by *Tsuga caroliniana* have not been found in the Southern Escarpment, this species is scattered throughout forests of this region (M. Schafale, C. Zartman *pers. comm.*). However, no temporary ponds have been recognized in the Southern Escarpment gorge region.

3.6.1.3 *The Piedmont Monadnocks*

The more xeric, infertile vegetation classes identified in Linville Gorge have some affiliation with the monadnocks situated on the western piedmont of North Carolina. The dominance of *Quercus montana* as a canopy species of the vegetation at Pilot Mountain (Williams & Oosting 1944) and Hanging Rock (McCurdy 1975) follows the pattern found at Linville Gorge. This reflects the dry climate of all three areas. *Quercus* forests at South Mountains appear to be dominated by a greater diversity of *Quercus* species (La Verne Smith 1982), however, this may reflect the less specialized level of descriptions in that study rather than the communities themselves. Specific Monadnock communities have closest association with the **Xeric Evergreen Forests** class. Some species differ in abundance, for example *Rhododendron catawbiense* has greater dominance on the Monadnocks. There is a larger proportion of the piedmont species present in the Monadnock flora (e.g. *Q. marilandica*). The Hemlock-Rhododendron-Galax Forest at Hanging Rock, dominated by *Tsuga caroliniana* and *R. catawbiense*, closely resembles the **Tsuga caroliniana/ Rhododendron maximum Forest** in species composition, stature and habitat. In this landscape the Hemlock-Rhododendron-Galax Forest occupies some of the habitats dominated by *T. canadensis* in Linville Gorge. However, in contrast to Linville Gorge, *T. canadensis* is a minor component at Hanging Rock and is absent from Pilot Mountain.

Two communities at Hanging Rock some resemblance to the already discussed non-ericaceous *Quercus montana* forests at Linville Gorge. The Chestnut Oak-Pitch pine-White Oak Community, common to south and southeast slopes, has closest association with the **Quercus montana/Oxydendrum/Cornus florida Forest** with its open understory and sparsely scattered grasses on the forest floor. The Chestnut Oak-Scarlet Oak-White Oak-Dogwood with a canopy of mixed *Quercus*, a subcanopy of *Cornus florida* and scattered shrubs and mesic herbs on the forest floor has closest affinities with the **Quercus montana/Cornus florida Forest**. There are no comparable communities on Pilot Mountain.

Comparisons of **Rock Outcrops** vegetation are difficult. This class is not well developed on Pilot Mountain, whereas at Hanging Rock this vegetation class has been destroyed by trampling.

Such comparisons with the Southern Appalachians at large and with more specific regions indicate that the xeric communities of Linville Gorge share some affiliation with the piedmont Monadnocks, the Southern Blue Ridge Escarpment gorges and other dry areas of the Southern Appalachian Mountains. However, Linville Gorge differs from the Southern Appalachians at large by the combination and abundance of communities present. In Linville Gorge *Quercus montana* dominates a broader range of communities, with small spatially restricted communities such as the **Rock Outcrops** and **Tsuga caroliniana/**

Rhododendron maximum Forest well represented, whereas regionally widespread vegetation classes such as the **Rich Cove and Slope Forests** have very restricted distribution. Moreover, in contrast to many Southern Appalachian landscapes, there is an overall dominance of vegetation associated with xeric and acidic conditions.

3.6.2 Vegetation - environment relationships

This study has shown that vegetation patterns within the Linville Gorge landscape are primarily controlled by gradients of soil nutrients (in particular Mn, pH and Ca), soil texture, topographic characteristics and geology. Across this landscape, the **Rock Outcrops** and **Rich Cove and Slope Forests** vegetation classes inhabit opposing extremes of the soil nutrient-texture gradient with the other classes distributed between (Figures 3.2, 3.3). The four major forest vegetation classes separate from one another by soil nutrients, texture, solar radiation, slope position and microtopographic shape (Figures 3.5, 3.6). The **Acidic Cove and Slope Forests** and **Xeric Evergreen Forest** occur on coarse-textured infertile sites which are typically underlain by lower quartzite. These two classes separate from one another by slope position and site moisture, with the former on sheltered lower-slope sites. The **Rich Cove and Slope Forests** and **Montane Oak Forests** inhabit more fertile sites with the latter class located on dryer sites with higher slope positions (Figures 3.5, 3.6). The distribution of these 4 classes across the Linville Gorge landscape corresponds with descriptions from other Southern Appalachian landscapes (e.g., Whittaker 1956, Callaway *et al.* 1987, McLeod 1988, Patterson 1994, Chapters 4 & 5). However, the dominance of the **Xeric Evergreen Forest** in Linville differs to most landscapes in this region. The low-elevation distribution of Linville Gorge, coupled with low-rainfall and infertile soil conditions, associated with underlying bedrock, at least in part account for the dominance of this class. Moreover, the topographic complexity of this landscape probably accentuates levels of soil infertility.

The high correlations between extractable manganese (Mn) and vegetation composition observed in this study have been documented in other Southern Appalachian landscapes (Graves & Monk 1985, McLeod 1988, Patterson 1994, Newell *et al. in press*, Chapters 4 & 5) and forests elsewhere (e.g., Palmer 1990, R.P. Duncan & R.K. Peet *unpub. data*). Manganese is known to precipitate readily in acidic, well-drained soils (Collins & Buol 1970) and perhaps serves as a surrogate for the combined influence of original fertility and degree of leaching. Within the pH range of these studies, Mn has been shown to be highly positively correlated with pH and soil moisture status (McLeod 1988, Patterson 1994, Chapters 4 & 5), although Mn is generally thought to be negatively correlated with pH (see Brady 1974). Reasons for the patterns observed in this study and other Southern Appalachian landscapes are not obvious. Further research is needed to be determine the specific links between soil moisture, available Mn and vegetation composition.

My results show that environmental factors associated with vegetation change with both scale of observation and specific vegetation group. At the landscape-scale, elevation is not significantly associated with distribution of the collective group of vegetation classes. However, at the single vegetation class-scale, elevation is a significant factor for describing compositional differences between individual community types (Figures 3.8, 3.9, 3.11, 3.12, 3.16, 3.17, 3.18, 3.19). Similarly, subtle differences in topographic shape and topographic complexity of the surrounding area are not strongly associated with vegetation patterns at the landscape-scale, but are important factors for distinguishing fine-scale environmental differences between types within a vegetation class. This emphasizes the importance of examining vegetation patterns at different spatial scales to fully understand the ecological processes associated with vegetation distribution.

This study reiterates and refines the significance of topography and the "topographic-moisture gradient" described in the past by Whittaker (1956), and others (e.g., Golden 1981, Callaway *et al.* 1987, McLeod 1988). However, the primary importance of soil nutrients and soil texture on vegetation distribution in Linville Gorge contrasts to previous studies in the Southern Appalachian Mountains which have identified elevation as the most important gradient (e.g., Whittaker 1956, Golden 1981, Callaway *et al.* 1987, Busing *et al.* 1993). Linville Gorge has a shorter elevational range than in areas studied by Whittaker (1956), Callaway *et al.* (1987) and McLeod (1988). However, the fact that the elevational range at Linville is similar to the landscapes studied by Golden (1981) and

Busing *et al.* (1993), where elevation was identified as the most important gradient, suggests environmental processes associated with vegetation patterns may change from one landscape to another. This highlights the need for future vegetation studies to include detailed soil information and quantified topographic characterization.

Most past vegetation studies within the Southern Appalachian Mountains have inferred the importance of soil and topography on vegetation distribution (e.g., Whittaker 1956, Rodgers 1965, Mowbray 1966, Racine 1966, DuMond 1970, Racine & Hardin 1975). Unlike many studies of the past, this present study was able to use quantitative topographic information. My results show the need for a broad range of topographic characteristics to adequately quantify vegetation-environment relationships. Characteristics such as site protection (LFI), site moisture (quantified using solar radiation and site moisture potential (TMI)) and microtopographic shape (section and profile curvature, TSI) were correlated with vegetation distribution.

Quantitative information in recent studies have identified various soil characteristics as the third most important environmental gradient influencing vegetation patterns in the Southern Appalachian Mountains. Individual studies have identified the significance of soil nutrients (Graves & Monk 1985, McLeod 1988), pH and water holding capacity (Callaway *et al.* 1987), pH and clay content of the B horizon (Golden 1981) and clay to sand ratio in the B horizon (Mowbray & Oosting 1968) on species composition and individual tree species distributions. However, analyses by McLeod (1988) and the results of this study suggest that soil may have primary influence on vegetation in moderate- and lower-elevation areas.

McLeod (1988) found that stands in the Craggy and Black Mountains were primarily distributed with respect to elevation. However, after fragmenting stands into two elevation-based strata, (*sensu* Peet 1980), he found that the two subsets showed strong correlations with different environmental variables. Above 1500 m, stands were distributed primarily along an elevational gradient (stand elevational range of 485m), whereas stands below 1500 m (elevational range of 1080m) were primarily influenced by soil nutrient and topographic gradients, and only secondarily elevation. Work by Busing *et al.* (1993) in a

1250-2025 m elevation area of the Smoky Mountains further confirms the importance of elevation at high-elevation sites. In much the same fashion, this study of Linville Gorge has found that vegetation distribution in a low-elevation mountain landscape of the Southern Appalachian Mountains relates to soil nutrients and topographic characteristics. A similar trend has been described by Patterson (1994) in another low-elevation locality further south in the North Carolina section of the Appalachians. These results suggest that within this region different processes may influence vegetation distribution within different broad topographic or elevational bands.

I hypothesize that vegetation inhabiting highly dissected mid- and lower-slope regions within the Southern Appalachians Mountains are influenced by a broader range of topographic and soil extremes (e.g. a gradient from highly exposed, xeric, infertile ridges to sheltered, nutrient-rich coves) than higher-elevation sites where such differences are more subtle due to the less dissected topography and the more exposed conditions associated with these sites. Such sites also tend to have thin soils and limited soil development. At high-elevations where these topographic subtleties exist, elevational factors appear to override other environmental factors and have the primary influence on vegetation distribution. This contrasts with lower-elevations (e.g. Linville Gorge, Ellicott Rock Wilderness) where dramatic topographical differences heighten topographic and soil extremes, seemingly fragmenting the effects of the overlying elevational gradient. The results of this study suggest that elevation will be of primary importance at lower-elevations only where differences in topography and soil are subtle (i.e., where topographic and soil gradients are short). The distribution of **Xeric Evergreen Forests** on the infertile, comparatively undissected slopes above the escarpments in Linville Gorge is one such example.

Compositional and environmental variation in Linville Gorge also reflects geologic differences. Soils underlain by lower quartzite tend to be less fertile and coarse-textured in comparison to the nutrient-rich, fine-textured soils of stands on gneiss bedrock. Stands on meta-arkose are intermediate between these two extremes. Few studies in the Southern Appalachian Mountains have examined vegetation in relation to geologic substrate.

Correlations between compositional variation and rock type have been observed by Wiser *et al.* (1996) in high-elevation Rock Outcrop communities in the Southern Appalachian Mountains and by Rohrer (1983) in a forest community study in the Hanging Rock area (Watauga County).

The results of this study reiterate the need for detailed soil analysis and quantitative topographic characterization to fully understand the vegetation patterns in the Southern Appalachian Mountains. This study also emphasizes the complexity of vegetation patterns in the Southern Appalachian Mountains and suggests that topographic complexity may be the most important factor for the distribution of species in the Southern Appalachian Mountains.

The combination of rugged topography, low rainfall, predominance of acidic bedrock (causing widespread infertility) and the lack of anthropogenic disturbance in Linville Gorge Wilderness have provided an environment in which an unusual aggregation and abundance of vegetation communities have been able to form and be maintained. The overall dominance of *Quercus montana* and vegetation associated with xeric or acidic conditions, and the presence of a significant number of spatially restricted ecosystems and species, illustrates the distinctiveness of this landscape in relation to the rest of the Southern Appalachian Mountains. Factors controlling the distribution of vegetation in Linville Gorge also differ from the Southern Appalachian region in general. In Linville vegetation is controlled primarily by soil nutrients, soil texture and topography, rather than elevation which is the primary environmental gradient in most other landscapes in this region. Moreover, the fact that this Wilderness is one of only three remaining large, intact areas of old-growth forest further amplifies the significance of this landscape and the importance of understanding vegetation communities and the ecological processes that are present in this unique portion of the Southern Appalachian Mountains.

3.7 Overall trends and future research needs

This study has documented the dominance of *Quercus montana* in the canopy of many community types. However, woody stem summary data identifies the virtual lack of

Q. montana (or other *Quercus* species) stems in the smaller stem size classes, with the exception of one type, the **Quercus montana/Galax Forest**. The lack of *Quercus* regeneration has been widely observed throughout eastern North America and is not confined to Linville Gorge or even the Blue Ridge (Lorimer 1989, Abrams 1992). At Linville, *Acer rubrum* presently dominates the smaller size classes in most community types, in conjunction with *Pinus strobus* and *Tsuga canadensis* in some types. This information suggests that with time the dominance of *Quercus montana* as a canopy species will diminish with *Acer rubrum* taking over this role. This trend is most likely a consequence of the loss of natural fire and is unlikely to be reversed without reinstating the natural fire regime. This highlights the need for research to determine a fire-disturbance regime which will enable present-day canopy species in Linville Gorge (with emphasis on *Quercus* species) to regenerate and maintain their dominance.

The results of this study make clear the roles of soil nutrients, soil texture and topography in the distribution of vegetation in Linville Gorge. However, more detailed study is needed to understand the specific links between soil nutrients, geology, topography and vegetation attributes such as community distribution and species richness.

This study highlights several community types that have limited spatial distribution in the Southern Appalachian Mountain region and provides information on their composition and ecology. To ensure the continuing survival of these spatially restricted types, particularly non-seral groups, such as the **Tsuga caroliniana/Rhododendron maximum Forest**, further study is necessary with research efforts concentrated on demographic issues and community type maintenance. Methods to reduce the effect of human disturbance on **Rock Outcrop** community types must also be identified. Present human activities continue to reduce the spatial distribution of these types threatening the existence of associated rare species and the overall long-term survival of these groups in Linville Gorge.

The impending invasions by pests such as gypsy moth, hemlock adelgid and dogwood anthracnose, and the increasing levels of air pollution make it important that we learn as much as we can about the old-growth forests of Linville Gorge as soon as possible.

The opportunity will soon be lost. This study has identified the presence of specific community types, their spatial distribution on the landscape and their relationships with specific environmental factors. However, the detailed demographic and life history information needed for understanding community dynamics and stability is still lacking.

CHAPTER 4. VEGETATION OF SHINING ROCK WILDERNESS

4.1 Community classification

Twenty nine community types were recognized in Shining Rock using Ward's clustering method (Figure 4.1, Table 4.1, Appendix 2). All 160 plots sampled and all 433 species were used in this classification. Eleven of the twelve vegetation classes present in the Southern Appalachian Mountains have been identified in Shining Rock (see Table 2.3). Synonymy between the Shining Rock classification and the nationally recognized classification scheme developed by The Nature Conservancy is tabulated in Appendix 2. In the appendix "new alliance" and "new association" identifies cases where the results of the project have revealed communities which need to be added to The Nature Conservancy classification.

Groupings in the classification of Shining Rock vegetation, generated using Ward's clustering technique, were accepted as community types at the R squared = 0.436 level (Figure 4.1). Divisions below this level subdivided closely associated groups, whereas those above lumped groups easily recognizable in the field. In this study, a total of 11 vegetation classes, 29 community types and 4 community sub-types were identified (Figure 4.1, Table 4.1).

4.2 Mapping

A detailed map of Shining Rock was produced showing the distribution and boundaries of the community types identified in this study (Appendix 5). Locations of the spatially restricted **Rock Outcrops** vegetation class were not mapped as this class is distributed on small, isolated openings scattered throughout the Wilderness that are spatially smaller than the lowest mapping polygon size (75 x 75 m) used.

Table 4.1. Hierarchical community classification of Shining Rock Wilderness. Each vegetation class is shown, listing all community types and community sub-types present. Names of the three levels of the hierarchy are as follows: Vegetation Class (e.g. code 5), Community type (e.g. code 5.6), Community sub-type (e.g. 5.6.1). A name enclosed by [] represents a tentative name owing to limited sample size. For the list of sample sites in each group see Appendix 2.

1. <u>Rock Outcrops</u>

2. <u>Non-Alluvial Wetlands</u>
   - 2.1 [Carex gynandra Wetland]
   - 2.2 Carex ruthii Wetland

3. <u>Shrub Balds</u>
   - 3.1 Picea/Rhododendron catawbiense Shrubland
   - 3.2 [Rhododendron catawbiense-Pieris Shrubland]

4. <u>Grasslands</u>
   - 4.1 [Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]
   - 4.2 Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland
   - 4.3 [Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]

5. <u>High-Elevation Mixed Hardwood Forests</u>
   - 5.1 Fagus/Carex pensylvanica Forest
   - 5.2 Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest
   - 5.3 Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest
   - 5.4 Betula alleghaniensis/Ageratina-Aster acuminatus Forest
   - 5.5 Quercus rubra-Picea/Carex pensylvanica Forest
   - 5.6 Quercus rubra/Kalmia Forest
     - 5.6.1 Quercus rubra/Kalmia-Rhododendron catawbiense sub-type
     - 5.6.2 Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type

6. <u>Spruce-Fir Forests</u>
   - 6.1 [Picea/Dennstaedtia Forest]

7. <u>Acidic Cove</u> and <u>Slope Forests</u>
   - 7.1 Tsuga canadensis-Betula lenta/Rhododendron maximum Forest
   - 7.2 Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest
   - 7.3 Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest

8. <u>Xeric Evergreen Forests</u>
   - 8.1 Quercus montana-Quercus rubra/Kalmia Forest
   - 8.2 Pinus pungens-Quercus montana/Kalmia Forest
   - 8.3 Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest

Table 4.1 *cont.* Hierarchical community classification of Shining Rock Wilderness vegetation.

9. Montane Oak Forests

- 9.1 Quercus montana/Oxydendrum/Kalmia Forest
- 9.2 Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest

10. Rich Cove and Slope Forests

- 10.1 Quercus rubra-Carya glabra/Cornus florida Forest
  - 10.1.1 Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type
  - 10.1.2 Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanicum sub-type
- 10.2 Liriodendron/Halesia Forest
- 10.3 Quercus rubra-Halesia/Acer saccharum Forest
- 10.4 Betula lenta-Robinia pseudo-acacia/Ageratina Forest
- 10.5 Tilia-Betula lenta Forest
- 10.6 Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest

11. Alluvial Forests

- 11.1 [Betula alleghaniensis/Salix nigra Alluvial Forest]

4.3 Relationship of vegetation composition to major environmental gradients across the Shining Rock landscape

To understand how vegetation patterns and specific vegetation classes and community types are distributed across the Shining Rock landscape with respect to environmental conditions, ordination (DCA) was used to identify major compositional gradients within the Shining Rock dataset. Associations between the first two compositional gradients and specific environmental variables were quantified using regression to identify site factors that correspond with vegetation patterns.

After the elimination of the low-elevation **Alluvial Forest** stand (plot 350), which was placed within the high-elevation stands in preliminary ordinations, the remaining 159-stand dataset, representing 10 of the 11 vegetation classes (Figure 4.1, Table 4.1), was used in the first DCA analysis. Ordinations were performed on subsets of closely associated vegetation classes in an effort to fully understand the compositional and environmental relationships of each vegetation class and associated community types. A scatterplot diagram shows the distribution of stands by vegetation class and/or community type (e.g., Figure 4.2) with stands positioned by their scores on the primary and secondary compositional gradients (Axis 1 and Axis 2) of the respective DCA ordination. Statistically significant relationships ($P \leq 0.01$) between the first two compositional gradients (axes) and environmental variables, identified in the regression analyses, are represented by a vector diagram (e.g. Figure 4.3); each environmental variable is represented by a vector where the direction of maximum change indicates the relative correlation with the two axes and the vector length indicates the strength of the association (ter Braak 1986, 1987).

4.3.1 Ordination of the 159 stand dataset

Vegetation classes are distributed across the Shining Rock landscape primarily along elevation, potential rainfall and topographic position gradients. The four mid- and lower-elevation vegetation classes, distributed diagonally from the upper center of the diagram to the lower left (Figure 4.2), are positioned at the lower end of the elevation gradient (Figure 4.3), typically further away from the rainfall source areas (ESCRIDGE & HIGHRIDG) than the high-elevation vegetation classes distributed on the right of the scatterplot. The vegetation classes are also separated by relative slope position, site protection (LFI), site moisture potential (TMI) and soil fertility (pH and Mn), with the **Rich Cove and Slope Forests** class positioned at one end of these gradients on more protected, moister, fertile, lower-slope sites than the other classes and the **Rock Outcrops** class situated at the opposing ends of these gradients.

The relationship between underlying geologic type and the major compositional gradients was also investigated. A multiple analysis of variance indicates that the three major geologic types have statistically significantly different soil chemistry and texture (Tables 4.2, 4.3). Stands were classified on the scatterplot by their bedrock type in an attempt to identify correlations between geology and vegetation patterns. However, while the few stands underlain by quartz and migmatite are mostly concentrated in the high-elevation portion of the diagram, the majority of stands did not separate well by rock type. Similar results were found in all subsequent ordination analyses and, as a consequence, no diagrams displaying stands classified by geologic type were included.

The ordination showed that the stands divided into two distinct vegetation class subsets. The four mid- and low-elevation vegetation classes form a separate cloud of points on the scatterplot from the remaining six high-elevation classes, with the separation between these two groups of classes running perpendicular to the elevation-rainfall gradient (Figures 4.2, 4.3). However, stands within each subset were not well grouped by their respective vegetation class and this restricts vegetation-environment interpretation. In an attempt to clarify compositional and environmental differences between individual vegetation classes the 159-stand dataset was fragmented into the two subsets (shown by the black line; Figure 4.2) with each analyzed separately.

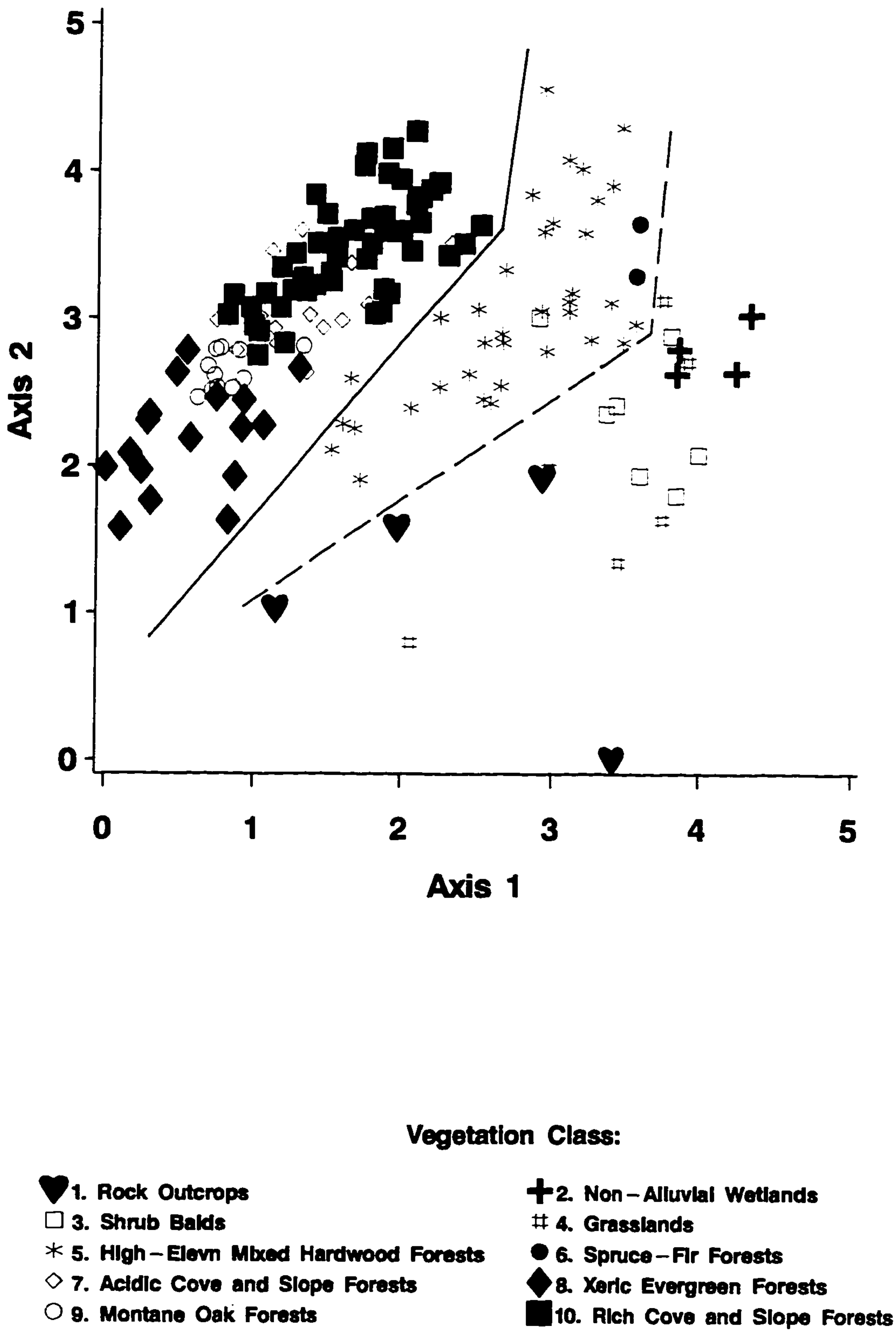
Subsequent ordinations of the mid- and low-elevation subset, consisting of the **Acidic Cove and Slope Forests, Montane Oak Forests, Rich Cove and Slope Forests** and **Xeric Evergreen Forests** classes are discussed at the beginning of the description for the **Acidic Cove and Slope Forests** (p. 375). Preliminary analyses of the six high-elevation vegetation classes maintained the separation of the **Grasslands, Non-Alluvial Wetlands,**

Rock Outcrops, **Shrub Balds** (shown by the dashed line; Figure 4.2) from the majority of stands in the remaining two vegetation classes, with the former group of classes consistently inhabiting drier (higher solar radiation), upper-slope, generally higher elevation positions, as shown in Figure 4.2. Accordingly, these classes were removed from the ordination of high-elevation stands. Ordinations of the **High-Elevation Mixed Hardwood Forests** and the **Spruce-Fir Forests** are discussed at the beginning of the **High-Elevation Mixed Hardwood Forests** description (p. 74).

4.4 Summary soil and species richness information

To aid in accessibility and for ease of interpretation and comparisons between different vegetation groups in Shining Rock, I have summarized average soil chemistry and textural information for all 11 vegetation classes in two tables (Tables 4.4, 4.5) and these are presented before the section containing the descriptions of each individual vegetation class. Similarly, species richness values for all vegetation classes and associated community types, averaged at each of the seven spatial scales measured, are presented in Table 4.6 before the vegetation class descriptions.

Figure 4.2. DCA ordination diagram of 159 sample plots and showing vegetation class distribution on the two major compositional gradients. The solid line represents separation of stands into two groups for subsequent ordinations, while stands to the right of the dotted line were eliminated from future ordinations.



5
4
3
2
1
0
Axis 2
0
1
2
3
4
5
Axis 1
Vegetation Class:
1. Rock Outcrops
2. Non-Alluvial Wetlands
3. Shrub Balds
4. Grasslands
5. High-Elevn Mixed Hardwood Forests
6. Spruce-Fir Forests
7. Acidic Cove and Slope Forests
8. Xeric Evergreen Forests
9. Montane Oak Forests
10. Rich Cove and Slope Forests

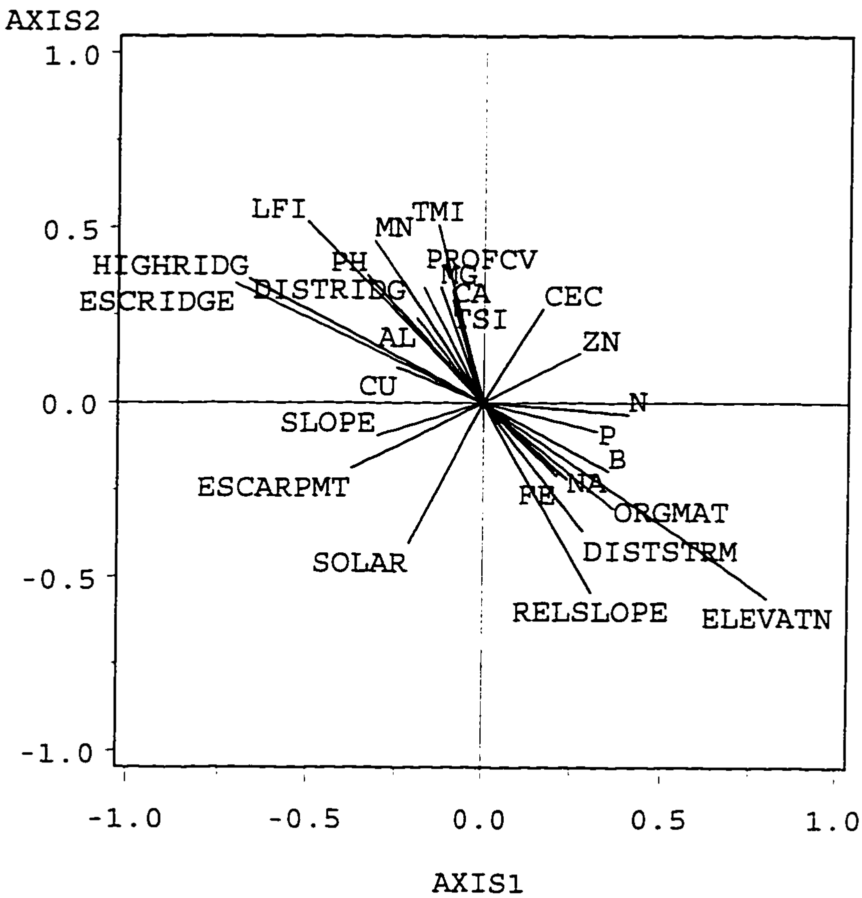


Figure 4.3. Vector diagram for DCA ordination of 159 sample plots showing association between species composition and major environmental gradients. DISTRIDG=distance to ridge, DISTSTRM=distance downslope to stream/cove, ESCARPMT=average distance to escarpment region, HIGHRIDG=distance to nearest high-elevation area, ESCRIDGE= ESCARPMTxHIGHRIDG, PROFCV=profile curvature, RELSLOPE=relative slope position, with increasing values corresponding to higher position. Small LFI values represent unprotected upper-slopes progressing through to high values representing sheltered, lower-slopes and coves. Low TSI values represent convex upper-slopes while high values represent concave lower-slopes.

Table 4.2. Mean soil nutrient and texture values for sample sites in each parent material type. Only the 131 stands with known parent material were used. Parent material type abbreviations are as follows: mg=mica gneiss, gms=garnet-mica schist, m=migmatite, q=quartz. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmat) (by loss on ignition) and soil bulk density (dens). Values of sand, silt and clay are given as percentages. N represents the number of stands in each parent material type.

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
mg	1349.75	0.48	504.67	1.24	301.87	82.14	80.03	67.66	69.75	12.96	26.65	59.11	3.35	10.66	4.20	23.53	0.73	39.96
gms	1267.41	0.47	309.81	1.11	350.28	88.97	79.63	68.41	71.63	12.00	24.50	61.78	3.22	9.16	4.01	26.69	0.66	36.42
m	1190.88	0.52	316.06	1.02	383.24	84.35	64.53	49.53	73.47	13.65	44.06	94.00	3.01	9.92	3.86	32.28	0.72	34.21
q	399.33	0.49	449.00	0.35	114.33	115.00	93.67	4.00	75.00	17.67	27.33	41.67	9.27	18.46	3.40	87.53	0.36	29.00

	Sand	Silt	Clay	N
mg	56.21	35.87	7.92	79
gms	43.63	50.87	5.51	32
m	35.00	61.34	3.66	17
q	0.93	94.23	4.84	3

Table 4.3. Results from a multivariate analysis of variance to determine the significance of soil characteristics (nutrients and texture) per parent material type. Only the 131 stands with known parent material and classified in the three major parent material types (mica gneiss, garnet-mica schist, migmatite) were included. These analyses were performed using the General Linear Models Procedure for unbalanced designs.

Statistic	F value	Pr > F
Wilks' Lamba	2.026	0.0006
Pillai's Trace	1.975	0.0010
Hotelling-Lauley Trace	2.076	0.0004
Roy's Greatest Root	3.117	0.0001

Table 4.4. Mean soil nutrient values by vegetation class and associated community types and sub-types. Groups are referenced by their abbreviation code. For full names see Table 4.1. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmt) (by loss on ignition) and soil bulk density (dens).

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
1.	1083.75	0.55	219.50	1.35	430.75	76.50	72.00	11.00	72.00	14.25	58.00	105.75	2.20	8.38	3.80	31.55	0.73	33.00
2.	812.25	0.62	411.75	1.35	284.25	63.50	75.25	71.75	71.00	38.25	55.25	103.25	3.61	12.17	4.03	43.27	0.90	37.56
2.1	777.00	0.71	532.00	1.11	383.00	93.00	121.00	194.00	70.00	22.00	128.00	215.00	4.50	17.25	3.80	21.75	0.92	33.00
2.2	824.00	0.59	371.67	1.43	251.33	53.67	60.00	31.00	71.33	43.67	31.00	66.00	3.31	10.48	4.11	50.44	0.88	39.08
3.	813.86	0.55	373.86	0.51	339.43	109.14	74.29	10.29	73.57	14.29	25.00	51.00	5.83	13.93	3.59	59.11	0.59	30.89
3.1	712.20	0.51	326.20	0.47	270.60	94.80	74.00	5.20	73.00	15.80	29.00	55.20	6.67	13.61	3.49	69.33	0.50	29.85
3.2	1068.00	0.65	493.00	0.60	511.50	145.00	75.00	23.00	75.00	10.50	15.00	40.50	3.75	14.75	3.85	33.55	0.82	33.50
4.	1187.83	0.63	814.17	1.93	443.67	90.67	80.83	48.00	73.33	13.17	38.33	79.33	4.95	14.37	4.15	24.19	0.81	40.04
4.1	1256.50	0.71	1594.50	2.78	411.50	101.00	108.50	48.50	75.00	12.00	29.00	35.50	7.95	19.17	4.65	24.98	0.82	50.75
4.2	1166.00	0.64	397.67	1.70	555.67	78.00	67.67	48.67	71.67	14.33	49.00	109.33	3.96	12.45	3.76	24.47	0.85	32.58
4.3	1116.00	0.46	503.00	0.94	172.00	108.00	65.00	45.00	75.00	12.00	25.00	77.00	1.90	10.51	4.30	21.80	0.64	41.00
5.	1388.56	0.47	274.97	1.06	351.31	80.64	61.33	54.53	71.53	11.53	26.56	63.83	2.85	7.88	4.04	25.09	0.72	36.82
5.1	1115.00	0.57	253.33	0.87	393.33	70.00	48.33	88.67	72.67	12.00	62.33	115.33	2.59	8.21	3.79	30.44	0.73	32.92
5.2	1313.88	0.50	311.00	1.31	371.13	85.13	66.13	29.38	72.25	12.25	21.63	59.00	3.40	9.16	4.01	26.81	0.69	36.30
5.3	1456.50	0.54	170.25	0.97	474.75	80.50	43.75	24.75	73.75	10.00	23.75	68.75	2.48	6.13	3.89	30.16	0.75	33.92
5.4	1421.71	0.42	341.71	0.97	303.86	77.86	63.29	46.29	69.43	10.57	22.43	50.71	2.06	8.02	4.17	20.08	0.78	39.36
5.5	1479.40	0.45	221.20	1.16	323.80	102.40	93.40	89.00	74.60	12.20	17.20	47.20	4.25	7.50	4.18	29.02	0.72	38.97
5.6	1439.67	0.45	274.67	0.97	317.00	70.33	49.89	66.00	69.44	11.78	28.67	68.22	2.47	7.52	4.04	21.24	0.70	36.72
5.6.1	1381.33	0.46	283.17	1.13	348.50	79.50	54.17	83.33	71.67	11.83	28.17	69.33	2.95	8.04	4.02	23.96	0.67	36.46
5.6.2	1556.33	0.42	257.67	0.65	254.00	52.00	41.33	31.33	65.00	11.67	29.67	66.00	1.50	6.47	4.08	15.79	0.76	37.25
6.	1395.50	0.58	171.50	0.55	529.50	52.00	56.00	10.00	75.00	12.00	25.50	76.00	2.26	7.76	3.51	32.78	0.84	30.00

Table 4.4. *cont.* Mean soil nutrient values by vegetation class and associated community types and sub-types. Groups are referenced by their abbreviation code. For full names see Table 4.1. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmt) (by loss on ignition) and soil bulk density (dens).

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
7.	1121.76	0.47	379.65	0.92	361.53	81.94	80.71	50.94	71.59	12.41	27.35	62.00	2.58	10.42	3.98	28.76	0.64	36.21
7.1	1068.83	0.55	517.17	0.79	407.67	91.33	101.67	76.50	71.00	13.17	28.83	63.50	2.36	11.94	4.11	28.27	0.76	38.63
7.2	1282.00	0.43	304.60	1.05	341.80	58.80	62.80	63.40	68.60	11.40	24.80	63.60	2.70	8.76	3.98	19.46	0.67	36.15
7.3	1041.17	0.43	304.67	0.95	331.83	91.83	74.67	15.00	74.67	12.50	28.00	59.17	2.71	10.30	3.85	37.00	0.51	33.85
8.	1228.94	0.46	240.94	1.24	362.29	77.82	51.00	25.00	68.00	11.41	16.88	52.65	2.27	7.09	4.07	23.76	0.68	37.64
8.1	1554.33	0.43	222.00	1.50	333.33	56.67	28.00	11.33	61.67	9.00	7.33	57.33	1.32	5.34	4.24	11.50	0.88	39.94
8.2	1197.25	0.43	262.38	1.02	353.88	92.13	60.00	19.50	69.13	12.00	17.88	50.50	2.87	8.06	4.00	28.95	0.59	36.09
8.3	1108.50	0.52	221.83	1.40	388.00	69.33	50.50	39.17	69.67	11.83	20.33	53.17	1.95	6.66	4.08	22.96	0.71	38.54
9.	1281.29	0.40	210.86	1.17	273.07	73.43	63.50	76.29	67.36	11.14	17.93	50.50	2.98	6.58	4.11	21.42	0.70	37.73
9.1	1212.56	0.41	212.78	1.04	293.67	76.78	69.44	85.11	67.78	11.11	19.11	51.11	2.86	7.02	4.07	23.16	0.68	37.00
9.2	1405.00	0.38	207.40	1.40	236.00	67.40	52.80	60.40	66.60	11.20	15.80	49.40	3.18	5.81	4.17	18.30	0.74	39.05
10.	1364.42	0.47	687.69	1.41	240.88	94.31	115.79	125.54	69.54	12.35	29.04	61.60	3.64	13.11	4.39	21.62	0.69	43.57
10.1	1377.24	0.44	558.18	1.74	213.35	92.71	116.71	177.24	68.35	12.47	22.82	56.29	2.77	10.71	4.54	19.55	0.67	46.15
10.1.1	1424.71	0.38	412.00	1.64	175.43	92.00	75.86	114.86	70.14	12.71	20.43	51.14	2.84	8.57	4.46	21.81	0.62	44.61
10.1.2	1344.00	0.48	660.50	1.80	239.90	93.20	145.30	220.90	67.10	12.30	24.50	59.90	2.73	12.21	4.59	17.98	0.70	47.23
10.2	1237.13	0.44	972.63	1.32	185.13	116.00	181.75	97.38	68.88	12.38	20.13	45.88	2.87	14.31	4.74	20.02	0.70	51.16
10.3	1545.60	0.47	401.60	1.39	263.20	88.80	69.80	60.60	71.60	12.60	16.80	53.60	3.57	9.63	4.19	22.85	0.77	38.75
10.4	1235.83	0.48	380.83	1.15	348.17	91.00	71.33	61.00	73.67	12.33	25.33	61.67	2.91	11.12	3.93	28.69	0.63	35.38
10.5	1280.30	0.55	1112.90	1.48	281.20	97.10	141.10	143.10	70.50	12.70	36.00	73.80	7.20	20.77	4.33	24.73	0.68	42.13
10.6	1615.67	0.42	511.33	0.79	200.17	73.17	65.83	106.00	66.33	11.17	60.83	83.83	1.96	10.47	4.26	16.30	0.78	40.75
11.	1005.00	0.39	230.00	1.22	239.00	19.00	41.00	80.00	56.00	11.00	30.00	47.00	2.30	4.93	4.30	7.10	0.92	41.00

Table 4.5. Mean soil texture values for each vegetation class and associated community types and sub-types. All groups are represented by their abbreviation code. For full names see Table 4.1. Values of sand, silt and clay are given as percentages.

	Sand	Silt	Clay
1.	57.00	35.44	7.56
2.	17.50	73.83	8.67
2.1	47.80	49.00	3.20
2.2	7.40	82.11	10.49
3.	20.46	74.65	4.89
3.1	7.52	87.98	4.50
3.2	52.80	41.32	5.88
4.	54.95	38.05	7.00
4.1	73.50	15.08	11.42
4.2	32.23	65.35	2.41
4.3	86.00	2.08	11.92
5.	53.40	40.35	6.26
5.1	47.23	46.66	6.11
5.2	29.98	67.67	2.36
5.3	77.35	11.98	10.67
5.4	67.71	23.91	8.38
5.5	47.84	47.06	5.11
5.6	57.58	35.62	6.80
5.6.1	46.03	48.39	5.58
5.6.2	80.67	10.08	9.25
6.1	46.70	45.74	7.56
7.	46.01	49.04	4.95
7.1	52.97	43.45	3.59
7.2	60.36	30.88	8.76
7.3	27.10	69.76	3.14
8.	47.92	45.18	6.90
8.1	38.47	58.03	3.51
8.2	40.25	53.34	6.42
8.3	62.87	27.88	9.26
9.	41.26	52.93	5.89
9.1	39.33	54.32	6.35
9.2	44.72	50.45	4.84
10.	52.03	41.24	6.73
10.1	41.82	52.95	5.23
10.1.1	29.23	66.29	4.49
10.1.2	50.64	43.62	5.74
10.2	56.85	35.84	7.31
10.3	50.46	43.80	5.74
10.4	35.17	59.91	4.93
10.5	60.08	32.53	7.40
10.6	79.27	8.98	11.75
11.	57.20	39.60	3.20

Table 4.6. Species richness at 7 different spatial scales. Separate partitions within this table show values for each vegetation class, and associated community types and sub-types. Each group is represented by its abbreviation code. For full names see Table 4.1. Values with a '*' indicate low and/or lower average richness for a specific spatial scale than the next smallest scale and is usually the result of a smaller number of plots sampled at the larger scale.

Group:	1000 m	400 m	100 m	10 m	1 m	0.1 m	0.01 m
1.	.	.	22.25	7.35	3.05	1.05	0.40
2.	40.00	34.00	26.06	14.53	7.91	4.13	1.63
2.1	.	.	26.50	10.50	5.75	3.00	1.75
2.2	40.00	34.00	25.92	15.88	8.63	4.50	1.58
3.	.	*6.00	15.04	6.39	2.23	0.83	0.40
3.1	.	*6.00	10.45	4.59	1.28	0.56	0.28
3.2	.	.	26.50	10.90	4.60	1.50	0.70
4.	.	29.00	25.54	14.76	9.33	3.70	1.43
4.1	.	.	23.75	13.65	9.23	3.53	1.45
4.2	.	29.00	22.92	13.63	8.50	3.71	1.42
4.3	.	.	37.00	20.40	12.00	4.00	1.40
5.	*41.67	41.23	27.18	13.08	6.06	2.20	0.74
5.1	.	27.00	21.17	9.68	6.29	2.24	0.93
5.2	*43.00	42.00	27.11	14.27	7.32	2.81	0.95
5.3	.	46.50	25.44	10.94	5.04	1.61	0.60
5.4	*32.00	37.00	28.00	14.54	6.43	2.84	0.85
5.5	.	48.67	31.67	14.80	6.66	2.73	1.02
5.6	50.00	42.67	26.89	12.02	4.68	1.13	0.31
5.6.1	50.00	39.17	24.38	10.61	3.96	1.13	0.34
5.6.2	.	49.67	31.92	14.84	6.13	1.13	0.25
6.	35.00	27.50	18.00	8.76	4.38	1.63	0.38
7.	.	23.18	13.59	5.34	1.69	0.42	0.12
7.1	.	19.50	14.29	5.42	1.58	0.42	0.08
7.2	.	18.75	9.30	3.40	0.93	0.08	0.00
7.3	.	28.20	16.47	6.87	2.45	0.72	0.27
8.	.	32.25	19.52	8.28	3.13	1.06	0.35
8.1	.	27.00	14.19	6.02	2.69	1.15	0.31
8.2	.	25.60	13.75	6.00	2.24	0.83	0.24
8.3	.	51.50	29.88	12.45	4.54	1.33	0.52
9.	64.00	55.40	36.07	16.67	5.55	1.26	0.27
9.1	64.00	49.57	29.89	13.24	4.31	1.00	0.25
9.2	.	69.00	47.20	22.85	7.78	1.73	0.30
10.	78.00	58.76	38.01	18.56	7.45	2.11	0.52
10.1	*81.00	72.29	46.13	22.63	8.91	2.11	0.50
10.1.1	88.40	78.29	50.25	25.55	10.99	2.63	0.70
10.1.2	*68.67	68.10	43.25	20.58	7.47	1.75	0.37
10.2	88.00	67.14	46.41	22.56	8.39	2.39	0.46
10.3	52.00	44.00	28.85	14.93	6.75	2.63	0.63
10.4	.	35.33	21.04	8.55	3.69	1.27	0.48
10.5	79.00	51.30	32.05	16.09	6.43	2.00	0.54
10.6	76.50	58.83	38.33	18.88	8.09	2.27	0.61
11.	.	.	26.00	9.00	3.00	0.20	0.00

4.5 Description of vegetation classes and community types

4.5.1 VEGETATION CLASS: 1. **Rock Outcrops**

Rock Outcrops have limited distribution, scattered throughout the Southern Appalachian Mountains on exposed summits and bluffs (Schafale & Weakley 1990, Wiser *et al.* 1996). In Shining Rock this class is restricted to small, isolated forest openings dispersed throughout the Wilderness. This group is limited to 2% of sites sampled. The stands present in this class cover a broad compositional range and a diversity of environmental conditions and do not represent a closely associated community type: for this reason the following discussion describes **Rock Outcrops** at the vegetation class level.

Synonymy

High Elevation Rocky Summit, Low Elevation Rocky Summit, Montane Acidic Cliff (Schafale & Weakley 1990), *Deschampsia flexuosa*/*Angelica triquinata* outcrop community p.p. (Wiser *et al.* 1996).

Constant species

Danthonia compressa, *Houstonia longifolia* var. *glabra*, *Quercus rubra*, *Rhododendron minus*, *Saxifraga michauxii*, *Vaccinium corymbosum*.

Listed species

Carex biltmoreana, *Carex misera*, *Houstonia longifolia* var. *glabra*, *Hypericum mitchellianum*, *Krigia montana*, *Luzula multiflora* var. *congesta*, *Robinia hispida* var. *fertilis*, *Sibbaldiopsis tridentata*.

Physiognomy

The vegetation is prostrate (0.1 to 0.3 m mean height), concentrated in small clumps where soil can accumulate. **Rock Outcrops** sites are open and variably sloped, with the rock surface typically partially covered with bryophytes (65-91% and 15-35% surface substrate respectively; Table 4.10).

Saxifraga michauxii, *Danthonia compressa* and *Houstonia longifolia* var. *glabra* are the most consistent herbaceous species with woody *Quercus rubra*, *Rhododendron minus* and *Vaccinium corymbosum* also constant (Tables 4.7, 4.8, 4.9). However, there is considerable variation in the composition of the four **Rock Outcrops** sites sampled and these have been grouped into three tentative community types. Within the [*Saxifraga michauxii* seepage] *Saxifraga michauxii* (cover 5) is the dominant species at one moist, low-elevation site (1359 m elevation), with *Rubus argutus*, *D. compressa* and *Fraxinus americana* (all with cover of 4) less abundant. *Saxifraga michauxii* and *Betula lenta* have sparse, but highest cover (of 2) at the other site (1303 m) within this tentative type. *Carex biltmoreana*, *Hypericum stragulum* and *Iris verna* (all cover of 3) dominate the exposed, mid-elevation (1426 m) [*Carex biltmoreana* Outcrop] site, in conjunction with woody *Kalmia*, *Q. montana*, *Acer rubrum* and *Amelanchier* (all cover of 3). In contrast, *D. spicata* (cover 3) dominates the highly exposed, high-elevation (1821 m) [*Danthonia spicata-Houstonia longifolia* high-elevation Outcrop] site, in association with limited levels of *Carex brunnescens* var. *sphaerostachya*, *C. umbellata*, *Hypericum stragulum*, *Houstonia longifolia* var. *glabra*, *Krigia montana*, *Pieris floribunda*, *Rhododendron minus*, *Sibbaldiopsis tridentata* and *Vaccinium corymbosum* (all with a cover of 2). Compositional differences between these sites reflect their isolation from one another and the influence of surrounding forested vegetation, as well as differences in environmental conditions such as moisture, site exposure and climatic changes associated with elevational change.

Habitat and Distribution

This vegetation class inhabits small, south-to southwest-facing, steep (slopes of 31-58°), outcrops on all three major geologic types, scattered throughout Shining Rock across a broad range of elevations (1303 to 1821 m; Table 4.10). The sites sampled represent only a few of the widely scattered, exposed rock outcrops present in the Wilderness. Outcrops are small (typically $100m^2$ to $200m^2$ in size) and isolated from one another within the forest matrix. Most sites outcrop on upper-slopes and typically have very dry conditions (Figures 4.2, 4.3), with very limited vascular cover. In contrast, the few lower-slope sites generally have much moister conditions, with more extensive vascular cover, such as those described in one of the [*Saxifraga michauxii* seepage] sites (plot 361) where *Saxifraga michauxii* (cover of 5) dominates.

Soil is very limited in distribution at each site, restricted to a very thin layer in small sheltered concavities and crevices. This vegetation class has typically sandy and infertile soils which are low in base saturation, Mn and pH levels in comparison to most other community types identified in this study (Tables 4.4, 4.5).

Distinguishing Features

This group contains a high number of nationally listed species in comparison to most other Shining Rock community types.

Succession and Disturbance

Forests adjacent to all sites burned in 1925, with at least 75% burned in 1942. At least 3 of the 4 plots in the **Rock Outcrops** inhabit slopes that were logged in the early part of the twentieth century (USFS *unpub. data*). This class is subjected to a harsh climate and must withstand the extremes of sun, wind and rain. Weather, in conjunction with limited abundance and depth of soil will continue to limit the invasion of woody species and secure the persistence of small, herbaceous species.

Discussion

The **Rock Outcrops** of Shining Rock do not fall neatly into descriptions of this class made by other Southern Appalachian studies. This reflects the broad elevational range, isolated distribution and variation in environmental conditions of individual outcrop sites in this study area. The [*Danthonia spicata-Houstonia longifolia* high-elevation Outcrop] stand (plot 381), situated at the summit of Cold Mountain, has some affiliation with Wiser *et al.*'s (1996) *Deschampsia flexuosa/Angelica triquinata* outcrop community. The other plots do not fit any of the communities described by Wiser *et al.* (1996) in their study of high-elevation rock outcrops or the mid-elevation outcrop communities at Linville Gorge Wilderness (Chapter 3).

Table 4.7. Average cover class and constancy of species present in the **Rock Outcrops** vegetation class. Values are given for the vegetation class, which is represented by its abbreviation code. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	1.
Number of plots:	4
Homoteneity:	0.455
	Cov/Con
Species	
ACER RUBRUM VAR RUBRUM	2 50
AGERATINA ALTISSIMA VAR ROANENSIS	2 25
AGROSTIS PERENNANS	1 25
AMELANCHIER LAEVIS	3 25
ANDROPOGON VIRGINICUS VAR VIRGINICUS	2 25
ARISAEMA TRIPHYLLUM	2 25
ASTER CHLOROLEPIS	1 25
ATHYRIUM ASPLENIOIDES	1 25
BETULA LENTA	2 25
BRACHYELYTRUM ERECTUM	1 25
CAREX AESTIVALIS	2 50
CAREX BILTMOREANA*	3 25
CAREX BRUNNESCENS VAR SPHAEROSTACHYA	2 25
CAREX GYNANDRA	2 25
CAREX MISERA*	2 25
CAREX UMBELLATA	2 25
CLETHRA ACUMINATA	2 25
COREOPSIS MAJOR VAR RIGIDA	2 25
CUSCUTA SP. #1	2 25
DANTHONIA COMPRESSA	2 75
DANTHONIA SPICATA	3 25
DESCHAMPSIA FLEXUOSA VAR FLEXUOSA	1 25
DICHANTHELIUM ACUMINATUM VAR FASCICULATUM	1 25
DICHANTHELIUM LAXIFLORUM	2 25
DICOT SP. #1	2 25
DIERVILLA SESSILIFOLIA	2 25
EPIGAEA REPENS	2 25
FRAXINUS AMERICANA	3 50
GALAX URCEOLATA	2 50
GAYLUSSACIA BACCATA	2 25
GENTIANA CLAUSA	1 25
HAMAMELIS VIRGINIANA	2 50
HOUSTONIA CAERULEA	2 25
HOUSTONIA LONGIFOLIA VAR GLABRA*	2 75
HYPERICUM MITCHELLIANUM*	1 25
HYPERICUM STRAGULUM	3 50
IRIS VERNA	3 25
KALMIA LATIFOLIA	2 50
KRIGIA MONTANA*	2 50

Group:	1.	
	Cov/Con	
LEUCOTHOE RECURVA	2	25
LILIUM MICHAUXII	2	25
LIRIODENDRON TULIPIFERA	1	25
LUZULA MULTIFLORA VAR CONGESTA*	2	25
MEDEOLA VIRGINIANA	2	25
MELAMPYRUM LINEARE	2	25
PIERIS FLORIBUNDA	2	25
PYCNANTHEMUM PYCNANTHEMOIDES VAR PYCNANTHEMOIDES	2	25
QUERCUS MONTANA	2	50
QUERCUS RUBRA	2	75
RHODODENDRON CATAWBIENSE	2	25
RHODODENDRON MAXIMUM	1	25
RHODODENDRON MINUS	2	75
ROBINIA HISPIDA VAR FERTILIS*	2	25
RUBUS ARGUTUS	4	25
RUMEX ACETOSELLA	1	25
SAXIFRAGA MICHAUXII	3	75
SIBBALDIOPSIS TRIDENTATA*	2	25
SMILAX ROTUNDIFOLIA	1	25
SOLIDAGO PATULA VAR PATULA	2	25
SOLIDAGO SP. #1	2	50
TSUGA CANADENSIS	3	50
TSUGA CAROLINIANA	2	25
UVULARIA PUBERULA VAR PUBERULA	1	25
VACCINIUM CORYMBOSUM	2	75
VACCINIUM PALLIDUM	2	25
VACCINIUM STAMINEUM	2	25
VIOLA BLANDA	1	25

Table 4.8. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **<u>Rock</u> <u>Outcrops</u>** vegetation class. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

1. Rock Outcrops

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM	25.00	75.00	0.00	100.00	0.09	14.29	20.78	17.53
FRAXINUS AMERICANA	100.00	25.00	0.00	125.00	0.12	9.62	24.23	16.92
RHODODENDRON MINUS	100.00	0.00	0.00	100.00	0.02	12.64	4.32	8.48
RUBUS ARGUTUS	175.00	0.00	0.00	175.00	0.00	13.46	0.68	7.07
ALL	400.00	100.00	0.00	500.00	0.23	50.00	50.00	50.00

Table 4.9. Vertical structure of woody species in the **Rock Outcrops** vegetation class. The height class of each stratum is measured in meters (m). Mean cover across all plots is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

1. Rock Outcrops

	<0.5m	6-0.5m	15-6m	35-15m	>35m
FRAXINUS AMERICANA	1	1			
RHODODENDRON MINUS	1	1			
RUBUS ARGUTUS	1	1			

Table 4.10. Average site information for the **Rock Outcrops** vegetation class. The vegetation class is represented by its abbreviation code. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Landform types (representing micro-scale topographic units) (**Out**=small outcrops) and Topographic position (representing macro-scale topographic units) (**US**=upper-slopes).

1. Rock Outcrops

	Group
	1.
Site Characteristics:	
Elevation (m)	1477
Slope (o)	45
Aspect (o)	S
Parent material	
Soil depth (cm)	3.7
Surface Substrate (%):	
Moss/Lichen	25
Wood	2
Rock	73
Organic Matter	6
Water	0
Topographic Characteristics:	
Relative Slope (%)	69
LFI	0.17
TSI	-0.02
Landform type	Out
Topographic position	US

4.5.2 VEGETATION CLASS: 2. Non-Alluvial Wetlands

Non-Alluvial Wetlands have very limited distribution throughout the Southern Appalachian Mountains (Schafale and Weakley 1990). In Shining Rock they are restricted to the central, high-elevation, eastern upper-slopes of the Shining Rock Ledge (Figures 4.2, 4.3, Appendices 2, 5).

COMMUNITY TYPE: [Carex gynandra Wetland]

Synonymy

High Elevation Seep p.p. (Schafale & Weakley 1990, Weakley & Schafale 1994).

Listed species

Abies fraseri, *Carex ruthii*, *Hypericum graveolens*, *Hypericum mitchellianum*.

Physiognomy

Although this community type is represented by only one plot, its composition is sufficiently different from the other three **Non-Alluvial Wetlands** plots to recognize two community types in this class. The sedge *Carex gynandra* and herb *Hypericum graveolens* (both cover of 7) form a dense 0.8 m tall herbaceous layer. *Hypericum mitchellianum* (cover 4), *Festuca subverticillata* (cover 3) and *Aster cordifolius* (cover 3) are scattered throughout (Table 4.11). *Pieris floribundus* shrubs (cover 5) inhabit slightly drier conditions surrounding the open wetland (Tables 4.11, 4.12, 4.13).

Habitat and Distribution

This community type occurs at wet sites on the upper, east-facing slopes of the Shining Rock Ledge (elevation of 1725 m; Figures 4.2, 4.3, Table 4.14). This site and others dominated by the same community type inhabit small, typically <300m^2 in size, gently sloping (7° slope angle), concave seepage openings in the **Fagus/Carex pensylvanica Forest** and the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense -Vaccinium simulatum Forest**.

The soils are coarser-textured than the other community type in this vegetation class and have low base saturation, pH and high Mn and soil density in comparison to other community types in this study (Tables 4.4, 4.5). This community type has highest P and S values of any community type or sub-type in the study. The soils in the **[Carex gynandra Wetland]** are very thin (3 to 29 cm depth), suggesting the presence of an impermeable layer near the surface (Table 4.14). The site is underlain by migmatite.

Distinguishing Features

This community type inhabits typically smaller, moister, more sheltered, concave sites than those inhabited by the **Carex ruthii Wetland**. Sites inhabited by the **[Carex gynandra Wetland]** type are mostly associated with small streams and sometimes form beneath the enclosed canopy of surrounding forests.

Succession and Disturbance

Charred stems provide evidence of relatively recent fire in this site and records suggest that this site was previously forested and burned in both major fires. Very intense fire in 1925 and subsequent soil erosion are thought to have depleted the soil profile (USFS *unpub. data*) which may partly account for the poor drainage in sites inhabited by this type.

The limited number of small-diameter *Betula alleghaniensis* stems in this site indicates that woody species can invade and survive in this system. However, the present moisture regime should preclude the growth of woody species beyond the sapling stage and maintain the open, sedge-dominated composition and structure of this type.

COMMUNITY TYPE: Carex ruthii Wetland

Synonymy

High Elevation Seep p.p. (Schafale & Weakley 1990, Weakley & Schafale 1994).

Listed species

Carex ruthii, Hypericum graveolens, Hypericum mitchellianum, Juncus gymnocarpus, Luzula multiflora var. *congesta*.

Physiognomy

One to two m tall *Vaccinium* shrubs (*V. corymbosum* in one site and *V. stamineum* in the other two plots) are sparsely scattered across the herbaceous canopy of this community type. The 0.5 m tall herbaceous layer is dominated by *Carex ruthii* (cover 7), with isolated clumps of *Osmunda cinnamomea* var. *cinnamomea* clumps (cover 4), *Carex gynandra* and *Scirpus georgianus* (cover 3) protruding above the sedge canopy. Mats of *Sphagnum* species dominate the ground with *Aster acuminatus* and *Deschampsia flexuosa* also prevalent (Tables 4.11, 4.12, 4.13). Low-cover species present in all three plots include; *Calamagrostis cinnoides, Carex flexuosa, Juncus acuminatus, Juncus gymnocarpus* and *Platanthera clavellata*.

Habitat and Distribution

This community type is part of a reasonably extensive **Carex ruthii Wetland - Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** mosaic on the shallow, eastern-facing, upper-slopes of the Shining Rock Ledge between Tennent Mountain and Ivestor Gap (see Figure 1.4). The **Carex ruthii Wetland** inhabits gently sloping (2° average slope angle) openings (average elevation of 1680 m; Figures 4.2, 4.3, Table 4.14) that are generally flat and larger in area than those inhabited by the **[Carex gynandra Wetland]**. One **Carex ruthii Wetland** site was large enough to contain a full 0.1 ha plot. The sites are underlain mica gneiss in contrast to the migmatite of the **[Carex gynandra Wetland]**.

The soils have highest silt content of any other community type in this study and are much finer-textured than **[Carex gynandra Wetland]** soils. **Carex ruthii Wetland** soils have lower Ca, Fe, Mg, Mn and higher Na, pH and soil density values than those in the former type (Tables 4.4, 4.5). The **Carex ruthii Wetland** has highest Na values of any community type or sub-type in the study.

Distinguishing Features

The **Non-Alluvial Wetlands** has the highest species richness of any group in this study at the two smallest scales of measurement, reflecting the high microscale-diversity and small size of species in these wetlands (Table 4.6). Richness is higher between 0.1 and $10m^2$ in the **Carex ruthii Wetland** than in the other **Non-Alluvial Wetlands** type reflecting compositional and structural differences between these two types. The **Carex ruthii Wetland** is inhabited by a more diverse range of small-sized plants whereas the **[Carex gynandra Wetland]** site is dominated by large clumps of *Carex gynandra* that probably limit the presence of other species.

Succession and Disturbance

Stumps in two sites suggests the former inhabitance of trees in this community type which corresponds with Forest Service historical records (USFS *unpub. data*). Records also suggest that sites in this type were burned in both major fires and charred stems in all three sites provide evidence for this. Intense fire in 1925 and subsequent soil erosion are thought to have depleted the soil profile (USFS *unpub. data*). The poorly drained conditions present today and dominance by open wetland vegetation may result from the reduced soil profile and close proximity of the underlying bedrock to the surface and its ability to impede water drainage from these sites.

The presence of shrubs in this type indicates that woody species can invade and survive in this system. However, *Betula allegheniensis* which is able to grow rapidly in high-light conditions (White *et al.* 1985) and is the dominant tree species in the surrounding forests, has not established in this type, suggesting that the present moisture regime may preclude most woody species invasion. In the future, under the present hydrologic conditions, the open, sedge-dominated composition and structure of this community type will be maintained.

Discussion

The **Non-Alluvial Wetlands** is one of three vegetation groups where sedges are the structural and compositional dominants of the group. However, the other two, **Grasslands** community types, inhabit dry, exposed sites. The moisture regime of the **Non-Alluvial Wetlands** sets it apart from all other groups in this study, while its uniqueness is also highlighted by the dominance of listed species in one community type.

Non-Alluvial Wetlands are one of the better described vegetation groups with limited spatial distribution, with much of the work undertaken by Schafale and Weakley (1990) and Weakley & Schafale (1994). These authors classify high-elevation **Non-Alluvial Wetlands** within their High Elevation Seep community type, whereas **Non-Alluvial Wetlands** occurring at lower-elevations, on flat or gently sloping valley floors, are grouped in the Southern Appalachian Bog community type. Although the **Non-Alluvial Wetlands** type in this present study does inhabit high-elevations, this community type does not fit neatly into the High Elevation Seep group described by Schafale and Weakley. In contrast to descriptions of the High Elevation Seep group, which inhabits "generally sloping.....(and)..relatively steep" sites (Weakley & Schafale 1994), **Non-Alluvial Wetlands** occur on shallow slopes, and inhabit site conditions with greater affinities to the valley floor sites inhabited by the Southern Appalachian Bog type. The composition of the two **Non-Alluvial Wetlands** types do not closely follow Schafale and Weakley's High Elevation Seeps group. Based on composition, these authors distinguish High Elevation Seeps from Southern Appalachian Bogs by the dominance of forbs in the former and abundance of graminoids, shrubs and well-developed *Sphagnum* mats in the latter. The dominance in both Shining Rock types by sedges, and the presence of *Sphagnum* mats in the **Carex ruthii Wetland**, suggests that at least the latter type lies on the boundary between High Elevation Seeps and Southern Appalachian Bogs.

The majority of wetlands described by Weakley & Schafale (1994) are adjacent to agricultural lands. As a result, these wetlands are mostly heavily grazed and partially degraded by the loss of surrounding forest buffers, hydrologic alteration and the use of fertilizers on nearby land (Weakley & Schafale 1994). In contrast, **Non-Alluvial Wetlands** at Shining Rock are isolated from all the human impacts described above. This highlights the significance of this vegetation class at Shining Rock and importance of maintaining this group in its present form.

Table 4.11. Average cover class and constancy of species present in the **Non-Alluvial Wetlands** vegetation class. Values are given for the vegetation class as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 4.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. Homoteneity is the mean constancy of the prevalent species.

Group:	2.	2.1	2.2
Number of plots:	4	1	3
Homoteneity:	0.642		0.735
	Cov/Con	Cov/Con	Cov/Con
Species			
ABIES FRASERI*	2 25	2 100	
ACER PENSYLVANICUM	1 25		1 33
ACER RUBRUM VAR RUBRUM	3 50		3 67
ACER SPICATUM	1 25	1 100	
AESCULUS FLAVA	2 25	2 100	
AGERATINA ALTISSIMA VAR ALTISSIMA	2 25	2 100	
AGROSTIS PERENNANS	2 50	2 100	1 33
AMELANCHIER LAEVIS	1 25		1 33
ANGELICA TRIQUINATA	2 25		2 33
ARONIA MELANOCARPA	2 75		2 100
ASTER ACUMINATUS VAR ACUMINATUS	3 75		3 100
ASTER CHLOROLEPIS	1 25		1 33
ASTER CORDIFOLIUS	2 25	2 100	
ASTER PUNICEUS	2 25	2 100	
BETULA ALLEGHANIENSIS	3 50	3 100	2 33
BROMUS PUBESCENS	1 25	1 100	
CALAMAGROSTIS CINNOIDES	2 75		2 100
CAREX FLEXUOSA	2 100	1 100	2 100
CAREX GYNANDRA	4 100	7 100	3 100
CAREX INTUMESCENS	2 25	2 100	
CAREX LEPTALEA	2 25	2 100	
CAREX RUTHII*	6 100	2 100	7 100
CAREX SCOPARIA VAR SCOPARIA	2 25	2 100	
CAREX VULPINOIDEA	2 25	2 100	
CUSCUTA SP. #1	2 25		2 33
DANTHONIA COMPRESSA	2 50		2 67
DENNSTAEDTIA PUNCTILOBULA	2 50		2 67
DESCHAMPSIA FLEXUOSA VAR FLEXUOSA	3 100	2 100	3 100
DIERVILLA SESSILIFOLIA	1 25		1 33
EUPATORIUM PURPUREUM	2 25	2 100	
FESTUCA SUBVERTICILLATA	2 25	2 100	
GLYCERIA MELICARIA	2 25		2 33
HOUSTONIA CAERULEA	2 25		2 33
HOUSTONIA PURPUREA VAR PURPUREA	2 25	2 100	
HOUSTONIA SERPYLLIFOLIA	1 50	1 100	1 33
HYPERICUM DENSIFLORUM	6 25		6 33
HYPERICUM GRAVEOLENS*	4 50	7 100	1 33
HYPERICUM HYPERICOIDES	1 25		1 33
HYPERICUM MITCHELLIANUM*	5 50	4 100	5 33
IMPATIENS CAPENSIS	2 25	2 100	
JUNCUS ACUMINATUS	2 100	1 100	2 100
JUNCUS EFFUSUS VAR SOLUTUS	2 50	2 100	2 33

Group:	2.	2.1	2.2
	Cov/Con	Cov/Con	Cov/Con
JUNCUS GYMNOCARPUS*	2 75		2 100
KALMIA LATIFOLIA	1 25		1 33
LUZULA ACUMINATA	1 25	1 100	
LUZULA MULTIFLORA VAR CONGESTA*	2 25	2 100	
LYCOPODIUM CLAVATUM VAR CLAVATUM	2 25		2 33
LYCOPODIUM OBSCURUM	2 25		2 33
LYONIA LIGUSTRINA VAR LIGUSTRINA	3 75		3 100
MENZIESIA PILOSA	2 25		2 33
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	4 75		4 100
PICEA RUBENS	1 25		1 33
PIERIS FLORIBUNDA	4 25	4 100	
PINUS RIGIDA	1 25		1 33
PLATANTHERA CLAVELLATA	1 100	1 100	1 100
PLATANTHERA PSYCODES	1 25	1 100	
POTENTILLA CANADENSIS VAR CANADENSIS	2 25		2 33
PRENANTHES SP. #1	1 25	1 100	
PRUNUS PENSYLVANICA	1 25		1 33
RHODODENDRON CATAWBIENSE	2 75		2 100
RIBES CYNOSBATI	1 25	1 100	
RUBUS ARGUTUS	4 25		4 33
RUBUS CANADENSIS	2 75	1 100	2 67
SCIRPUS GEORGIANUS	3 75		3 100
SOLIDAGO SP. #1	2 25		2 33
SOLIDAGO GLOMERATA	4 50		4 67
SOLIDAGO PATULA VAR PATULA	2 75	2 100	2 67
SORBUS AMERICANA	1 50		1 67
TSUGA CANADENSIS	1 25		1 33
VACCINIUM CORYMBOSUM	6 25		6 33
VACCINIUM ERYTHROCARPUM	2 25		2 33
VACCINIUM PALLIDUM	1 50		1 67
VACCINIUM STAMINEUM	4 50		4 67
VIBURNUM NUDUM VAR CASSINOIDES	2 75		2 100
VIOLA AFFINIS	2 25		2 33
VIOLA BLANDA	2 25	2 100	
VIOLA SAGITTATA	1 25		1 33

Table 4.12. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Non-Alluvial Wetlands** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

2. Non-Alluvial Wetlands

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	90.00	42.50	0.00	132.50	0.11	3.66	8.26	5.96
BETULA ALLEGHANIENSIS	5.00	12.50	0.00	17.50	0.06	0.87	8.65	4.76
PIERIS FLORIBUNDA	337.50	62.50	0.00	400.00	0.11	24.24	16.44	20.34
VACCINIUM CORYMBOSUM	790.00	25.00	0.00	815.00	0.14	18.57	10.26	14.41
VACCINIUM STAMINEUM	287.50	0.00	0.00	287.50	0.04	21.30	21.80	21.55
ALL	1667.50	180.00	0.00	1847.50	0.55	75.01	75.00	75.00

2.1 [Carex gynandra Wetland]

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
BETULA ALLEGHANIENSIS	0.00	50.00	0.00	50.00	0.22	3.03	34.25	18.64
PIERIS FLORIBUNDA	1350.00	250.00	0.00	1600.00	0.42	96.97	65.75	81.36
ALL	1350.00	300.00	0.00	1650.00	0.65	100.00	100.00	100.00

2.2 Carex ruthii Wetland

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	120.00	56.67	0.00	176.67	0.15	4.88	11.01	7.95
VACCINIUM CORYMBOSUM	1053.33	33.33	0.00	1086.67	0.18	24.75	13.67	19.21
VACCINIUM STAMINEUM	383.33	0.00	0.00	383.33	0.06	28.40	29.07	28.73
ALL	1773.33	140.00	0.00	1913.33	0.52	66.67	66.66	66.66

Table 4.13. Vertical structure of woody species in the **Non-Alluvial Wetlands** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

2. Non-Alluvial Wetlands

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1			
ARONIA MELANOCARPA	1				
BETULA ALLEGHANIENSIS	1	1			
PIERIS FLORIBUNDA	1	1			
VACCINIUM CORYMBOSUM	1	1			
VACCINIUM STAMINEUM	1				

2.1 [Carex gynandra Wetland]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
BETULA ALLEGHANIENSIS	1	2			
PIERIS FLORIBUNDA	1	3			

2.2 Carex ruthii Wetland

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBURM	1	1			
ARONIA MELANOCARPA	1				
LYONIA LIGUSTRINA VAR					
LIGUSTRINA	1				
RHODODENDRON CATAWBIENSE	1	1			
VACCINIUM CORYMBOSUM	1	2			
VACCINIUM STAMINEUM	1	1			

Table 4.14. Average site information for the **Non-Alluvial Wetlands** vegetation class. Groups are represented by their abbreviation code. For full names see Table 4.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. *indicates that soil depth was only measured for two plots. The following abbreviations are used; Parent material types (**M**=migmatite, **MG**=mica gneiss), Landform types (representing micro-scale topographic units) (**SS**=side slopes) and Topographic position (representing macro-scale topographic units) (**US**=upper-slopes).

2. Non-Alluvial Wetlands

	Group		
	2.	2.1	2.2
Site Characteristics:			
Elevation (m)	1685	1725	1672
Slope (o)	5	7	2
Aspect (o)	E	E	E
Parent material	MG	M	MG
Soil depth (cm)	41.5	17.2	*53.5
Surface Substrate (%):			
Moss/Lichen	58	0	89
Wood	2	2	2
Rock	0	2	0
Organic Matter	33	89	14
Water	5	5	4
Topographic Characteristics:			
Relative Slope (%)	84	93	74
LFI	0.18	0.23	0.14
TSI	-0.01	-0.02	-0.00
Landform type	SS	SS	SS
Topographic position	US	US	US

4.5.3 VEGETATION CLASS: 3. <u>Shrub Balds</u>

The **<u>Shrub Balds</u>** vegetation class is scattered at high-elevations throughout the Southern Appalachian Mountains, inhabiting extremely exposed peaks, sharp ridges and steep slopes. The class has a characteristically dense shrub stratum, typically dominated by ericaceous species, with a few stunted tree species present in some locations (McLeod 1988, Schafale & Weakley 1990). In Shining Rock **<u>Shrub Balds</u>** are mostly restricted to exposed portions of the high-elevation ridge in the center of the Wilderness (Figures 4.2, 4.3) and the upper-slopes of Cold Mountain. This class is most often found in association with the **<u>Grasslands</u>** vegetation class. The **<u>Shrub Balds</u>** class represents 3% of the vegetation mapped in this Wilderness (Appendices 2, 5).

COMMUNITY TYPE: Picea/Rhododendron catawbiense Shrubland (3.1)

Synonymy

exposed form of Red Spruce--Fraser Fir Forest (Schafale & Weakley 1990), ridges and steep, upper, south slopes subtype of Red Spruce Forest (Whittaker 1956), dry *Rhododendron* site type of Spruce Forest Site Type (Crandell 1958), Spruce Forests p.p. (McLeod 1988), Spruce Forests (White *et al.* 1993).

Constant species

Picea rubens, *Rhododendron catawbiense*, *Vaccinium stamineum*.

Listed species

Abies fraseri.

Physiognomy

Picea and *Rhododendron catawbiense* are the two species that dominate all sites within this community type (Tables 4.15, 4.16, 4.17). Stature varies greatly (range 1 to 22 m, mean canopy height 11.4 m) between sites, reflecting differences in site exposure, slope position and probable stand age. The most exposed stand clings to the walls of Shining Rock (see Figure 1.4), the exposed quartz massif, and the two dominant species form scattered, stunted clumps in association with *Aronia melanocarpa*. Between the shrub clumps several sedge species are restricted to crevices in the exposed rock. The other stunted form of this community type is more widespread, extending across the broad exposed summit of Shining Rock Knob. In this form the two major species are codominated by *Vaccinium stamineum* and *Pieris floribunda*.

In more sheltered sites this community is taller and forest-like in appearance, ranging in height from 16 to 22 meters. In these sites *Picea* forms a moderately dense canopy over an extremely dense 6 to 8 m tall *Rhododendron catawbiense* shrub layer (Tables 4.15, 4.16, 4.17). The low species diversity of these taller stands is most apparent on the forest floor, where the only species, *Vaccinium erythrocarpum* has very scattered distribution.

Habitat and Distribution

This type inhabits high-elevation, west-to-north-facing summits and upper-slopes between 1752 and 1820 meters (mean elevation 1780, SD 29 m; Figures 4.2, 4.3, Table 4.18). Sites vary in slope angle (1 to 33°, mean 22°, SD 13°), reflecting topographic differences in the landforms inhabited. The taller forms of this community type occur in more sheltered, upper-slope sites. This type inhabits a range of bedrock types, with three sites situated on the quartz massif and the remaining two on garnet-mica schist and migmatite.

The soils are infertile, organic and moderately coarse-textured with highest silt and organic matter content and lowest sand, soil density, base saturation, Mn and pH levels of any group classified in this study (Tables 4.4, 4.5). The **Picea/Rhododendron catawbiense Shrubland** has lower Al, B, Ca, Cu, Fe, K and higher Na, P, S and Zn levels than the **[Rhododendron catawbiense-Pieris Shrubland]**.

Distinguishing Features

The **Picea/Rhododendron catawbiense Shrubland** has the highest mean elevation of all community types in this study and is the only type sampled on quartz bedrock in this study. This community type has lower species diversity at all spatial scales than the other **Shrub Balds** type, reflecting the overwhelming dominance by only two species (Table 4.6). Diversity levels are similar to those in the **Tsuga canadensis-Quercus rubra/ Rhododendron maximum Forest**, a lower-elevation type also dominated by a coniferous canopy and a dense ericaceous shrub layer.

The **Picea/Rhododendron catawbiense Shrubland** ranges from stunted, heath-like stands, to taller forest stands and therefore has structural as well as compositional similarities with both the **Shrub Balds** and **Spruce-Fir Forests** vegetation classes (Tables 4.15, 4.16, 4.17, 4.27, 4.28, 4.29). The dominance of heath species gave this community type closer affiliation with the **[Rhododendron catawbiense-Pieris Shrubland]** than **Spruce-Fir Forests** in the Ward's classification and this association was substantiated in preliminary ordination analyses. As a result, the **Picea/Rhododendron catawbiense Shrubland** was retained in the **Shrub Balds** vegetation class.

Succession and Disturbance

Sites inhabited by this community type were cleared in the 1880's for pasture and a logging camp (USFS *unpub. data*). Descriptions of sites adjacent to Shining Rock Gap, by Wells (1937), suggest that these pastures resembled the **Vaccinium corymbosum /Danthonia compressa-Carex pensylvanica Grassland**. Historical records suggest that all sites within this type were burned in the 1925 and 1942 fires (USFS *unpub. data*).

This community type is successional and probably initially developed from a low shrub-dominated **Grasslands** community type (Appendix 7) in which *Picea* was able to establish. The extreme conditions associated with the Shining Rock massif suggests that the **Picea/Rhododendron catawbiense Shrubland** stands will remain stunted and heath-like at this locality. This community type may also remain stunted on the most exposed areas of Shining Rock Knob. In more sheltered areas, summary stem information suggests that the present dominant tree species will eventually form an enclosed canopy over the shrub canopy, resembling the three tall forest stands in this community type.

Comparisons of structure and composition between the younger two forest stands (*Picea* stems mostly 5 to 20 cm diameter; two 35 cm stems 45 years old) and the older forest stand (*Picea* stems mostly 40 to 59 cm diameter, 51 cm diameter *Picea* approximately 78 years of age, 55 cm *Picea* stem approximately 91 years), suggests that the present composition and stature of the two younger forest stands will be maintained as *Picea* stems increase in diameter. Shrub density is thinning in the older forest stand, with a substantial proportion of *Rhododendron* stems dying. Few *Picea* saplings are present in this stand, which possibly reflects the difficulties this species has in penetrating through the deep *Rhododendron* litter and its inability to establish in deep shade (White & Cogbill 1992). As the shrub stratum thins, increasing light levels in the understory should enable seedling establishment to become more successful. *Abies*, *Picea* and *Betula alleghaniensis*, the most common tree species in areas adjacent to this community type are the most likely tree species to establish. If sites are sheltered and moist, understory species such as *Dennstaedtia punctilobula* will begin to establish and this community type will probably succeed into the **[Picea/Dennstaedtia Forest]** (Appendix 7). However, most **Picea/Rhododendron catawbiense Shrubland** sites have dryer conditions than the present **Spruce-Fir Forests** in Shining Rock. This **Shrubland** community type may possibly develop to resemble Crandell's (1958) Viburnum-Vaccinium-Lycopodium site type of the Spruce Forest Type, with mostly bare ground and scattered species such as *Huperzia lucidula*, *Clintonia borealis* and *Aster chlorolepis*.

COMMUNITY TYPE: [Rhododendron catawbiense-Pieris Shrubland] (3.2)

Synonymy

Heath Bald (Schafale & Weakley 1990), Rhododendron Bald Community (Brown 1941), high-elevation variant of Heath Balds (Whittaker 1956), Heath bald community (Ramseur

1960), Heath Balds (McLeod 1988), Heath Balds (White *et al.* 1993), [*Rhododendron catawbiense-Kalmia* Shrubland] (Chapter 5).

Physiognomy

Clumps of *Rhododendron catawbiense* and *Pieris floribunda* dominate the almost impenetrable shrub stratum of this community with *Ilex montana* scattered throughout type (4 m mean height; Tables 4.15, 4.16, 4.17). A few tree saplings, dominated by *Prunus serotina* at one site and *Amelanchier laevis* at the other, protrude above the dense shrub canopy. The ground consists of a dense litter layer with *Dennstaedtia punctilobula* having consistent but limited abundance (Table 4.18). *Aster acuminatus* var. *acuminatus*, *Aster chlorolepis*, *Aster macrophylla*, *Carex pensylvanica*, *Galax urceolata*, *Listera smallii* and *Prenanthes* species have very sparse distribution throughout this stratum.

Habitat and Distribution

This community type clothes the upper-slopes of many high-elevation knobs and was sampled on the slopes of Shining Rock and Dog Loser Knobs (elevations 1748 and 1793 m, slopes 4° and 13°; Table 4.18, Appendix 5). The **[Rhododendron catawbiense-Pieris Shrubland]** inhabits highly exposed areas (Figures 4.2, 4.3), often shrouded in fog, subject to high rainfall and driving wind and snow during the winter months. The stature of this heath becomes very stunted with increasing exposure and proximity to slope summits, while it grades into the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** on the slopes below.

The soils are shallow, coarse-textured and relatively fertile, with highest K levels of any group in the study (Tables 4.4, 4.5). In comparison to the **Picea/Rhododendron catawbiense Shrubland**, the **[Rhododendron catawbiense-Pieris Shrubland]** has more fertile soils with higher base saturation, Al, Cu, Fe, pH and soil density and lower Na, P, organic matter, S and Zn. Both sites are underlain by mica gneiss rock type.

Distinguishing Features

The fact that the **[Rhododendron catawbiense-Pieris Shrubland]** has by far the highest number of stems per hectare (49,900) of any community type or sub-type described in this study highlights the density of the shrub stratum in this community type (Table 4.19). Species richness is low in comparison to other vegetation classes, but higher at all scales measured than in the other **Shrub Balds** community type, that is dominated by only two species (Table 4.6).

Succession and Disturbance

Blackened stems provide evidence for past disturbance by fire in both sites. Sites are thought to have burned in both major fires and were probably subjected to extremely hot fires during 1925. Site use history differs, with 1 site cleared for pasture and the other logged for timber (USFS *unpub. data*). Descriptions by Wells (1937) suggest that some **[Rhododendron catawbiense-Pieris Shrubland]** sites may have previously been inhabited by a community resembling the **Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland**.

Although the **[Rhododendron catawbiense-Pieris Shrubland]** is successional, the present stunted stature and composition may well be maintained in highly exposed situations, as Whittaker (1956) and White *et al.* (1993) have suggested for similar communities elsewhere. In more sheltered situations the composition and structure of this community may change considerably over time. However, the initial changes may be very slow. The leaves of *Rhododendron* species are nutrient poor, highly fibrous and as a consequence, decay slowly, producing a thick litter layer and acidic soils (Clinton & Vose 1996). Such conditions, combined with the deep, year-round shade associated with the ericaceous shrub layer, restrict initial tree establishment to small openings in the dense shrub stratum. Although there is no quantitative information to substantiate this, we project that with time the shrub canopy will break up, increasing light levels within the shrub stratum which will provide conditions more conducive for successful seedling establishment. Summary stem information suggests that successional *Amelanchier* and *Prunus serotina* will increase in dominance. These species may eventually form a canopy over the shrub stratum, resembling some of the younger stands described in the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest**. With time *Betula alleghaniensis*, abundant in adjacent high-elevation forests, may dominate the canopy and the **[Rhododendron catawbiense-Pieris Shrubland]** will resemble successionally more advanced forms of the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** (Appendix 7).

Discussion

This study represents one of the few that have quantified the characteristics of the **Shrub Balds** vegetation class (but see Brown 1941, Whittaker 1962, Whittaker 1963, McLeod 1988, Risk 1993, Chapter 5). The **[Rhododendron catawbiense-Pieris Shrubland]** corresponds closely to most descriptions of heath bald communities throughout the Southern Appalachian Mountains (e.g., Cain 1931, Brown 1941, Whittaker 1956, Ramseur 1960, McLeod 1988, White *et al.* 1993, Chapter 5). The **Picea/Rhododendron catawbiense Shrubland** has also been described by previous authors (e.g., Whittaker 1956, Crandell 1958, White *et al.* 1993). This type appears to have a much more restricted distribution throughout the Southern Appalachian Mountains than the former **Shrub Balds** type and is most often found in association with **Spruce-Fir Forests**.

The **Picea/Rhododendron catawbiense Shrubland** and the **[Picea/Dennstaedtia Forest]** are the two community types dominated by *Picea*. However, the **[Picea/Dennstaedtia Forest]**, in the **Spruce-Fir Forests** vegetation class, lacks the dense *Rhododendron* shrub layer present in the **Picea/Rhododendron catawbiense Shrubland**, but instead is dominated by large diameter *Picea* with an open understory dominated by a mosaic of *Abies* thickets and fern clumps. Schafale & Weakley (1990) and White *et al.* (1993) associate *Rhododendron catawbiense* heath-dominated *Picea* stands with exposed, xeric sites and such differentiations can be made between the two *Picea* community types in Shining Rock where the **Picea/Rhododendron catawbiense Shrubland** inhabits more exposed positions than the **[Picea/Dennstaedtia Forest]**. The disturbance regime also differs, with sites in the former cleared for grazing and a log camp site. The soils of the two types are similar in texture, organic matter, density and fertility, with the lowest pH values of all types in this study (Tables 4.4, 4.5). The **Picea/Rhododendron catawbiense Shrubland** has higher base saturation, Ca, Fe, pH and Zn values and much lower Al and Fe levels than the **[Picea/Dennstaedtia Forest]**. Soil chemical differences may correspond with differences in underlying bedrock. For example, low Al levels in the **Picea/ Rhododendron catawbiense Shrubland**, underlain by quartz, are similar to typical values found for soils underlain by quartzite at Linville Gorge Wilderness (Chapter 3).

Table 4.15. Average cover class and constancy of species present in the **Shrub Balds** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 4.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	3.	3.1	3.2
Number of plots:	7	5	2
Homoteneity:	0.504	0.57	0.827
	Cov/Con	Cov/Con	Cov/Con
Species			
ABIES FRASERI*	1 14	1 20	
ACER RUBRUM VAR RUBUM	4 14	4 20	
ACER SPICATUM	1 14		1 50
AGERATINA ALTISSIMA VAR ROANENSIS	2 14		2 50
AMELANCHIER LAEVIS	3 57	2 60	7 50
ANGELICA TRIQUINATA	2 29		2 100
ARONIA MELANOCARPA	3 43	3 60	
ASTER ACUMINATUS VAR ACUMINATUS	2 43	2 20	2 100
ASTER CHLOROLEPIS	2 29		2 100
ASTER MACROPHYLLUS	2 29		2 100
ASTER UNDULATUS	1 14	1 20	
BETULA ALLEGHANIENSIS	5 29	5 40	
BETULA LENTA	5 14	5 20	
CAREX SP.#3	1 14	1 20	
CAREX BRUNNESCENS VAR SPHAEROSTACHYA	1 29	1 40	
CAREX PENSYLVANICA	2 29		2 100
CLINTONIA UMBELLULATA	2 14	2 20	
DANTHONIA COMPRESSA	1 14	1 20	
DENNSTAEDTIA PUNCTILOBULA	2 43	2 20	3 100
DESCHAMPSIA FLEXUOSA VAR FLEXUOSA	1 29	1 20	1 50
EUPATORIUM PURPUREUM	1 14		1 50
GALAX URCEOLATA	2 29		2 100
ILEX MONTANA	4 43	1 20	5 100
JUNCUS TENUIS VAR TENUIS	1 14	1 20	
KALMIA LATIFOLIA	2 29	2 20	1 50
LISTERA SMALLII	1 43	1 20	1 100
LUZULA ACUMINATA	2 29		2 100
LYCOPODIUM CLAVATUM VAR CLAVATUM	2 29	2 20	2 50
LYCOPODIUM OBSCURUM	1 14		1 50
LYSIMACHIA QUADRIFOLIA	1 14		1 50
MELAMPYRUM LINEARE	2 29	2 20	1 50
MENZIESIA PILOSA	3 14	3 20	
MONOTROPA UNIFLORA	1 14	1 20	
PICEA RUBENS	7 86	7 100	3 50
PIERIS FLORIBUNDA	5 71	4 60	7 100
POLYPODIUM VIRGINIANUM	1 14	1 20	
PRENANTHES SP. #1	2 29		2 100
PRUNUS SEROTINA	5 43	5 20	6 100
QUERCUS RUBRA	1 14		1 50
RHODODENDRON CATAWBIENSE	7 100	6 100	9 100

Group:	3.		3.1		3.2	
	Cov	Con	Cov	Con	Cov	Con
ROBINIA PSEUDOACACIA	1	14			1	50
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1	29	1	20	1	50
SMILAX HERBACEA	1	14			1	50
SORBUS AMERICANA	2	71	3	60	1	100
TRILLIUM UNDULATUM	1	29			1	100
TSUGA CANADENSIS	6	14	6	20		
VACCINIUM ERYTHROCARPUM	2	57	2	60	1	50
VACCINIUM PALLIDUM	1	43	2	40	1	50
VACCINIUM STAMINEUM	4	86	4	80	2	100
VIBURNUM NUDUM VAR CASSINOIDES	3	29	4	20	1	50
VIOLA BLANDA	1	14			1	50

Table 4.16. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Shrub Balds** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

3. Shrub Balds

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
PICEA RUBENS	314.29	591.07	44.64	950.00	22.28	13.93	54.07	34.00
PIERIS FLORIBUNDA	4490.48	3214.29	0.00	7704.76	6.06	17.06	13.13	15.09
RHODODENDRON CATAWBIENSE	6657.14	4298.21	0.00	10955.36	8.01	55.03	19.09	37.06
ALL	12461.90	8578.57	44.64	21085.12	40.78	100.00	100.00	100.00

3.1 Picea/Rhododendron catawbiense Shrubland

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
PICEA RUBENS	340.00	827.50	62.50	1230.00	31.19	19.32	75.70	47.51
RHODODENDRON CATAWBIENSE	3320.00	2117.50	0.00	5437.50	3.98	56.60	10.69	33.64
VACCINIUM STAMINEUM	560.00	80.00	0.00	640.00	0.14	7.15	1.95	4.55
ALL	6346.67	3150.00	62.50	9559.17	38.83	100.00	100.00	100.00

3.2 [Rhododendron catawbiense-Pieris Shrubland]

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
AMELANCHIER LAEVIS	0.00	400.00	0.00	400.00	2.95	0.94	10.34	5.64
PIERIS FLORIBUNDA	12500.00	11250.00	0.00	23750.00	21.12	45.86	40.08	42.97
PRUNUS SEROTINA	0.00	550.00	0.00	550.00	3.11	1.24	8.57	4.90
RHODODENDRON CATAWBIENSE	15000.00	9750.00	0.00	24750.00	18.08	51.10	40.08	45.59
ALL	27750.00	22150.00	0.00	49900.00	45.64	100.00	100.01	100.00

Table 4.17. Vertical structure of woody species in the **Shrub Balds** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

3. Shrub Balds

	<0.5m	6-0.5m	15-6m	35-15m	>35m
AMELANCHIER LAEVIS	1	1	1		
ARONIA MELANOCARPA	1	1			
BETULA ALLEGHANIENSIS	1	1	1		
ILEX MONTANA	1	1			
PICEA RUBENS	2	3	3	3	
PIERIS FLORIBUNDA	1	4			
PRUNUS SEROTINA	1	2	2		
RHODODENDRON CATAWBIENSE	1	7	1		
SORBUS AMERICANA	1	1			
TSUGA CANADENSIS	1	1	1		
VACCINIUM STAMINEUM	1	2			

3.1 Picea/Rhododendron catawbiense Shrubland

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ARONIA MELANOCARPA	1	1			
BETULA ALLEGHANIENSIS	1	1	1		
BETULA LENTA	1	1	1		
PICEA RUBENS	2	3	5	4	
PIERIS FLORIBUNDA	1	2			
PRUNUS SEROTINA	1	1	1		
RHODODENDRON CATAWBIENSE	2	6	2		
SORBUS AMERICANA	1	1			
TSUGA CANADENSIS	1	1	1		
VACCINIUM STAMINEUM	1	3			
VIBURNUM NUDUM VAR					
CASSINOIDES	1	0			

3.2 [Rhododendron catawbiense-Pieris Shrubland]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
AMELANCHIER LAEVIS	1	3	4		
ILEX MONTANA	1	5			
PICEA RUBENS	1	2			
PIERIS FLORIBUNDA	1	7			
PRUNUS SEROTINA	1	5	3		
RHODODENDRON CATAWBIENSE	1	9			
VACCINIUM STAMINEUM	1	1			

Table 4.18. Average site information for the **Shrub Balds** vegetation class. Groups represented by their abbreviation code. For full names see Table 4.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**M**=migmatite, **Q**=quartz,), Landform types (representing micro-scale topographic units) (**R**=ridge, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**US**=upper-slopes).

3. Shrub Balds

	Group		
	3.	3.1	3.2
Site Characteristics:			
Elevation (m)	1778	1780	1771
Slope (o)	18	22	9
Aspect (o)		W-N	SW,E
Parent material	Q	M	Q
Soil depth (cm)	27.6	27.3	28.8
Surface Substrate (%):			
Moss/Lichen	21	25	10
Wood	2	3	2
Rock	32	44	2
Organic Matter	60	50	86
Water	0	0	0
Topographic Characteristics:			
Relative slope (%)	84	80	92
LFI	0.02	0.03	-0.01
TSI	-0.02	-0.02	-0.02
Landform type	SS	SS,R	SS
Topographic position	US	US	US

4.5.4 VEGETATION CLASS: 4. Grasslands

The **Grasslands** vegetation class contains a typically diverse range of herbaceous species with only limited shrub and small tree presence. This class is uncommon in the Southern Appalachians, with distribution typically restricted to the gentle slopes, ridge-tops and knobs of the high-mountains in this region (Schafale & Weakley 1990). In Shining Rock, the **Grasslands** class is confined to the broad, high-elevation ridge in the center of the Wilderness and the summit of Cold Mountain (Appendix 5). This class is often found in close association with the **Shrub Balds** vegetation class. These two classes survive in the most extreme weather conditions present in this landscape. They are subjected to freezing winter winds, snow accumulation, periods immersed in fog, saturation by summer orographic rain storms and full exposure to intense solar radiation over the summer months.

COMMUNITY TYPE: [Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland] (4.1)

Synonymy

Grassy Bald (Schafale & Weakley 1990), Grassy Bald (Whittaker 1956), Grassland Bald, forested balds p.p. (Mark 1958), Grass Bald community (Ramseur 1960), Grass Balds (McLeod 1988).

Listed species

Luzula multiflora var. *congesta*, *Solidago lancifolia*.

Physiognomy

This community type is dominated by a dense 0.4 m tall herbaceous stratum. The two samples in this type differ in stature. The most open site is dominated by *Carex pensylvanica* (cover of 7) with patches of *Ageratina altissima* var. *roanensis*, *Dennstaedtia punctilobula* and *Rhododendron catawbiense* also abundant (all cover of 4; Tables 4.19, 4.20, 4.21). *Aster acuminatus* var. *acuminatus*, *Bromus pubescens* and *Robinia hispida* are present with more restricted cover. The second site has an "orchard-like" appearance, with 8 m tall *Prunus serotina* and *R. catawbiense* shrubs scattered above the dense herbaceous carpet. The ground layer is dominated by *Carex pensylvanica*, *D. puntilobula* (both cover of 7) and *Ageratina altissima* var. *roanensis* (cover 6).

Habitat and Distribution

The two sites in this community type inhabit the slopes (mean slope 4°, SD 1.4°) in Beech Spring Gap (mean elevation 1709 m, SD 0.7m; Table 4.22). The open site is characteristic of the herbaceous vegetation at the center of the Gap and on adjacent open slopes, whereas the shrubby site represents the vegetation surrounding the open grassland on the slopes rising up from the Gap.

The soils are sandy, with a high clay component and very low silt (Table 4.5). The **[Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]** has fertile soils in comparison to other community types in Shining Rock, with high base saturation, cation exchange capacity, K, Mg, N and pH levels (Table 4.4). Moreover, this type has highest Ca, Cu and Zn values of any group in this study, which may reflect nutrient accumulation from the slopes above. Both sites are underlain by mica gneiss.

Distinguishing Features

Consistent with other **<u>Grasslands</u>** types, the **[Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]** has very high species richness at the three smallest spatial scales, reflecting the small physical size of vascular plants present in these communities (Table 4.6). Moreover, this community type has the highest diversity levels in the **<u>Grasslands</u>** class at the smallest spatial scale, which probably is a reflection of the more fertile conditions inhabited by this group.

Succession and Disturbance

Sites now inhabited by the **[Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]** were logged for timber and were subsequently burned during both major fires. Records suggest that these sites were subjected to very intense heat and subsequent soil erosion in the 1925 fire (USFS *unpub. data*).

Observations in other Southern Appalachian Mountain high-elevation areas (e.g., Brown 1941, Lindsay & Bratton 1979) have shown that **Grasslands** are successional and can only be maintained by active management, either by fire or possibly heavy browsing. This suggests that without recurrent disturbance invading woody species will begin to dominate the **[Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]** sites. Based on composition of the second, shrubbier plot, with time shrub cover of the open plot will increase with *Rhododendron catawbiense* and *Prunus serotina* dominant. The woody component of the shrubby site with become more widespread in the future, with the herbaceous patches rapidly reducing in abundance as shrub density increases. Stands will succeed to the **[Rhododendron catawbiense-Pieris Shrubland]**, in the **Shrub Balds** class (Appendix 7).

COMMUNITY TYPE: Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland (4.2)

Synonymy

Grassy Bald (Schafale & Weakley 1990), Shining Rock Gap Bald (Wells 1937), Grassy Bald Community (Brown 1941), Grassy Bald (Whittaker 1956), Grassland Bald (Mark 1958), Grass Bald community (Ramseur 1960), Grass Balds (McLeod 1988).

Constant species

Aster acuminatus var. *acuminatus, Carex pensylvanica, Danthonia compressa, Deschampsia flexuosa* var. *flexuosa, Houstonia purpurea* var. *purpurea, Prenanthes* species, *Rumex acetosella, Solidago arguta* ssp. *caroliniana, Vaccinium corymbosum*.

Listed species

Hypericum graveolens, Hypericum mitchellianum, Krigia montana, Luzula multiflora var. *congesta*.

Physiognomy

This community type has an open and shrubby form. The two open sites have a dense 0.5 m tall herbaceous layer dominated by *Danthonia compressa, Carex pensylvanica* (both cover of 6) with *Deschampsia flexuosa* abundant in one site (cover of 6) and *Aster macrophylla* in the other (cover of 5; Tables 4.19, 4.20, 4.21). *Vaccinium corymbosum* has very limited distribution (cover 2) within these open, herb-dominated sites. However, in the one shrubby plot *V. corymbosum* forms a 1.3 m tall, dense, but patchy shrub stratum (cover 7), in conjunction with clumps of *Pieris floribunda* (cover 6) and *Rhododendron catawbiense* (cover 5). There are shorter herbaceous areas between the shrub clumps dominated by *Danthonia* (cover 6) with *Deschampsia* (cover 3) also abundant. *Aster acuminatus* var. *acuminatus, Houstonia purpurea* var. *purpurea, Prenanthes* species, *Rumex acetosella* and *Solidago arguta* ssp. *caroliniana* have consistent low cover in both forms at all three sites.

Habitat and Distribution

The **Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland** covers extensive areas along the shallow sloping (mean slope 7°, SD 4°, range 4-12°), convex, high-elevation ridges (elevational range of 1651 to 1775 m) in the center of Shining Rock (Table 4.22, Appendix 5). This type occurs at the southern-end of the Shining Rock Ledge and the upper-end of the Fork Mountain ridgeline. The open variant carpets the comparatively lower-elevation gaps and adjacent slopes and grades into the shrubby version as the slopes rise towards the broad, rounded high-points.

In contrast to the two other **Grasslands** types, this community type has very silty soils with low clay and sand content (Table 4.5). Differences in texture may relate to different underlying bedrock, with two sites in this group underlain by migmatite and only one by mica gneiss. Multivariate analysis of variance results indicate statistically significant differences in the texture of the different geologic types (Table 4.3). The soils are infertile, with highest Fe, Na, P, S and lowest base saturation, Ca, K and pH of the three **Grasslands** community types (Table 4.4).

Succession and Disturbance

Historic information suggests that sites in this community type were burned in the 1925 and 1942 fires. In contrast to the **[Rhododendron catawbiense/Carex pensylvanica -Dennstaedtia Grassland]** type, sites inhabited by the **Vaccinium corymbosum/ Danthonia compressa-Carex pensylvanica Grassland** were cleared and used for pasture for 40 years or so (USFS *unpub. data*). These sites were probably heavily grazed by animals used in the logging operations. Sites may have also been exposed to introduced species as large quantities of hay brought in from Tennessee, were consumed on these pastures (J. Alger *pers. comm.*). Today this community type is regularly browsed by deer, used by hikers for camping and seasonally visited by blueberry pickers.

Research by Brown (1941) and Lindsay & Bratton (1979) suggests that **Grasslands** can only be maintained with recurrent disturbance. Without disturbance woody shrub species, such as *Vaccinium corymbosum* and *Pieris floribunda* will invade the open sites, and with time will resemble the shrubby site. The herbaceous component of the shrubby version will probably be forced out as shrub cover increases and takes on a **Shrub Balds**-like appearance. Descriptions by Wells (1937) suggest that this community type once inhabited slopes adjacent to the Shining Rock Gap presently inhabited by the **[Rhododendron catawbiense-Pieris Shrubland]** and the **Picea/Rhododendron catawbiense Shrubland**. High-elevation species common in adjacent forests, such as

Betula alleghaniensis or *Fagus*, will eventually invade and this group will succeed to the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** in comparatively sheltered sites, or to the **Fagus/Carex pensylvanica Forest** on the more exposed, upper-slope situations (see Figures 4.4, 4.5; Appendix 7).

COMMUNITY TYPE: [Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland] (4.3)

Synonymy

Grassy Bald p.p. (Schafale & Weakley 1990), Fire Meadow p.p. (McLeod 1988), [*Crategus flabellata/Fragaria virginiana/Phlox carolina* Grassland] p.p. (Chapter 5).

Listed species

Luzula multiflora var. *congesta*, *Sibbaldiopsis tridentata*.

Physiognomy

Phlox carolina ssp. *carolina* (cover of 7) forms the matrix of this 0.6 m tall, lush meadow with clumps of *Schizachyrium scoparium* and prostrate *Vaccinium stamineum* (both cover of 6) scattered throughout (Tables 4.19, 4.20, 4.21). *Solidago arguta* ssp. *caroliniana* and *Aster paternus* are less abundant. Four woody species; *Kalmia latifolia*, *Rhododendron calendulaceum*, *Rhododendron catawbiense* and *Robinia pseudo-acacia* (all cover of 4) are sparsely scattered across the meadow with taller, 1.6 m high clumps of *Rhododendron catawbiense* (cover of 4) concentrated around the edges of the meadow, adjacent to continuous shrub and small tree cover.

Habitat and Distribution

This community type is situated on the main, broad, east-west ridge leading to the summit of Cold Mountain (westerly-facing, 12° slope, elevation of 1745 m; Table 4.22). For such a highly exposed ridgeline this type is relatively sheltered, nestled within the taller surrounding shrub and stunted *Fagus* forest.

The soils of this plot are coarse-textured but with a high fine component and have highest sand (86%) and clay (12%) of any group in this study (Table 4.5). This type also has the lowest Fe levels of any group in the study (Table 4.4). The **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** has moderately high pH levels, but in comparison to the other two **Grasslands** groups has lower B, cation exchange capacity, Cu, organic matter, soil density and Zn levels.

Distinguishing Features

The **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** has greater small-scale species diversity (between 0.1m^2 and 100m^2) than the other two **Grasslands** types with values at the 0.1m^2 and 1m^2 scales highest of any group in this study (Table 4.6). This reflects the dominance of small-sized herbaceous species in this type.

Although not present within the sample plot, five *Lilium philadelphicum* var. *philadelphicum* plants were found within 5 meters of the plot boundary in the same community type. This is the first official sighting of this species on Cold Mountain since recorded by George Ramseur in 1957 (Biological Conservation Database, *unpub. data*)

Succession and Disturbance

Historical records show that this community was only burned in the 1925 fire (USFS *unpub. data*), however, charred shrub stems provide evidence for more recent fire in this community type. Fire may have been ignited by lightening or possibly by farmers to maintain an open community. Somewhere in this vicinity Wells (1937) noted evidence for fire in the five years prior to 1937. Although records do not indicate that the area inhabited by this community type has been grazed, the flat topography of this region and the abrupt change in composition and structure of the surrounding vegetation communities suggests that the area was purposely cleared. It is possible that this area was periodically burned by blueberry pickers to maintain *Vaccinium* dominance (see Wells 1937).

Wells (1937) and Ramseur (1960) documented the existence of a **Grasslands** type dominated by *Danthonia compressa*, *Potentilla canadensis* and *Achillea millefolium* on Cold Mountain. Wells' (1937) group extended 14 acres along the "south side ridge top near and east side of the peak" of Cold Mountain, at an elevation of 1790 m (Wells 1937). This description appears nearer the summit of Cold Mountain than the present **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** type (Table 4.19) and reads as though it did not inhabit the main east-west summit ridgeline. Areas corresponding to the probable locations of Wells (1937) description are presently inhabited by the **Fagus/Carex pensylvanica Forest** and a stunted heath variant of the **Betula alleghaniensis/Ageratina-Aster acuminatus Forest** (for details of this variant see the type description in the **High-Elevation Mixed Hardwood Forests** vegetation class). However, it seems somewhat likely that Wells' (1937) community did extend down the main east-west summit ridge. The **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** may have developed on the moister and more sheltered, lower end of Wells' (1937) community, accounting for compositional differences between the two groups. I do not believe that Wells' type formerly inhabited sites now occupied by the **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]**.

The **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** needs active management to be maintained in its present form. Without fire, shrub species will invade the meadow and it will succeed to the shrub-stunted forest communities presently surrounding it (Appendix 7).

Discussion

Although the origin of the **Grasslands** vegetation class in the Southern Appalachian Mountains has generated much debate for many decades (e.g. Wells 1936, Wells 1937, Mark 1958), there has been little quantification of the compositional and structural patterns within this group and most studies have concentrated on the floristics of this class (e.g., Wells 1937, Brown 1941, Mark 1959). Probably the best descriptions are those of Brown (1941) on Roan Mountain, and his, like most other authors (e.g., Wells 1937, Brown 1941, Mark 1958, Core 1966, Lindsay & Bratton 1979, McLeod 1988) highlight the dominance of *Danthonia compressa*. The **Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland**, the most widespread grassland community type in Shining Rock, is also dominated by this species. However, *Danthonia compressa* is absent from the second-most widespread group, the **[Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]**.

Wells (1937) distinguished between balds dominated by *Danthonia compressa* and *Carex flexuosa*, associating the latter with wetter, deeper soils. Similar differentiation may be plausible for the two Shining Rock types mentioned above. The composition of the **[Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]** has some resemblance to the Mount Sterling and Andrews Balds communities dominated by *Carex flexuosa* (Wells 1937). In the present study, the **[Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]** inhabits moist situations at the concave base and lower slopes of a comparatively sheltered gap. This contrasts to the windswept, broadly convex habitat of the **Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland,** where *Danthonia compressa* is dominant.

Other authors (e.g., Lindsay & Bratton 1979, McLeod 1988) associate the dominance of *Danthonia compressa* with grazing, trampling by grazers and sustained disturbance. Similarly, land-use differences may partially account for compositional and soil fertility differences between the two major **Grasslands** types in Shining Rock. Sites inhabited by the **[Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]** were logged for timber and subsequently burned intensely in 1925, whereas those inhabited by the **Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland**, with *D. compressa* dominant, were cleared in the 1880's and grazed for 40 or more years. Sustained intensive grazing may account for the less fertile soil conditions of this latter community type, and this is substantiated by the fact that lightly or nongrazed **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** and **[Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]** sites have more fertile soils.

There are other compositional differences between the **[Rhododendron catawbiense/Carex pensylvanica Grassland]** and the **Vaccinium corymbosum/ Danthonia compressa-Carex pensylvanicum Grassland**. *Danthonia compressa* and *Deschampsia flexuosa* are dominant species in the **Vaccinium corymbosum/Danthonia compressa-Carex pensylvanicum Grassland** in contrast to *Ageratina altissima* and *Dennstaedtia punctilobula* in the **[Rhododendron catawbiense/Carex pensylvanica Grassland]**. Although these two community types are similar in structure, *Vaccinium corymbosum* is the major shrub species in the former group, whereas *Rhododendron catawbiense* dominates the latter type. The height and density of shrub stratum in the "shrubby" site in each type differs. The "orchard-like" appearance of the **[Rhododendron catawbiense/Carex pensylvanica Grassland]** contrasts to the very stunted and denser, but patchy shrub stratum in **Vaccinium corymbosum/Danthonia compressa-Carex pensylvanicum Grassland**. These differences possibly relate to contrasting site exposure. The latter type inhabits highly exposed, windswept areas on the main Shining Rock Ledge, whereas **[Rhododendron catawbiense/Carex pensylvanica Grassland]** occurs in a more sheltered gap.

An absence of sedges and dominance of herbaceous species separates the **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** from the former two types in Shining Rock (Tables 4.19, 4.20). The **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** has loose affiliations with the "fire meadow" described by McLeod (1988) and the [*Crategus flabellata/Fragaria virginiana/Phlox carolina* Grassland], maintained at Joyce Kilmer by mowing (Chapter 5), but otherwise has not been documented in the Southern Appalachians. Similar vegetation has been observed on roadside margins of the Blue Ridge Parkway (G. Kauffman *pers. comm.*). Recurrent fire, land-use history differences and absence of soil erosion may account for the compositional differences between the **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** and the other two **Grasslands** types.

Table 4.19. Average cover class and constancy of species present in the **Grasslands** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 4.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	4.	4.1	4.2	4.3
Number of plots:	6	2	3	1
Homoteneity:	0.58	0.84	0.69	
	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species				
ACER RUBRUM VAR RUBRUM	3 33		3 67	
ACHILLEA MILLEFOLIUM	2 17			2 100
AGERATINA ALTISSIMA VAR ROANENSIS	3 67	5 100	2 67	
AGROSTIS PERENNANS	2 50	2 100	1 33	
ALLIUM CERNUUM VAR CERNUUM	2 17			2 100
AMELANCHIER LAEVIS	4 33		4 67	
ANDROPOGON VIRGINICUS VAR VIRGINICUS	1 17			1 100
ANGELICA TRIQUINATA	2 67	2 100	2 67	
ARNOGLOSSUM ATRIPLICIFOLIUM	2 17			2 100
ASTER ACUMINATUS VAR ACUMINATUS	3 83	4 100	3 100	
ASTER CHLOROLEPIS	2 33	1 50	2 33	
ASTER MACROPHYLLUS	3 50	2 50	4 67	
ASTER PATERNUS	3 17			3 100
ASTER RETROFLEXUS	2 17			2 100
ASTER UNDULATUS	2 17			2 100
BROMUS PUBESCENS	3 50	3 100	2 33	
CALAMAGROSTIS CINNOIDES	2 17	2 50		
CAMPANULA DIVARICATA	2 17		2 33	
CAREX ALLEGHENIENSIS	3 33		3 67	
CAREX COMMUNIS	2 17		2 33	
CAREX FLEXUOSA	2 67	2 100	2 33	1 100
CAREX PENSYLVANICA	6 83	7 100	5 100	
CAREX SCOPARIA VAR SCOPARIA	1 17		1 33	
CAREX UMBELLATA	2 33		2 33	1 100
CHAMAELIRIUM LUTEUM	1 17			1 100
CIRSIUM DISCOLOR	2 17		2 33	
COREOPSIS MAJOR VAR RIGIDA	2 17		2 33	
CRATAEGUS MACROSPERMA	2 33		1 33	2 100
DANTHONIA COMPRESSA	5 67		6 100	2 100
DANTHONIA SERICEA	1 17		1 33	
DENNSTAEDTIA PUNCTILOBULA	4 67	5 100	2 67	
DESCHAMPSIA FLEXUOSA VAR FLEXUOSA	3 100	2 100	4 100	2 100
DIERVILLA SESSILIFOLIA	1 50	1 50	2 67	
DIPHASIASTRUM DIGITATUM	2 17			2 100
EPIGAEA REPENS	1 17		1 33	
ERIGERON PULCHELLUS VAR PULCHELLUS	1 17			1 100
EUPATORIUM PURPUREUM	1 17	1 50		
FESTUCA SUBVERTICILLATA	2 17	2 50		
FRAGARIA VIRGINIANA VAR VIRGINIANA	2 17		2 33	
HIERACIUM CAESPITOSUM	1 17		1 33	

Group:	4.	4.1	4.2	4.3
	Cov/Con	Cov/Con	Cov/Con	Cov/Con
HIERACIUM PANICULATUM	1 17		1 33	
HIERACIUM PILOSELLA VAR PILOSELLA	1 17		1 33	
HIERACIUM SCABRUM VAR SCABRUM	1 17		1 33	
HOUSTONIA PURPUREA VAR PURPUREA	2 67		1 100	2 100
HOUSTONIA SERPYLLIFOLIA	2 33		2 67	
HYPERICUM SP. #1	1 17	1 50		
HYPERICUM GRAVEOLENS*	1 17		1 33	
HYPERICUM MITCHELLIANUM*	2 17		2 33	
JUNCUS TENUIS VAR TENUIS	2 33	2 100		
KALMIA LATIFOLIA	4 17			4 100
KRIGIA MONTANA*	2 17		2 33	
LUZULA ACUMINATA	2 33	2 100		
LUZULA MULTIFLORA VAR CONGESTA*	2 67	1 50	2 67	2 100
LYCOPODIUM OBSCURUM	2 33	1 50	2 33	
LYSIMACHIA QUADRIFOLIA	2 17			2 100
MAIANTHEMUM CANADENSE	1 17	1 50		
MONARDA CLINOPODIA	1 17			1 100
PEDICULARIS CANADENSIS	2 17			2 100
PHLEUM PRATENSE	3 33	4 50	2 33	
PHLOX CAROLINA SSP CAROLINA	7 17			7 100
PIERIS FLORIBUNDA	3 50	2 100	6 33	
POA AUTUMNALIS	2 17			2 100
POA PRATENSIS	1 50	1 50	2 67	
POLYGONUM CONVOLVULUS VAR CONVOLVULUS	2 17		2 33	
POTENTILLA CANADENSIS VAR CANADENSIS	2 33		1 33	2 100
PRENANTHES SP. #1	1 83	2 100	1 100	
PRUNUS PENSYLVANICA	1 17		1 33	
PRUNUS SEROTINA	6 17	6 50		
PRUNELLA VULGARIS	1 50		1 67	2 100
PTERIDIUM AQUILINUM	2 17			2 100
PYCNANTHEMUM MONTANUM	2 17		2 33	
RHODODENDRON CALENDULACEUM	4 17			4 100
RHODODENDRON CATAWBIENSE	5 67	5 100	5 33	4 100
RIBES ROTUNDIFOLIUM	1 17		1 33	
ROBINIA HISPIDA	3 50	3 100	2 33	
ROBINIA PSEUDOACACIA	4 17			4 100
RUBUS CANADENSIS	2 50	2 50	1 33	2 100
RUDBECKIA HIRTA	2 17			2 100
RUMEX ACETOSELLA	2 83	2 50	2 100	2 100
SCHIZACHYRIUM SCOPARIUM	6 17			6 100
SENECIO OBOVATUS	1 17		1 33	
SIBBALDIOPSIS TRIDENTATA*	2 17			2 100
SILENE VIRGINICA VAR VIRGINICA	2 17			2 100
SOLIDAGO SP. #1	2 33		2 67	
SOLIDAGO SP. #2	1 17		1 33	
SOLIDAGO ARGUTA SSP CAROLINIANA	3 67		2 100	4 100
SOLIDAGO LANCIFOLIA*	2 33	2 100		
SOLIDAGO PATULA VAR PATULA	2 17	2 50		
SOLIDAGO RUGOSA	2 17		2 33	
STACHYS LATIDENS	1 17		1 33	
THELYPTERIS NOVEBORACENSIS	2 17	2 50		
VACCINIUM CORYMBOSUM	5 50		5 100	
VACCINIUM STAMINEUM	4 33		2 33	6 100
VIOLA BLANDA	2 50	2 100	2 33	

Table 4.20. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Grasslands** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

4. Grasslands

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	5.56	30.56	0.00	36.11	0.18	2.58	7.35	4.96
AMELANCHIER LAEVIS	0.00	25.00	0.00	25.00	0.31	2.38	9.51	5.94
PRUNUS SEROTINA	0.00	166.67	0.00	166.67	0.95	5.13	7.48	6.30
RHODODENDRON CATAWBIENSE	491.67	450.00	0.00	941.67	1.45	46.64	45.53	46.08
VACCINIUM CORYMBOSUM	736.11	33.33	0.00	769.44	0.09	23.35	10.86	17.10
ALL	1330.56	708.33	0.00	2038.89	3.00	83.34	83.33	83.33

4.1 [Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
PRUNUS SEROTINA	0.00	500.00	0.00	500.00	2.86	15.39	22.43	18.91
RHODODENDRON CATAWBIENSE	125.00	1350.00	0.00	1475.00	4.19	84.62	77.58	91.10
ALL	125.00	1850.00	0.00	1975.00	7.05	100.00	100.00	100.00

4.2 Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBUM	11.11	61.11	0.00	72.22	0.37	5.16	14.70	9.93
AMELANCHIER LAEVIS	0.00	50.00	0.00	50.00	0.61	4.76	19.01	11.89
RHODODENDRON CATAWBIENSE	433.33	0.00	0.00	433.33	0.03	7.69	6.53	7.11
VACCINIUM CORYMBOSUM	1472.22	66.67	0.00	1538.89	0.18	46.69	21.72	34.20
ALL	2044.44	183.33	0.00	2227.78	1.21	66.67	66.66	66.66

4.3 [Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
RHODODENDRON CATAWBIENSE	1400.00	0.00	0.00	1400.00	0.25	87.50	98.44	92.97
ALL	1600.00	0.00	0 00	1600.00	0.25	100.00	100.00	99.99

Table 4.21. Vertical structure of woody species in the **Grasslands** vegetation class. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

4. Grasslands

	<0.5m	6-0.5m	15-6m	35-15m	>35m
PIERIS FLORIBUNDA	1				
PRUNUS SEROTINA	1	1			
RHODODENDRON CATAWBIENSE	1	3			
VACCINIUM CORYMBOSUM	2	2			

4.1 [Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
PRUNUS SEROTINA	1	3	2		
RHODODENDRON CATAWBIENSE	1	5	1		

4.2 Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1			
AMELANCHIER LAEVIS	1	1			
PIERIS FLORIBUNDA	2	1			
RHODODENDRON CATAWBIENSE	1	2			
VACCINIUM CORYMBOSUM	3	3			

4.3 [Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
KALMIA LATIFOLIA	2	1			
RHODODENDRON CATAWBIENSE	1	4			
ROBINIA PSEUDOACACIA	1	4			

Table 4.22. Average site information for the **Grasslands** vegetation class. Groups represented by their abbreviation code. For full names see Table 4.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**M**=migmatite, **MG**=mica gneiss), Landform types (representing micro-scale topographic units) (**R**=ridge) and Topographic position (representing macro-scale topographic units) (**C**=crest, **US**=upper-slopes).

4. Grasslands

	Group			
	4.	4.1	4.2	4.3
Site Characteristics:				
Elevation (m)	1724	1709	1727	1745
Slope (o)	7	4	7	12
Aspect (o)		NE-E	SE-SW	W
Parent material	MG	MG	M	MG
Soil depth (cm)	40.0	41.7	35.6	70.3
Surface Substrate (%):				
Moss/Lichen	1	1	1	1
Wood	1	2	1	0
Rock	3	1	4	3
Organic Matter	95	96	95	94
Water	0	0	0	0
Topographic Characteristics:				
Relative slope (%)	91	82	96	94
LFI	0.04	0.04	0.05	-0.02
TSI	-0.02	-0.00	-0.03	-0.02
Landform type	R	R	R	R
Topographic position	US	US	C	US

4.5.5 VEGETATION CLASS: 5. <u>**High-Elevation Mixed Hardwood Forests**</u>

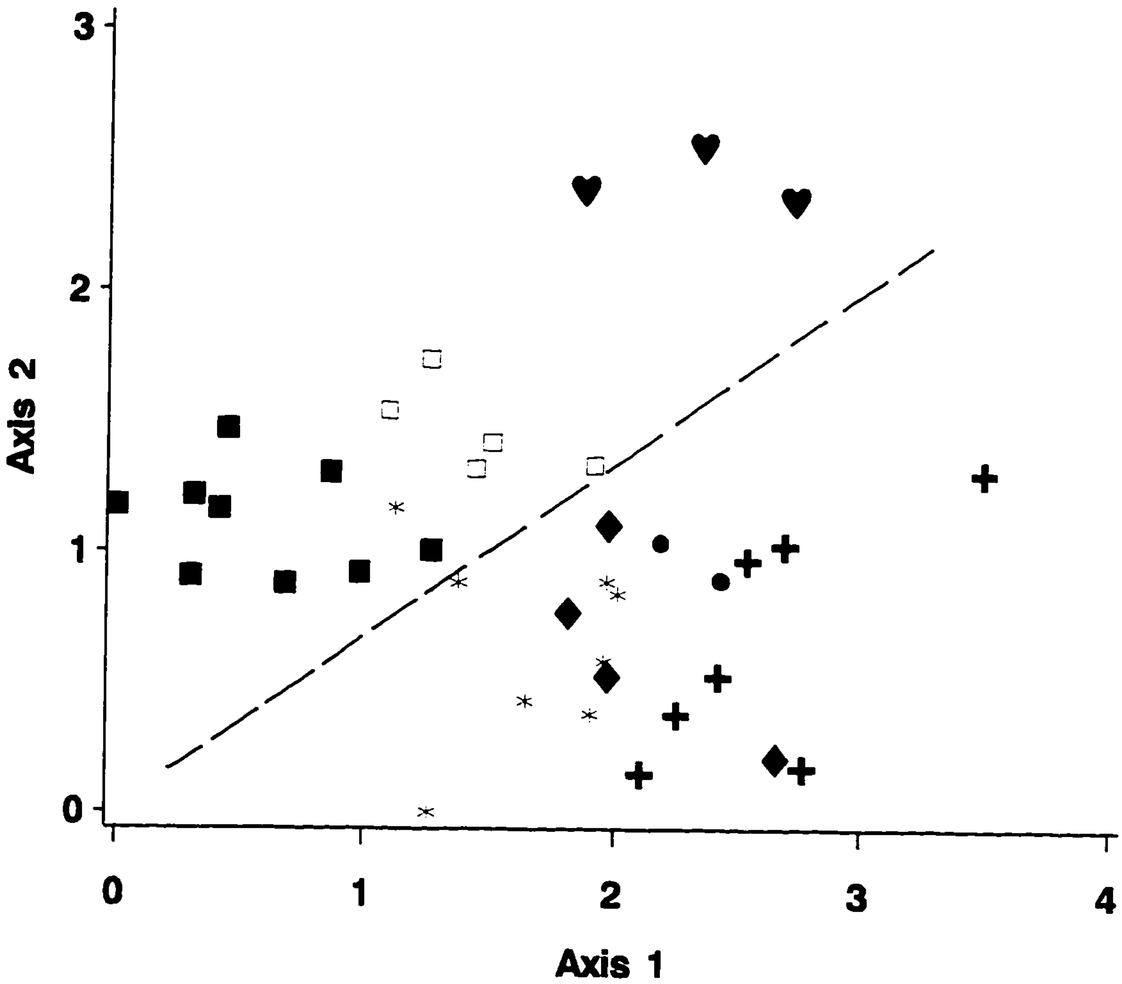
This vegetation class is widely distributed throughout the high-elevation areas in the Southern Appalachian Mountains, where it is often found in association with the **Grasslands, Shrub Balds** and **Spruce-Fir Forests** vegetation classes. The **High-Elevation Mixed Hardwood Forests** class inhabits relatively exposed sites that are susceptible to fire, wind and ice storms (Schafale & Weakley 1990). In Shining Rock this vegetation class dominates the central high-elevation ridges and associated upper-slopes (Figures 4.2, 4.3) and represents 20% of the vegetation mapped (Appendices 2, 5).

An ordination of the **High-Elevation Mixed Hardwood Forests** and **Spruce-Fir Forests** classes was used to help identify site differences between individual community types. Types are separated by topographic position, orientation, site moisture potential and proximity to high-rainfall sources (Figures 4.4, 4.5). The three drier, ridge and off-ridge types (the **Fagus/Carex pensylvanica Forest**, the **Quercus rubra-Picea/Carex pensylvanica Forest** and the **Quercus rubra/Kalmia Forest**) are well separated from the other types, inhabiting dryer sites (low TMI) with higher slope positions (high relative slope) than the remaining 4 types. The **Fagus/Carex pensylvanica Forest** separates from the two *Quercus rubra*-dominated types by inhabiting more exposed (higher solar radiation) sites with higher rainfall potential. Differences between the four remaining types were not clear and these were ordinated separately to help clarify site relationships between individual types.

The three *Betula alleghaniensis*-dominated types and the **[Picea/Dennstaedtia Forest]** separate by soil texture, soil nutrients (Mn), site moisture (TMI), elevation and distance to the Escarpment rainfall source (Figures 4.6, 4.7). The **Betula alleghaniensis/ Ageratina-Aster acuminatus Forest** occurs at lower-elevations than the other types, inhabiting moister sites (high TMI), with more fertile (Mn), finer-textured soils, reflecting its inhabitance of coves and other concave sites. In contrast, the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** has coarser-textured soils with higher silt content than the other types. The **Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest** and the **[Picea/ Dennstaedtia Forest]** typically have less influence of Escarpment-generated rainfall than other types.

The latter ordination shows that the **[Picea/Dennstaedtia Forest]** is not readily distinguished from the *Betula alleghaniensis* community types in the **High-Elevation Mixed Hardwood Forests** class on the basis of species composition. This probably reflects the close spatial proximity of both classes, similar disturbance regimes and similar environmental conditions, and the close successional links between the two vegetation classes. A similar pattern was observed by Ramseur (1960) and he recorded a 75% overlap in species between *Picea-* and *B. alleghaniensis*-dominated communities.

Figure 4.4. DCA ordination diagram showing the distribution of the **High-Elevation Mixed Hardwood Forests** and the **Spruce-Fir Forests** classes on the two major compositional gradients. Stands to the right of the dashed line were reordinated separately.



Community type:

5.1 Fagus/Carex pensylvanica Forest
5.2 Betula alleghaniensis – Prunus pen./R. catawbiense – V. simulatum Forest
5.3 Betula alleghaniensis/Acer spicatum – Rhododendron catawbiense Forest
5.4 Betula alleghaniensis/Ageratina – Aster acuminatus Forest
5.5 Quercus rubra – Picea/Carex pensylvanica Forest
5.6 Quercus rubra/Kalmia Forest Forest
6.1 Picea/Dennstaedtia Forest

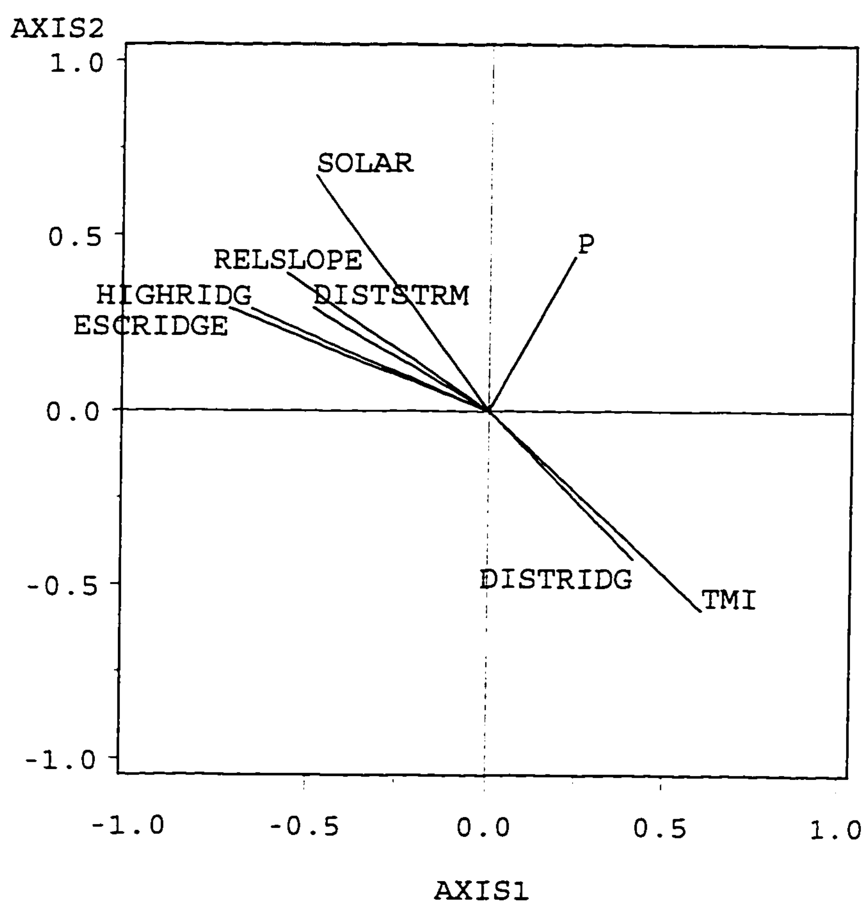
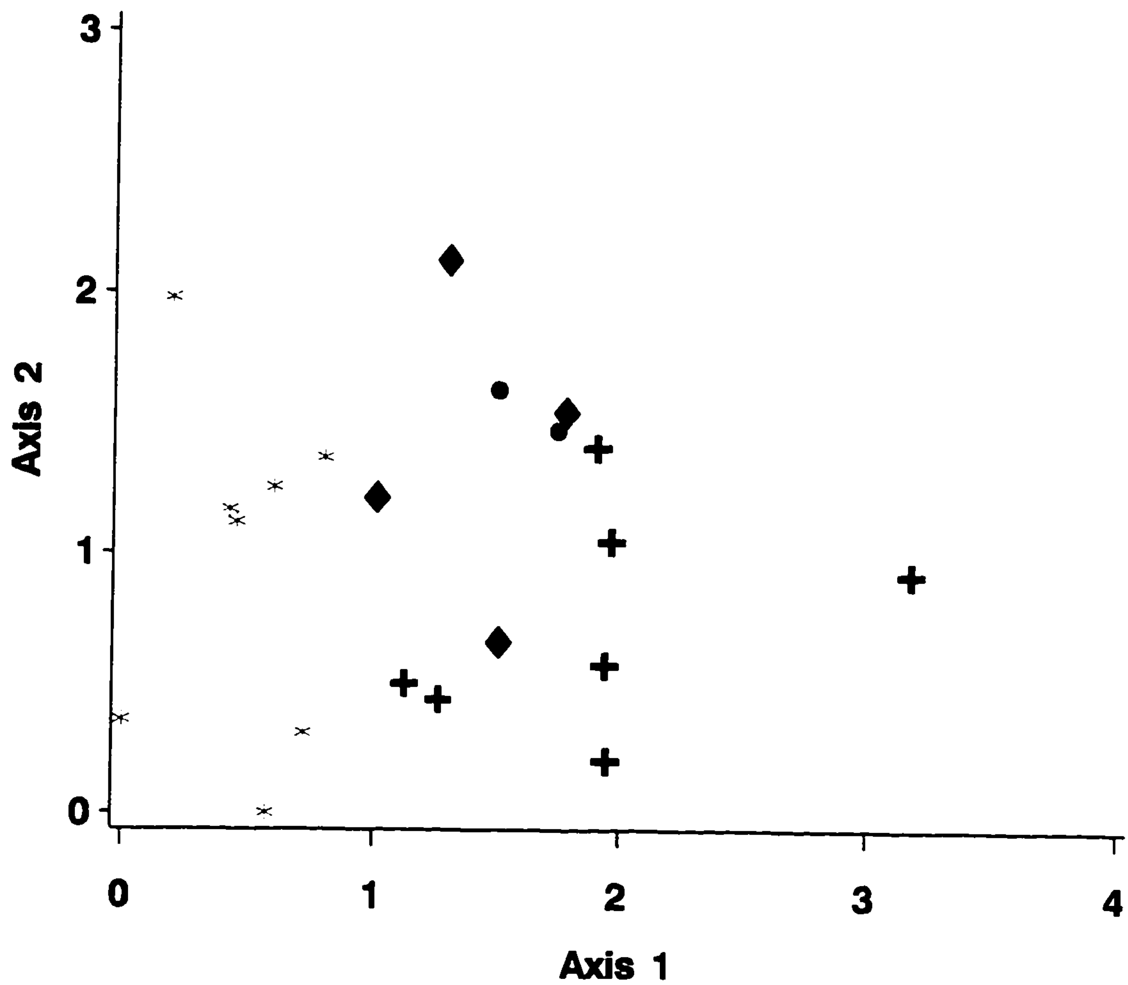


Figure 4.5. Vector diagram for DCA ordination of the **High-Elevation Mixed Hardwood Forests** and the **Spruce-Fir Forests** showing association between species composition and major environmental gradients. DISTRIDG=distance to ridge, DISTSTRM=distance downslope to stream/cove, ESCRIDGE=distance to Escarpment x HIGHRIDG, HIGHRIDG=distance to nearest high-elevation area, RELSLOPE=relative slope position, with increasing values corresponding to higher position. Small TMI values represent low site moisture potential while large values represent high site moisture.

Figure 4.6. DCA ordination diagram showing the distribution of the *Betula alleghaniensis* types in the **High-Elevation** **Mixed** **Hardwood** **Forests** and the **Spruce-Fir** **Forests** on the two major compositional gradients.



Community type:

* 5.2 Betula alleghaniensis – Prunus pensylvanica/R. catawbiense – V. simulatum F.
◆ 5.3 Betula alleghaniensis/Acer spicatum – Rhododendron catawbiense Forest
+ 5.4 Betula alleghaniensis/Ageratina – Aster acuminatus Forest
● 6.1 Picea/Dennstaedtia Forest

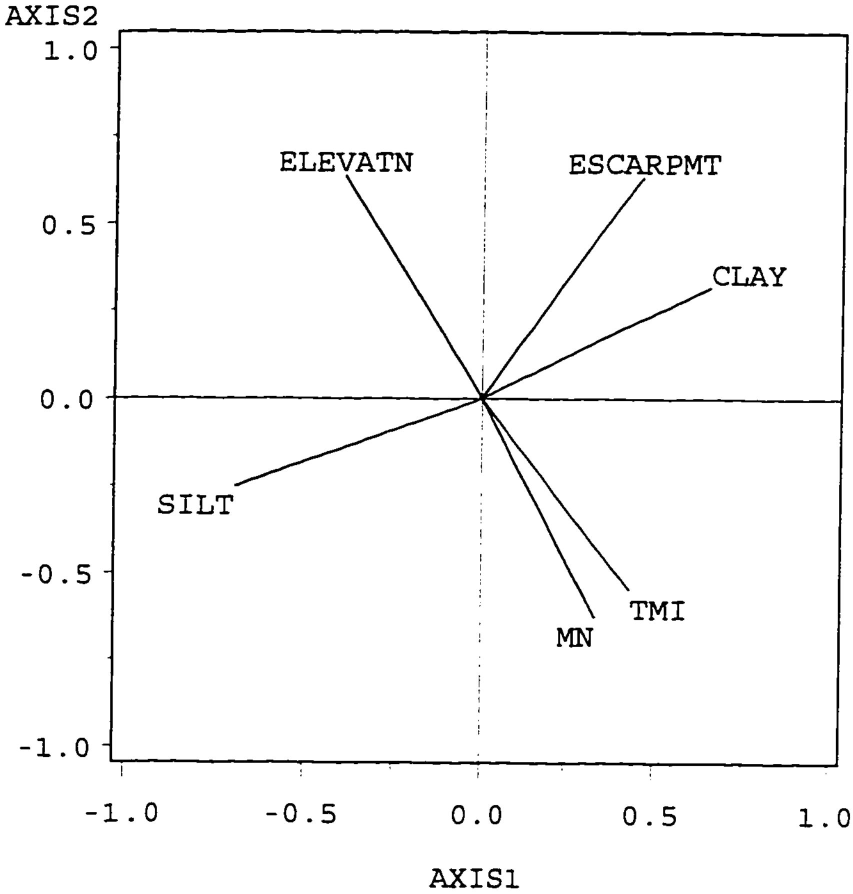


Figure 4.7. Vector diagram for DCA ordination of the *Betula alleghaniensis* types in the **High-Elevation Mixed Hardwood Forests** and the **Spruce-Fir Forests** showing association between species composition and major environmental gradients. ESCARPMT =average distance to the Escarpment region. Small TMI values represent low site moisture potential while large values represent high site moisture.

COMMUNITY TYPE: Fagus/Carex pensylvanica Forest (5.1)

Synonymy

Beech Gap subtype of Northern Hardwood Forest (Schafale & Weakley 1990), ridge variant of Typic subtype of Northern Hardwood Forest (Schafale & Weakley 1990), Beech Gap (Russell 1953), south slope variant of Gray Beech Forest (Whittaker 1956), Beech Gap (Crandell 1958), Beech Forest (Ramseur 1960), Beech gap forest (Pittillo & Smathers 1979), Beech forest (Callaway *et al.* 1987), exposed variant of Beech, Birch Forest (McLeod 1988), Northern Hardwood Forest (White *et al.* 1993), *Fagus/Carex pensylvanica* Forest (Chapter 5).

Constant species

Ageratina altissima var. *roanensis*, *Arisaema triphyllum*, *Carex pensylvanica*, *Fagus grandifolia*, *Solidago curtisii*.

Listed species

Abies fraseri, *Hypericum graveolens*.

Physiognomy

Fagus grandifolia forms a dense monotypic canopy (Tables 4.23, 4.24, 4.25). There are tall thickets of small-sized *Fagus* stems in the two shorter, probably younger stands (8 and 11 m canopy height), whereas the older, taller (22 m height) stand has an open understory below the *Fagus* canopy. Ground composition varies with elevation and exposure, rather than stand age. There is a dense carpet of *Carex pensylvanica* (cover of 7 and 8) in the two lower-elevation sites, whereas dense patches of *Galax urceolata* (cover 7) dominate the exposed, high-elevation stand, with *C. pensylvanica* restricted to clumps (cover 5) scattered amongst the *Galax*. Compositional differences between these two elevation forms were recognized in the Ward's classification, with the TRIM function separating the high-elevation *Galax* stand (plot 381) from the other two plots; however, differences were not sufficient to recognize two sub-types within this community type.

Habitat and Distribution

The two lower-elevation (elevations of 1715 and 1725 m) **Fagus/Carex pensylvanica Forest** stands inhabit the moderately sloped (23 and 25°), exposed, upper-faces of the Shining Rock Ledge (Figures 4.4, 4.5, Table 4.26). Stands form an almost continuous "treeline" below the **Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland** on the eastern faces of this Ledge, whereas they are more restricted to the drier areas on the western side of the Ledge. The third **Fagus/Carex pensylvanica Forest** stand is situated on an exposed, shallow-sloping (12° slope), off-ridge site east of the summit of Cold Mountain (Figure 1.4, elevation of 1800 m). There this type inhabits the dryer, east-facing, upper-slopes and ridges, whereas the **Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest** is dominant on the moister, less exposed westerly faces. This *Betula-Fagus* site separation pattern parallels the slope-aspect separation of Birch and Beech Gaps observed by Crandell (1958) in the Great Smoky Mountains.

The **Fagus/Carex pensylvanica Forest** has moderately coarse-textured soils. The soils are infertile, typically with low values for base saturation, cation exchange capacity, K, Mg and pH and high Fe and Mn in comparison to average values for the **High-Elevation Mixed Hardwood Forests** class (Tables 4.4, 4.5). The **Fagus/Carex pensylvanica Forest** has lowest Al and highest B, P and S levels in comparison to other types in this vegetation class. All three stands are underlain by one of the 3 major parent material types (Table 4.26).

Distinguishing Features

This is the only community type dominated by *Fagus grandifolia*. In comparison with other **High-Elevation Mixed Hardwood Forests** types, the **Fagus/Carex pensylvanica Forest** has lowest species richness between the $10m^2$ and $400m^2$ scales, reflecting the overwhelming dominance by two species; *Fagus grandifolia* and *Carex pensylvanica* (Table 4.6). This is the only type in this study where the canopy and herbaceous layer are each dominated by a single species.

Succession and Disturbance

The stands in this community type postdate the 1925 fire. All sites inhabited by this type were burned in 1925, with only one burned in 1942 (USFS *unpub. data*). Historic information (USFS *unpub. data*) suggests that the younger, lower-elevation stand (7 & 8 cm diameter *Fagus* aged 30 and 35 years) inhabits a site previously pastured or immediately adjacent to pastured land. Based on the composition and structure of the older, lower-elevation stand (plot 359; two 35 cm diameter *Fagus* aged 68 and 73 years), we project that the composition of the younger stand will change little as it matures. Stem density, however, will decline considerably to an open understory beneath a canopy of a few large-diameter *Fagus* trees. The existence of *Fagus* saplings in the older stand and absence of other woody seedlings suggests the continuing dominance by *Fagus* in the canopy (Table 4.28).

In the exposed conditions on Cold Mountain, trees in the higher-elevation stand have retarded growth and probably will always remain dwarfed in stature. Little seems to have changed in the stunted stature of *Fagus* forests in this area since Ramseur described them in 1960. The lack of other tree species in the understory of this stand suggests the continuing existence of *Fagus* in the canopy.

COMMUNITY TYPE: Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest (5.2)

Synonymy

Typic subtype of Northern Hardwood Forest (Schafale & Weakley 1990), Cove Hardwood Forest p.p. (Whittaker 1956), Fire cherry-blackberry community, Fire cherry-heath community, Fire cherry-yellow birch community (Ramseur 1960), Beech, Birch Forests p.p. (McLeod 1988).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Ageratina altissima* var. *roanensis*, *Amelanchier laevis*, *Aster acuminatus* var. *acuminatus*, *Aster chlorolepis*, *Aster macrophyllus*, *Athyrium asplenioides*, *Carex flexuosa*, *Danthonia compressa*, *Dennstaedtia punctilobula*, *Deschampsia flexuosa* var. *flexuosa*, *Eupatorium purpureum*, *Ilex montana*, *Prenanthes* species, *Prunus pensylvanica*, *Rhododendron catawbiense*, *Solidago curtisii*, *Vaccinium simulatum*.

Listed species

Abies fraseri, *Brachyelytrum septentrionales*, *Carex leptonervia*, *Carex ruthii*, *Luzula multiflora* var. *congesta*, *Senecio obovatus.*

Physiognomy

Betula alleghaniensis dominates the open canopy of this type in most sites, in conjunction with *Acer rubrum*, *Prunus pensylvanica*, *Amelanchier laevis* and *Ilex montana* (Tables 4.23, 4.24, 4.25). The lower constancy of *Betula alleghaniensis* and variable canopy height (range 6-20 m, mean of 13.4 m) reflects the broad range of successional stages embedded within this successional community type. *Betula* is absent from many younger, stunted sites, with *Acer rubrum* and/or *Prunus serotina* the major canopy species. Shrub stratum stature, composition and density varies with successional phase. *Rhododendron catawbiense* and *Vaccinium simulatum* are typically the dominant species, forming a dense stratum in younger- and mid-succesional sites. In contrast, however, these species form a scattered shrub layer in older, taller *Betula*-dominated sites. Dense *Rubus canadensis* thickets are present in some younger stands where the canopy is open. The forest floor is typically diverse and lush in areas devoid of dense shrub cover. *Ageratina* and *Aster acuminatus* var. *acuminatus* are the major species with *Aster chlorolepis*, *Dennstaedtia punctilobula* and *Eupatorium purpureum* also abundant. *Aster macrophyllus*, *Athyrium asplenioides*, *Carex flexuosa*, *Danthonia compressa*, *Deschampsia flexuosa* var. *flexuosa*, *Prenanthes* species and *Solidago curtisii* are present throughout with low abundance.

Habitat and Distribution

This community type occurs between elevations of 1624 and 1770 m (mean elevation of 1692, SD 47 m), mostly on west-to-north-facing, flat to moderately sloping (4-34° slope range, mean 20°), upper-faces of the central high-elevation ridges (Figures 4.6, 4.7, Table 4.26). Sites are underlain by both mica gneiss (63%) and migmatite (37%).

The soils are silty with low sand content in comparison to other **High-Elevation Mixed Hardwood Forests** types, but generally have similar soil chemistry to average values in this vegetation class (Figures 4.6, 4.7, Tables 4.4, 4.5). However, the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** has highest cation exchange capacity and Cu levels in comparison to the other community types in this vegetation class.

Distinguishing Features

The **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** can be distinguished from the other two **High-Elevation Mixed Hardwood Forests** community types dominated by *Betula alleghaniensis*, by the co-dominance of *Acer rubrum*, *Prunus pensylvanicum* and *Vaccinium simulatum*, and the presence of *Rubus canadensis*, which collectively reflect the successional nature of this community type.

The **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** has the highest species richness levels at the $1m^2$ scale and second highest at the $0.1m^2$ and $10m^2$ scales in comparison to other **High-Elevation Mixed Hardwood Forests** groups (Table 4.6). This is largely a product of the abundant small herbaceous species present in this community type.

Succession and Disturbance

Historic records indicate that all sites in this type were intensely burned in 1925 and suffered subsequent soil erosion. In 1942 roughly 50% of sites were burned again (USFS *unpub. data*). Charcoal and charred wood provide evidence for fire in 88% of sites. All stands were logged in the 1920's (USFS *unpub. data*). While no chestnut stumps were visible at any site in this community type, live sprouts are present in a limited number of stands, indicating that chestnut was at least a minor component of forests previously present on these sites.

This is a successional community type. The successional species *Prunus pensylvanica* and *Rubus canadensis* are abundant, but are dying out in some sites, which illustrates the successional process at work. The abundance of these species will decrease as *Betula allegheniensis* forms an enclosed canopy. The dense shrub layer in younger stands will also open as the *Betula* canopy closes over. The presence of *B. allegheniensis* saplings in this community type ensures its future short-term-dominance of the canopy.

A description of the local Shining Rock Gap environs by Wells (1937), suggests that most sites now inhabited by the **Betula alleghaniensis-Prunus pensylvanica/ Rhododendron catawbiense-Vaccinium simulatum Forest** were formerly dominated by fire cherry, *Prunus pensylvanica*. Ramseur (1960) suggests that fire cherry is singularly dominant in early succession and describes six successional phases that develop from this initial community. The **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** incorporates three of the phases described by Ramseur (1960). The two successionally younger variants of the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** resemble the fire cherry-blackberry phase and fire cherry-heath community, which Ramseur suggested constitute a successional sequence. Ramseur also suggests that the fire cherry-heath community phase succeeds into **Shrub Balds**. However, this contrasts to the interpretation presented in this present study (see Appendix 7). I suggest that fire cherry-heath forms develop into open *Betula alleghaniensis* dominated stands, which represent Ramseur's fire cherry-yellow-birch community. Ramseur (1960) indicates that **Spruce-Fir**

Forests are the endpoint of all successional phases. However, *Picea* is only a very minor component of the present **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest**, suggesting that if Ramseur's projections are correct the *Betula* to *Picea* transition is only in its initial stages.

COMMUNITY TYPE: Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest (5.3)

Synonymy

Typic subtype of Northern Hardwood Forest (Schafale & Weakley 1990), Cove Hardwood Forest (Whittaker 1956), Birch Gap (Crandell 1958), Boulder fields p.p. (Pittillo & Smathers 1979), Beech, Birch Forest (McLeod 1988), Northern Hardwood Forest (White *et al.* 1993).

Constant species

Abies fraseri, Acer pensylvanicum, Acer spicatum, Ageratina altissima var. *roanensis, Aster acuminatus* var. *acuminatus, Aster chlorolepis, Aster macrophyllus, Athyrium asplenioides, Betula alleghaniensis, Carex pensylvanica, Dennstaedtia punctilobula, Fagus grandifolia, Maianthemum canadense, Melanthium parviflorum, Prunus serotina, Rhododendron catawbiense, Sorbus americana, Tiarella cordifolia* var. *cordifolia, Trillium erectum, Viola blanda.*

Listed species

Abies fraseri, Brachyelytrum septentrionales, Luzula multiflora var. *congesta.*

Physiognomy

Betula alleghaniensis is the dominant canopy species (6 to 20 m canopy height range, mean of 13 m). However, canopy composition varies with elevation and successional stage. The high-elevation tall forest stand is dominated by *B. alleghaniensis*, with *Prunus serotina*, *Sorbus americana* and *Fagus grandifolia* scattered throughout the canopy and lower strata (Tables 4.23, 4.24, 4.25). One exposed, high-elevation stand immediately below-the summit ridge of Cold Mountain consists of a 6 m tall *Rhododendron catawbiense-Amelanchier* shrubland with scattered emergent *Sorbus*, *Fagus* and *B. alleghaniensis*. In contrast, *Quercus rubra* and *B. alleghaniensis* codominate the canopy of the two lower-elevation stands. *Acer spicatum* and *R. catawbiense* dominate the shrub layer of all stands, together with scattered *Acer pensylvanicum* and *Abies fraseri*. *Pieris floribunda* is present in this stratum on the more exposed sites. The forest floor is a little rocky with lush plant cover in the three tall forest stands in this group. *Ageratina altissima* var. *roanensis*, *Athyrium asplenioides* and *Carex pensylvanica* are the three dominant species with *Aster acuminatus* var. *acuminatus*, *Aster chlorolepis*, *Dennstaedtia punctilobula* and *Maianthemum canadense* abundant with less cover. *Aster macrophyllus*, *Melanthium parviflorum*, *Tiarella cordifolia* var. *cordifolia*, *Trillium erectum* and *Viola blanda* are present with limited cover. Dominance of species on the forest floor varies between sites. *Carex pensylvanica* with *Ageratina* and *Aster acuminatus* var. *acuminatus* are the dominant species in the two lower-elevation sites, whereas *Athyrium asplenioides* and *Aster chlorolepis* have highest abundance in the high-elevation tall forest stand.

Habitat and Distribution

This community type inhabits north-to-east and west-facing secondary ridges, off-ridge sites and upper-slopes between 1677 and 1824 m (1748 m average, SD 81; Table 4.26). Slopes vary (13-34° range, mean 24°). Sites in this type are grouped at two elevations. The high-elevation (1812, 1824 m) stands occur immediately below the summit ridge of Cold Mountain (Figure 1.4), and are underlain by mica gneiss. The lower-elevation sites occur on an upper-slope and secondary ridge on the face below Dog Loser Knob, and are underlain by garnet-mica schist.

The soils have highest sand and clay and lowest silt content of any **High-Elevation Mixed Hardwood Forests** type and are typically infertile with high Al and low base saturation and pH in comparison to the vegetation class average values (Tables 4.4, 4.5). This type has lowest cation exchange capacity, Ca, Mg and Mn values of any type in this vegetation class.

Distinguishing Features

The **Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest** has lower species richness at all scales than the other two *Betula alleghaniensis*-dominated **High-Elevation Mixed Hardwood Forests** types (Table 4.6). Low micro-scale species diversity can partly be explained by the dominance of large-sized forest floor species such as *Dennstaedtia punctilobula* and *Athyrium asplenioides*.

Succession and Disturbance

All four sites in this community type were burned in the 1925 fire. The two Cold Mountain sites were not burned in the 1942 fire. All sites were probably logged (USFS *unpub. data*). A standing dead *Abies* in the canopy of the high-elevation forest stand and the presence of *Abies* saplings in the understory suggests that this species was an occasional component of the canopy, in at least the high-elevations sites.

This community type is successional and young. Average canopy-sized *Betula alleghaniensis* range in age from 40 to 55 years. The successionally least advanced shrub stand may develop to resemble the other high-elevation stand. However, the exposed locality of this plot may serve to permanently maintain its shrubby appearance. The presence of *Picea* saplings (Tables 4.24, 4.25) in this type suggests that the present composition and structure of this type may change with time, with *Picea* eventually codominant with *B. alleghaniensis*, or replacing *Betula* in the canopy (Appendix 7). Small *Quercus rubra* stems in the two low-elevation sites suggests that this species will continue to be a component of the canopy.

COMMUNITY TYPE: Betula alleghaniensis/Ageratina-Aster acuminatus Forest (5.4)

Synonymy

Typic subtype of Northern Hardwood Forest (Schafale & Weakley 1990), Cove Hardwood Forest (Whittaker 1956), *Aster* site type of Spruce Hardwoods Forest (Crandell 1958), Yellow birch-buckeye Forest (Callaway *et al.* 1987), Beech, Birch Forest (McLeod 1988), Northern Hardwood Forest (White *et al.* 1993), *Fagus-Betula alleghaniensis/Dryopteris intermedia* Forest p.p. (Chapter 5).

Constant species

Abies fraseri, *Acer pensylvanicum*, *Ageratina altissima* var. *roanensis*, *Agrostis perennans*, *Arisaema triphyllum*, *Aster acuminatus* var. *acuminatus*, *Aster chlorolepis*, *Athyrium asplenioides*, *Betula alleghaniensis*, *Carex aestivalis*, *Picea rubens*, *Prenanthes* species.

Listed species

Abies fraseri, *Brachyelytrum septentrionales*, *Cardamine clematitis*, *Carex leptonervia*, *Carex ruthii*, *Cinna latifolia*, *Phegopteris connectilis*.

Physiognomy

Betula alleghaniensis is the dominant canopy species (mean height of 18 m, SD 1.8 m) in this community type (Tables 4.23, 4.24, 4.25). The subdominance of other species varies from site to site, reflecting differences in site moisture status. *B. alleghaniensis* is solely dominant on dryer sites. However, *Aesculus flava* codominates the canopy of moist, high-elevation cove sites and *Fagus grandifolia* is a canopy subdominant in an upper-slope seepage site. The understory is typically open with only scattered *Picea rubens* present. There is a dense herbaceous stratum with *Ageratina altissima* var. *roanensis* consistently most abundant. Cover of this species varies and is highest (cover of 7) on moister sites. *Aster acuminatus* var. *acuminatus* and *Aster chlorolepis* are consistent codominants with highest cover (both of 7) on dryer, upper-slope sites. *Carex pensylvanica* and *Dennstaedtia* *punctilobula* also have high cover in a limited number of sites. *Agrostis perennans*, *Arisaema triphyllum*, *Athyrium asplenioides*, *Carex aestivalis* and *Prenanthes* species have low, but consistent cover throughout all sites.

Habitat and Disturbance

This community type occurs south of Stairs Mountain, inhabiting high-elevation (1623 to 1693 m range), moderately steep (mean slope of 22°), northwest-to-east-facing upper-slopes, where it occurs on moist, upper-slope seepage or cove sites (Figures 1.3, 4.6, 4.7, Table 4.25, Appendix 5). A small stream runs through the center of each of the two cove stands. There is also a lower-elevation site (1370 m) situated on the margin of the Little East Fork of the Pigeon River. 57% of stands in this group occurred on mica gneiss bedrock, with 29% underlain by migmatite and 14% by garnet-mica schist.

The **Betula alleghaniensis/Ageratina-Aster acuminatus Forest** soils have relatively fertile conditions in comparison to **High-Elevation Mixed Hardwood Forests** average nutrient values (Tables 4.4, 4.5). This type has highest base saturation and Ca and lowest Fe and organic matter levels of any type or sub-type in this vegetation class.

Distinguishing Features

The listed species *Cardamine clematitis* is present only in the **Betula alleghaniensis/Ageratina-Aster acuminatus Forest**. *Carex ruthii*, also listed, has high cover in moister sites within this type.

The **Betula alleghaniensis/Ageratina-Aster acuminatus Forest** has the highest species richness at the 0.1m^2 scale in comparison to all other forest community types in this study (Table 4.6), which reflects the small-scale diversity and small physical size of the herbaceous species present. However, at larger scales, richness levels are lowest of all **High-Elevation Mixed Hardwood Forests** types, indicating dominance by a restricted range of small-sized plants.

Larger-sized (mostly between 45 and 55 cm; aged 55 to 87 years) *Betula alleghaniensis* dominate the canopy of this community type than the other two *B.*

allegheniensis-dominated **High-Elevation Mixed Hardwood Forests** types and this is reflected by the higher densities of ≥40 cm stems in the **Betula alleghaniensis/ Ageratina-Aster acuminatus Forest** (Table 4.24). However, the low total stem density of this type reflects its open understory and lack of shrub stratum, which contrasts to the other two *B. alleghaniensis* types.

Succession and Disturbance

In 1925 all sites in this community type were intensively burned and suffered subsequent erosion. Historic records suggest that 60% of sites were burned in 1942. Most sites were probably logged with the history of two unknown (USFS *unpub. data*). There is no evidence for the past presence of chestnut in this community type. The presence of small-sized *Betula alleghaniensis* stems ensures the dominance of this species in the canopy (Table 4.24). Small-sized *Aesculus* are present in the two cove sites, presently codominated by this species, suggesting that *Aesculus* will continue to codominate these sites. The existence of *Picea rubens* in the understory of this community type indicates that this species may in time become a component of the canopy. Historic logging records suggest that 60% of sites in this type were previously dominated by *Picea rubens* (USFS *unpub. data*).

COMMUNITY TYPE: Quercus rubra-Picea/Carex pensylvanica Forest (5.5)

Synonymy

"orchard forest" variant of the High Elevation Red Oak Forest (Schafale & Weakley 1990), high-elevation variant of Red Oak-Chestnut Forest (Whittaker 1956), mixed fern phase of the high elevation red oak forests p.p. (DeLapp 1978), Red Oak Forests (McLeod 1988), Northern Hardwood Forest (White *et al.* 1993).

Constant species

Acer rubrum var. *rubrum*, *Ageratina altissima* var. *roanensis*, *Amelanchier laevis*, *Amianthium muscaetoxicum*, *Aster macrophyllus*, *Carex pensylvanica*, *Danthonia compressa*, *Dennstaedtia punctilobula*, *Dioscorea quaternata*, *Ilex montana*, *Lysimachia quadrifolia*, *Picea rubens*, *Prenanthes* species, *Prunus pensylvanica*, *Quercus rubra*, *Smilax herbacea*, *Solidago curtisii*, *Thelypteris novaboracensis*, *Vaccinium simulatum*.

Listed species

Abies fraseri, *Brachyelytrum septentrionales*, *Luzula multiflora* var. *congesta*.

Physiognomy

Large-diameter *Quercus rubra* (mostly between 43 and 85 cm) dominate the canopy (mean height 23 m, SD 5.3 m) of this community type with *Acer rubrum* and *Picea rubens* scattered throughout (Tables 4.23, 4.24, 4.25). *Acer rubrum*, *Picea* and *Amelanchier* have variable abundance in the subcanopy. The understory is typically open with *Picea* saplings present in some sites. Beneath this, *Vaccinium stamineum* and *Ilex montana* form an open shrub layer. The forest floor is typically dry, consisting of a dense matrix of *Carex pensylvanica*, with *Thelypteris novaboracensis* also abundant. *Aster acuminatus* var. *acuminatus* has variable distribution with high-cover on the ridge and off-ridge sites. *Ageratina altissima* var. *roanensis* and *Amianthium muscaetoxicum* have patchy distribution, while *Aster macrophyllus*, *Danthonia compressa*, *Dennstaedtia punctilobula*, *Dioscorea quaternata*, *Lysimachia quadrifolia*, *Prenanthes* species, *Smilax herbacea* and *Solidago curtisii* have low cover throughout. Forest floor diversity is inversely related to elevation, with highest levels in the two lower-elevation, mid- and upper-slope sites and lowest diversity in the two highest elevation sites.

Habitat and Distribution

The **Quercus rubra-Picea/Carex pensylvanica Forest** occurs at high-elevations between 1576 and 1753 m (average elevation of 1648 m, SD 70 m) in the central area of the Wilderness (Table 4.26, Appendix 5). This type typically inhabits southwest-to-west-facing ridge and off-ridge sites and upper-slopes (Figures 4.4, 4.5, Table 4.26). Four of the five sites are underlain by garnet-mica schist bedrock.

The soils are moderately coarse-textured and have highest Al, K, Mg, pH and Zn levels of any community type in the **High-Elevation Mixed Hardwood Forests** vegetation class (Tables 4.4, 4.5).

Distinguishing Features

The **Quercus rubra-Picea/Carex pensylvanica Forest** has much higher basal area values (50.87m^2) than any other **High-Elevation Mixed Hardwood Forests** group, reflecting the dominance of large diameter *Quercus rubra* (Table 4.23). The density of large *Q. rubra* stems is such that this type has third highest densities of ≥40 cm stem measurements in this study, surpassed only by the **[Picea/Dennstaedtia Forest]** and the **Quercus montana-Quercus rubra/Kalmia Forest** (Tables 4.24, 4.28, 4.36).

The **Quercus rubra-Picea/Carex pensylvanica Forest** has highest species richness levels at the 1m^2 scale and high levels between 10m^2 and 400m^2 in comparison to other **High-Elevation Mixed Hardwood Forests** types and sub-types (Table 4.6). High values at the 0.1m^2 scale reflect the dominance of small-sized herbaceous plants, while high diversity at the larger scales indicates the scattered distribution of individual species.

Succession and Disturbance

Both major fires swept through the stands in this community type. Records suggest that lower-elevation sites at the summit of Old Butt Knob were never logged (USFS *unpub. data*), although field aging of canopy trees indicates the youth of both stands. Four of the five stands have canopies ranging between 65 and 90 years of age. The canopy of the fifth site (plot 421) is old, despite its close proximity to a tram line, with two 53 cm diameter *Quercus rubra* aged 159 and 195 years and a 67 cm diameter *Picea* aged 119 years. *Castanea dentata* is present in the two lower-elevation sites, suggesting that chestnut may have been a minor component at the lower-elevation limits of this type. The location of this type on high-elevation ridgelines and associated upper-slopes exposes it to natural disturbances such as high winds and ice storms (Schafale & Weakley 1990).

Summary stem information suggests that *Quercus rubra* will continue to dominate the canopy with *Acer rubrum* subdominant and *Picea* scattered throughout the canopy (Table 4.24).

COMMUNITY TYPE: Quercus rubra/Kalmia Forest (5.6)

Synonymy

High Elevation Red Oak Forest (Schafale & Weakley 1990), Red Oak-Chestnut Forest (Whittaker 1956), Red Oak Forests (McLeod 1988), Northern Hardwood Forests (White *et al.* 1993), *Quercus rubra/Thelypteris* Forest p.p. (Chapter 5).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Amelanchier laevis*, *Castanea dentata*, *Conopholis americana*, *Kalmia latifolia*, *Lysimachia quadrifolia*, *Picea rubens*, *Prenanthes* species, *Rhododendron calendulaceum*, *Rhododendron catawbiense*, *Solidago curtisii*.

Listed species

Abies fraseri, *Brachyelytrum septentrionales*, *Luzula multiflora* var. *congesta*.

Physiognomy

The canopy of this community type is dominated by large-diameter *Quercus rubra* (between 41 and 74 cm) with *Acer rubrum* also present (Tables 4.23, 4.24, 4.25). *Betula lenta* and *Q. montana* presence varies between sites. The understory is open with *Picea rubens* scattered throughout, in association with *Kalmia latifolia*, *Castanea dentata*, *Acer pensylvanicum*, *Amelanchier* and *Rhododendron catawbiense*. Forest floor species composition varies with *Dennstaedtia punctilobula*, *Carex pennsylvanica* and *Galax urceolata* having the most abundant, but somewhat variable cover. Variability at the community type level reflects the existence of two distinctive sub-types.

Community sub-types:

Quercus rubra/Kalmia-Rhododendron catawbiense sub-type (5.6.1)
Synonymy: "orchard forest" variant of the High Elevation Red Oak Forest (Schafale & Weakley 1990), lower-elevation variant of the Red Oak-Chestnut Forest (Whittaker 1956), *Rhododendron catawbiense* phase of high elevation red oak forests p.p. (DeLapp 1978).

Quercus rubra and *Acer rubrum* dominate the canopy of this sub-type with *Q. montana* present in some sites (Tables 4.23, 4.24, 4.25). *Acer rubrum* is the major subcanopy species while *Castanea dentata* dominates the understory in association with scattered *Picea rubens*, *Amelanchier* and *Acer pensylvanicum*. The shrub layer is typically dominated by isolated clumps of *Kalmia latifolia* and *Rhododendron catawbiense*, with these two species forming an extremely dense shrub stratum in two sites intensely burned in 1942 (USFS *unpub. data*). *Carex pensylvanicum*, *Dennstaedtia punctilobula* and *Galax urceolata* are dominants of the forest floor except at the two burned sites where stem densities restrict ground cover.

Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type (5.6.2)
Synonymy: deciduous phase of the high elevation red oak forests p.p. (DeLapp 1978), Black Birch overstory subtype of High-Elevation Red Oak Forests p.p. (Stephenson & Adams 1989).

Quercus rubra dominates the canopy with levels of *Betula lenta*, *Q. montana*, *Acer rubrum* and *Picea rubens* varying between sites (Tables 4.23, 4.24, 4.25). *Rhododendron minus* and *R. calendulaceum* dominate the 2 to 4 m tall shrub stratum. Abundance of *Vaccinium stamineum*, *R. catawbiense*, *Castanea dentata* and *Kalmia latifolia* in this stratum varies between sites. The ground is inhabited by a diverse range of low cover species, including; *Chimaphila maculata* var. *maculata*, *Conopholis americana*, *Danthonia compressa*, *Houstonia purpurea* var. *purpurea*, *Luzula multiflora* var. *congesta*, *Maianthemum racemosum*, *Prenanthes* species, *Pycnanthemum montanum*, *Solidago curtisii*, *Viola blanda* and *Zizia trifoliata*.

Habitat and Distribution

The **Quercus rubra/Kalmia Forest** occurs at moderately high-elevations on upper-slopes and ridges (Figures 4.4, 4.5). The two sub-types in this group vary in elevational range, site orientation, soil depth, texture and nutrient status. The ***Quercus rubra/ Kalmia-Rhododendron catawbiense sub-type*** inhabits predominantly northeast- and west-facing ridgelines, off-ridge sites and upper-slopes (5-30° slope range, mean of 18°, SD 10.7°) on Old Butt Knob and Chestnut Ridge at elevations between 1548 and 1639 m (1583 m average, SD 36 m; Table 4.26, Appendix 5). 83% of the sites in this subtype are underlain by garnet-mica schist. Soil depth varies greatly between sites (7.6-83.8 cm, 45.3 cm average, SD 22 cm) but is on average deeper than those in the other sub-type (Table 4.26). Soil texture and nutrient content are similar to the average values for this vegetation class (Tables 4.4, 4.5).

Stands within the ***Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type*** inhabit the ridgeline immediately north of Deep Gap and its associated west-facing, upper-slope. This group has a lower elevational range than the former sub-type (1469-1586 m, 1546 m average, SD 66 m), with sites steeper on average (mean of 22°, 18-26° range, SD 4°; Table 4.26). All stands in this sub-type are underlain by mica gneiss. The soils are very sandy, with highest sand and lowest silt percentages of any type or sub-type in the **High-Elevation Mixed Hardwood Forests** class (Table 4.5). The ***Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type*** also has fertile soils that have higher base saturation and pH values than vegetation class averages (Table 4.4). Moreover, this sub-type has highest Al, Cu, K, N, organic matter and Zn levels of any **High-Elevation Mixed Hardwood Forests** group. The greater ericaceous component and the dominance of *Rhododendron minus* in the ***Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type*** reflects the rockier site conditions of this sub-type in comparison to the ***Quercus rubra/Kalmia-Rhododendron catawbiense sub-type*** site conditions.

Distinguishing Features

At the community type level, the **Quercus rubra/Kalmia Forest** has similar species richness values to the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** (Table 4.6). However, species richness levels vary between sub-types, with the ***Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type*** having highest richness between the $10m^2$ and $400m^2$ scales of any type or sub-type in the **High-Elevation Mixed Hardwood Forests** class. In contrast, at the smallest scale this sub-type has lowest diversity of any group in this class, reflecting the limited abundance and scattered distribution of the species within this sub-type.

The ***Quercus rubra/Kalmia-Rhododendron catawbiense sub-type*** has a high density of ≥40 cm stems, which is visible in the high basal area (41.88 m^2; Table 4.24) measurements of this type. However, the ≥40 cm stem density and total basal area of the ***Quercus rubra/Kalmia-Rhododendron catawbiense sub-type*** are much lower than those of the **Quercus rubra-Picea/Carex pensylvanica Forest**, the other **High-Elevation Mixed Hardwood Forests** type dominated by *Quercus rubra*. Higher stem densities in the **Quercus rubra/Kalmia Forest** may reflect a higher level of disturbance to the canopy stratum, caused by, for example, the death of chestnut (Schafale & Weakley 1990), fire or logging and the presence of a distinct shrub stratum.

Succession and Disturbance

All sites in this community type were burned in the 1925 fire. No ***Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type*** sites were burned in 1942, while in contrast, 84% of sites in the other sub-type were burned, with two probably subject to very intense fires (USFS *unpub. data*). All ***Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type*** stands were logged. However, there is no documentation of logging for 66% of the ***Quercus rubra/Kalmia -Rhododendron catawbiense sub-type*** stands. Absence of logging may reflect the inaccessibility of these stands and their intermediary position between the two heavily logged areas. With logging companies concentrating on Spruce at the higher elevations and hardwoods in the valleys below, sites inhabited by the ***Quercus rubra/Kalmia-Rhododendron catawbiense sub-type*** could well have missed being cut (J. Alger *pers. comm.*).

Chestnut stumps and/or logs are present in 78% of the stands in the **Quercus rubra/Kalmia Forest**, while live sprouts of this species still persist in 89% of stands. Chestnut sprouts dominate the ***Quercus rubra/Kalmia-Rhododendron catawbiense sub-type*** understory, but have only limited presence in the ***Quercus rubra-Betula lenta/ Rhododendron minus-Rhododendron calendulaceum sub-type***. Both chestnut sprouts and wood abundance are higher in the ridge sites, with five or more chestnut logs/stumps present within the bounds of some plots. This suggests that *Castanea* may have dominated the canopy with *Quercus rubra* in at least the ridge sites.

The extremely high abundance of *Quercus rubra* samplings in this community type assures its future role in the canopy of both sub-types (Table 4.24). Limited *Betula lenta* sapling numbers in the ***Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type*** indicates the successional status of this species and its reduced dominance in the future canopy.

Discussion

Three of the six **High-Elevation Mixed Hardwood Forests** community types are dominated by *Betula alleghaniensis*. These three occur in close proximity to one another at Shining Rock, separated by topographic differences. The successionally least advanced **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** inhabits the more exposed, intensely burned, upper-slopes on the central high-elevation ridgeline. The **Betula alleghaniensis/Ageratina-Aster acuminatus Forest** and the **Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest** inhabit slopes below the former type, separated by subtle topographic shape differences that correspond to differences in site moisture and fertility (Figures 4.6, 4.7, Tables 4.23, 4.24, 4.26). The **Betula alleghaniensis/Ageratina-Aster acuminatus Forest** inhabits more fertile, moister locations in high-elevation coves and seepage slopes, while the **Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest** occurs on dryer, infertile, slightly convex, sandy sideslopes and secondary ridges.

Community type differences in species composition and structure reflect site condition differences between the three *Betula alleghaniensis* types. The two infertile types, the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest** and the **Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest** have a distinctive shrub component. *Rhododendron catawbiense*, dominant in both types, occurs in conjunction with *Kalmia latifolia* and *Vaccinium simulatum* in the former, and with *Acer spicatum* in the latter type. Site exposure, moisture and soil texture differences account for variation in shrub species dominance, with *A. spicatum* inhabiting more sheltered, dry and rockier conditions (Figures 4.6, 4.7). The dry conditions of the **Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest** are also shown by the dominance of *Carex pensylvanica* which has only patchy or low distribution in the other two *B. alleghaniensis* groups. The absence of a distinctive shrub stratum in the **Betula alleghaniensis/Ageratina-Aster acuminatus Forest** reflects its moister, more fertile conditions.

Although the **High-Elevation Mixed Hardwood Forests** are widespread throughout the Southern Appalachians, this class has received only limited documentation (but see Brown 1941, Russell 1953, Crandell 1958, DeLapp 1978, McLeod 1988, Chapter 5). Lack of quantified information makes it difficult to compare types identified in this study of Shining Rock with similar community types across the Southern Appalachian region. The overwhelming dominance of *Betula alleghaniensis* forests across the high-elevations of Shining Rock contrasts to most other descriptions of Southern Appalachian **High-**

Elevation Mixed Hardwood Forests. Other studies have typically described a mixed dominance of *Acer saccharum*, *Betula alleghaniensis*, *Fagus grandifolia* and *Aesculus flava* (Brown 1941, McLeod 1988, and Schafale & Weakley 1990). While a few Southern Appalachian studies have described the dominance of high-elevation *Betula alleghaniensis* forests on boulder substrates (Pittillo & Smathers 1979, Schafale & Weakley 1990) and steep, moist, concave northerly slopes (Crandell 1958), this present study documents the inhabitance of *B. alleghaniensis* forests across a much broader range of site conditions. Both P. White (*pers. comm.*) and Core (1966) suggest that *B. alleghaniensis* is a successional species that gains canopy dominance after a major disturbance. In Shining Rock, this species does dominate areas that were extensively logged, burned and suffered severe soil erosion. However, many high-elevation Southern Appalachian areas were damaged by similar events during roughly the same time period (see Saunders 1979, Pyle 1988), but today are not dominated by *B. alleghaniensis*.

Betula alleghaniensis dominance in Shining Rock may be a consequence of the historic forest distribution. Historic records from this landscape suggest that the present *B. alleghaniensis* community types inhabit areas previously occupied by *Picea* forests (USFS *unpub. data*). *Betula alleghaniensis*, typically a component of the **Spruce-Fir Forests** (Oosting & Billings 1951, Crandell 1958, White *et al.* 1985), was probably one of the few tree species present in these former *Picea* forests. Moreover, the ability of *Betula* to grow rapidly in high-light conditions (White *et al.* 1985), coupled with the susceptibility of *Picea* to desiccation (White & Cogbill 1992), and its selective removal by logging from the high-elevations of Shining Rock, has probably enabled *B. alleghaniensis* to attain its present dominance of the high-elevations in this landscape.

Forests dominated by *Betula alleghaniensis* have been documented in the high-elevations of the central Blue Ridge of Virginia and West Virginia (Core 1966, Johnson & Ware 1982). Johnson & Ware (1982) suggest that these forests are more typical of the more Northern Appalachian Mountains than the Southern Appalachians, but do not provide any explanation for this. Disturbance may have been more intense and widespread in the Northern Mountains. However, further south in the central Smoky Mountains, Golden

(1981) attributes the codominance of *Betula* in high-elevation forests to the cooler, moister climate of this area. Such a hypothesis may also partly explain *B. alleghaniensis* dominance in Shining Rock with its close proximity to the high-rainfall Escarpment front. Moreover, cooler conditions may have slowed the successional rate of development in relation to other high-elevation areas, and thus account for the persistence of *B. alleghaniensis*.

The **Fagus/Carex pensylvanica Forest** in Shining Rock is similar to the dry, exposed variants of the *Fagus* forest associated with high-ridges in other regions of the Southern Appalachians (e.g., Russell 1953, Whittaker 1956, Crandell 1958, Ramseur 1960, McLeod 1988, Schafale & Weakley 1990, Chapter 5). These contrast to the moister, less exposed, generally north-facing variant, described by Brown (1941), Whittaker (1956), Crandell (1958) and Ramseur (1960), that are codominated by *Acer saccharum*, *Betula alleghaniensis* and *Aesculus flava* in the canopy and have herbaceous species dominant on the forest floor (also see Chapter 5).

Schafale & Weakley (1990) describe two variants of the *Fagus*-sedge dominated forest and separate them by site exposure. Tall *Fagus* forest, present on less windswept, extreme site conditions (Schafale & Weakley 1990) correspond to the two lower-elevation stands at Shining Rock. The exposed, high-elevation "dwarfed or stunted" Beech Gap variant (Schafale & Weakley 1990) resembles the stand on Cold Mountain, although this stand is dominated by *Galax*. Ramseur (1960) also separates the Cold Mountain exposed, "shrubby, deciduous community dominated by beech" from the more typical *Fagus* forests, giving the former close association with the **Shrub Balds** vegetation class.

This present study of Shining Rock provides information on the composition, structure and ecology of high-elevation *Quercus rubra* forests. Quantitative information on the high-elevation *Q. rubra*-dominated forests in the Southern Appalachian Mountains previously has been limited to the regional analysis by DeLapp (1978) and landscape-scale studies by Whittaker (1956) and McLeod (1988). In Shining Rock, the two high-elevation *Q. rubra* types separate by site conditions, species composition, stand structure and elevation (Tables 4.23, 4.24, 4.25). In contrast to the large-diameter trees in the **Quercus rubra-Picea/Carex pensylvanica Forest,** the **Quercus rubra/Kalmia Forest** contains high densities of smaller-sized stems, possibly reflecting structural changes associated with chestnut death. The composition of the ericaceous shrub layer varies between the two types. *Rhododendron* species and *Kalmia* form a dense stratum in the latter, while the open shrub layer is dominated by *Ilex montana* and *Vaccinium stamineum* in the **Quercus rubra-Picea/Carex pensylvanica Forest**. Both types inhabit ridgetops and upper-slopes but the latter type inhabits higher-elevations than the former and this is reflected by the presence of higher-elevation species such as *Picea*, *Ilex* and *Vaccinium*, the limited abundance of *Castanea* and absence of *Q. montana* and *Kalmia*.

Separation of the two high-elevation *Quercus rubra* forests by elevation follows the pattern described by Whittaker (1956) in the Smoky Mountains. The dominance of sedges and ferns in the higher-elevation **Quercus rubra-Picea/Carex pensylvanica Forest** corresponds to descriptions of the herbaceous layer in Red Oak forests above 1635 m (Whittaker 1956). Whittaker (1956) also observed structural differences between lower- and high-elevation *Q. rubra* stands, documenting the presence of higher shrub cover in stands below 1635 m. This parallels the pattern at Shining Rock with higher shrub cover in the lower-elevation **Quercus rubra/Kalmia Forest**.

To date, DeLapp (1978) has undertaken the most thorough study of Southern Appalachian high-elevation red oak forests. The two high-elevation *Quercus rubra* types in Shining Rock have association with three of the seven phases identified by DeLapp (1978). This contrasts to the Red Oak Forests in the Black and Craggy Mountains that are associated with five of the seven phases (McLeod 1988). The ***Quercus rubra/Kalmia-Rhododendron catawbiense sub-type*** loosely resembles DeLapp's *Rhododendron catawbiense* phase, but the former has fewer **Shrub Bald** species. There is some affiliation between the ***Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type*** and DeLapp's deciduous phase, but the Shining Rock sub-type has a greater ericaceous shrub component. Less fertile conditions in the Shining Rock type may account for higher ericaceous presence (pH of 4.08, Shining Rock, Table 4.4; pH 4.4 to 4.9, p. 112 DeLapp (1978)). The **Quercus rubra-Picea/Carex pensylvanica Forest** has some resemblance to DeLapp's mixed fern phase, although his phase does not include *Picea* *rubens*. *Picea* is absent from all DeLapp's phases, probably reflecting the selection of his sites rather than the absence of this species from high-elevation *Quercus rubra* community types. McLeod also documented the presence of *Picea* in Red Oak Forests above 1465 m in the Black and Craggy Mountains.

Table 4.23. Average cover class and constancy of species present in the **High-Elevation Mixed Hardwood Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type and sub-type. Each group is represented by its abbreviation code. For full group names see Table 4.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	5.	5.1	5.2	5.3	5.4	5.5	5.6	5.6.1	5.6.2
Number of plots:	36	3	8	4	7	5	9	6	3
homoteneity:	0.509	0.655	0.642	0.659	0.627	0.672	0.609	0.651	0.753
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species									
ABIES FRASERI*	3 50	2 33	2 25	3 100	3 86	3 60	2 22	2 33	
ACER PENSYLVANICUM	3 81	2 33	2 88	4 75	3 86	2 60	3 100	3 100	2 100
ACER RUBRUM VAR RUBRUM	5 69		6 100		3 43	6 100	5 100	7 100	3 100
ACER SACCHARUM VAR SACCHARUM	4 25	2 33	4 38	6 25	3 29	6 20	2 11		2 33
ACER SPICATUM	4 31		2 38	6 75	3 57		4 11	4 17	
ACHILLEA MILLEFOLIUM	1 3						1 11		1 33
ACTAEA PACHYPODA	3 6				3 29				
AESCULUS FLAVA	4 28	4 67		1 25	4 71	4 40			
AGERATINA ALTISSIMA VAR ROANENSIS	3 81	2 100	4 75	4 75	4 100	3 100	1 56	1 50	2 67
AGROSTIS PERENNANS	2 36		2 38	2 25	2 86	2 40	1 11	1 17	
AGROSTIS STOLONIFERA	1 8			2 25	1 29				
AMELANCHIER LAEVIS	4 75	1 33	4 100	6 50	2 29	4 100	3 100	3 100	4 100
AMIANTHIUM MUSCAETOXICUM	2 31		1 13	2 50		3 80	2 44	2 67	
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	1 8			1 25	2 29				
ANGELICA TRIQUINATA	2 28		2 63	2 50	1 14	1 40			
AQUILEGIA CANADENSIS	2 3					2 20			
ARABIS LAEVIGATA VAR LAEVIGATA	1 6		1 13		1 14				
ARALIA NUDICAULIS	2 6			1 25		2 20			
ARALIA RACEMOSA VAR RACEMOSA	2 6						2 22	2 17	1 33
ARISAEMA TRIPHYLLUM	2 50	1 100	1 38	2 50	2 100	2 60			
ARNOGLOSSUM ATRIPLICIFOLIUM	2 6					2 20	2 11		2 33
ARONIA MELANOCARPA	2 3		2 13						

Group:	5.	5.1	5.2	5.3	5.4	5.5	5.6	5.6.1	5.6.2
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
ASTER ACUMINATUS VAR ACUMINATUS	3 72	1 67	4 100	3 75	4 86	5 60	2 44	2 67	
ASTER CHLOROLEPIS	3 72	2 67	3 88	3 75	3 100	2 60	2 44	2 33	2 67
ASTER CORDIFOLIUS	1 8					1 20	2 22	2 33	
ASTER MACROPHYLLUS	2 64	1 33	2 75	2 75	2 29	3 100	2 67	2 83	2 33
ASTER UNDULATUS	2 8		1 13				2 22		2 67
ATHYRIUM ASPLENIOIDES	2 67		2 75	4 100	2 86	2 40	1 67	1 67	2 67
AUREOLARIA LAEVIGATA	2 6					1 20	2 11		2 33
BETULA ALLEGHANIENSIS	6 64	1 33	7 63	7 100	8 100	3 60	3 33	3 50	
BETULA LENTA	4 22		2 13	5 25	2 14		5 56	5 33	6 100
BOTRYCHIUM VIRGINIANUM	1 3				1 14				
BRACHYELYTRUM ERECTUM	1 6				1 29				
BRACHYELYTRUM SEPTENTRIONALES*	2 25		2 25	2 25	1 14	2 40	1 22	1 33	
BROMUS PUBESCENS	1 8		1 25			1 20			
CAMPANULA DIVARICATA	2 11					2 20	2 33		2 100
CARDAMINE CLEMATITIS*	1 6				1 29				
CAREX SP.#1	2 6		2 25						
CAREX AESTIVALIS	2 56		2 63	2 50	2 100	2 60	1 33	2 33	1 33
CAREX APPALACHICA	2 11			1 25	2 14	2 20	2 11		2 33
CAREX BRUNNESCENS VAR SPHAEROSTACHYA	1 3				1 14				
CAREX COMMUNIS	1 25		2 63		2 29		1 22	1 33	
CAREX DIGITALIS	2 11		2 25			2 20	1 11	1 17	
CAREX FLEXUOSA	2 45		2 100	1 25	3 43	2 20	1 11	1 17	
CAREX INTUMESCENS	2 11		2 38		2 14				
CAREX LEPTONERVIA*	2 20		2 38		2 57				
CAREX PENSYLVANICA	4 69	7 100	3 63	4 100	5 43	6 100	3 56	4 67	1 33
CAREX RUTHII*	3 11		1 13		4 43				
CAREX UMBELLATA	3 6						3 22		3 67
CARYA GLABRA	1 3						1 11	1 17	
CARYA OVATA	1 3						1 11		1 33
CASTANEA DENTATA	4 31		4 13	2 25		6 20	4 89	4 100	5 67
CAULOPHYLLUM THALICTROIDES	2 3				2 14				
CHAMAELIRIUM LUTEUM	1 8		1 13				1 22	1 33	
CHELONE GLABRA	2 11			2 50	2 29				
CHELONE LYONII	2 3				2 14				
CHIMAPHILA MACULATA VAR MACULATA	1 14						1 56	1 33	1 100
CIMICIFUGA RACEMOSA	3 6				3 14	2 20			

Group:	5.	5.1	5.2	5.3	5.4	5.5	5.6	5.6.1	5.6.2
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
CINNA LATIFOLIA*	1 3				1 14				
CIRCAEA ALPINA VAR ALPINA	1 14	1 33			2 43	1 20			
CIRCAEA CANADENSIS	1 3				1 14				
CIRSIUM DISCOLOR	1 3					1 20			
CLEMATIS VIORNA	1 8	1 33	1 13				1 11		1 33
CLINTONIA UMBELLULATA	1 31	2 33		2 50	1 14	1 60	1 44	1 50	1 33
COLLINSONIA CANADENSIS	1 19		1 25			2 60	1 22	1 17	1 33
CONOPHOLIS AMERICANA	1 31		2 13			1 60	1 78	1 67	2 100
CORNUS ALTERNIFOLIA	2 19		2 25	3 50	1 29	4 20			
CORNUS FLORIDA	2 6		2 13				1 11		1 33
CRATAEGUS MACROSPERMA	3 22	2 33	4 13	2 25	2 14	3 60	1 11		1 33
CUSCUTA SP. #1	1 28		2 50		1 29	2 40	1 22	1 33	
CYSTOPTERIS PROTRUSA	1 3		1 13						
DANTHONIA COMPRESSA	2 58	2 33	2 75	1 25	2 43	2 80	2 67	2 50	2 100
DENNSTAEDTIA PUNCTILOBULA	3 67	2 33	3 88	3 75	4 71	2 80	4 44	4 67	
DESCHAMPSIA FLEXUOSA VAR FLEXUOSA	2 50	2 33	2 88	2 25	1 43	2 60	2 33	2 33	2 33
DICHANTHELIUM BOSCII	1 6					1 40			
DICHANTHELIUM COMMUTATUM	1 3					1 20			
DIERVILLA SESSILIFOLIA	2 8		2 38						
DIOSCOREA QUATERNATA	2 31	2 67		2 25		2 80	2 44	2 50	2 33
DIPHASIASTRUM DIGITATUM	2 6		2 25						
DRYOPTERIS CAMPYLOPTERA	2 6			2 25	2 14				
DRYOPTERIS INTERMEDIA	2 28	1 67	2 25	2 25	2 57		1 11	1 17	
EPIGAEA REPENS	1 3		1 13						
ERIGERON PULCHELLUS VAR PULCHELLUS	1 6						1 22		1 67
EUPATORIUM PURPUREUM	2 50		3 75	2 50	2 71	2 40	1 33	1 50	
EUPHORBIA COROLLATA	1 6						1 22		1 67
FAGUS GRANDIFOLIA	5 28	9 100	2 13	4 75	5 29	5 20			
FESTUCA SUBVERTICILLATA	2 11	1 33	1 13		2 14		2 11		2 33
FRAXINUS AMERICANA	2 6						2 22		2 67
GALAX URCEOLATA	4 17	7 33					3 56	4 67	2 33
GALIUM CIRCAEZANS	2 6					1 20	2 11		2 33
GALIUM TRIFLORUM	2 8				2 43				
GENTIANA DECORA	1 17	1 33				1 20	1 44	1 67	
GLYCERIA MELICARIA	2 3				2 14				
GOODYERA PUBESCENS	1 8		1 13				1 22		1 67
HALESIA TETRAPTERA VAR MONTICOLA	2 11					3 40	2 22	1 17	2 33

Group:	5.	5.1	5.2	5.3	5.4	5.5	5.6	5.6.1	5.6.2
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
HIERACIUM PANICULATUM	1 25		1 25			1 60	2 44	1 33	2 67
HIERACIUM SCABRUM VAR SCABRUM	1 3		1 13						
HOUSTONIA CAERULEA	2 6		2 25						
HOUSTONIA PURPUREA VAR PURPUREA	1 25	1 33				2 40	1 67	1 50	2 100
HOUSTONIA SERPYLLIFOLIA	2 33	1 67	2 38		2 57	2 40	1 11	1 17	
HUPERZIA LUCIDULA	1 11			1 25	2 14	1 20	1 11	1 17	
HYDRANGEA ARBORESCENS	2 6			2 25		2 20			
HYDROPHYLLUM CANADENSE	2 3				2 14				
HYPERICUM SP. #1	2 31		2 38		2 57	2 60	1 11		1 33
HYPERICUM GRAVEOLENS*	1 3	1 33							
HYPERICUM MITCHELLIANUM*	1 8	1 33	1 13			1 20			
ILEX MONTANA	4 47		4 88	6 25	1 29	4 80	3 33	3 50	
IMPATIENS PALLIDA	2 8				2 29	1 20			
KALMIA LATIFOLIA	4 42	2 67	5 38			2 60	5 78	6 83	5 67
LAPORTEA CANADENSIS	1 14	2 33			1 43	1 20			
LEUCOTHOE RECURVA	2 8						2 33	2 50	
LIGUSTICUM CANADENSE	2 11					2 20	2 33	2 50	
LILIUM MICHAUXII	1 17		1 13	1 50		1 60			
LIRIODENDRON TULIPIFERA	1 3						1 11	1 17	
LISTERA SMALLII	1 14		1 38	1 25			1 11	1 17	
LUZULA ACUMINATA	2 31	2 100	2 13	1 25	2 43	2 40	1 11	1 17	
LUZULA MULTIFLORA VAR CONGESTA*	1 22		2 13	1 25		1 40	1 44	2 17	1 100
LYCOPODIUM CLAVATUM VAR CLAVATUM	2 6		2 25						
LYCOPODIUM OBSCURUM	1 14		1 63						
LYONIA LIGUSTRINA VAR LIGUSTRINA	2 6		2 25						
LYSIMACHIA QUADRIFOLIA	2 42		1 13	2 25		2 80	2 100	1 100	2 100
MAIANTHEMUM CANADENSE	2 28	2 33		3 100	2 29	2 20	2 22	2 17	2 33
MAIANTHEMUM RACEMOSUM	1 39	1 67		1 25	1 43	1 40	1 67	1 50	1 100
MEDEOLA VIRGINIANA	1 33		1 13		1 43	2 60	2 56	2 67	1 33
MELAMPYRUM LINEARE	1 8						1 33	1 50	
MELANTHIUM PARVIFLORUM	2 19			2 75	2 29		2 22	2 33	
MENZIESIA PILOSA	2 6						2 22	2 33	
MONARDA CLINOPODIA	2 14	1 33			2 14	2 60			
MONARDA DIDYMA	2 3				2 14				
MONOTROPA UNIFLORA	1 25		1 25	1 50	1 43		1 22	1 17	1 33

Group:	5.	5.1	5.2	5.3	5.4	5.5	5.6	5.6.1	5.6.2
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
OENOTHERA FRUTICOSA VAR FRUTICOSA	1 3						1 11		1 33
OSMORHIZA CLAYTONII	2 3				2 14				
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	2 17		2 13	2 25	1 14	2 20	2 22	2 33	
OXALIS MONTANA	2 3				2 14				
OXALIS STRICTA	2 8				2 43				
PEDICULARIS CANADENSIS	2 11					2 40	2 22	2 17	2 33
PENSTEMON CANESCENS	1 3						1 11		1 33
PHEGOPTERIS CONNECTILIS*	1 3				1 14				
PICEA RUBENS	4 64	2 33	4 25	3 50	5 100	5 80	4 78	4 83	3 67
PIERIS FLORIBUNDA	3 22	2 67	7 13	6 50	1 14	2 40			
PINUS PUNGENS	3 6						3 22		3 67
PINUS STROBUS	1 8						1 33	1 17	2 67
PLATANTHERA CLAVELLATA	1 11	1 33	1 38						
POA ALSODES	2 17	2 67	2 38		1 14				
POA AUTUMNALIS	2 3					2 20			
POA CUSPIDATA	1 11	2 33				1 20	1 22	1 17	1 33
POLYGONATUM BIFLORUM VAR BIFLORUM	1 31	1 33	1 13	2 50	1 14	2 40	1 44	1 33	1 67
POLYGONUM CONVOLVULUS VAR CONVOLVULUS	1 3	1 33							
POLYPODIUM VIRGINIANUM	1 14			2 50	1 14		2 22	2 33	
POLYSTICHUM ACROSTICHOIDES	1 17		1 13		1 43	1 20	2 11		2 33
PORTERANTHUS TRIFOLIATUS	1 3						1 11		1 33
POTENTILLA CANADENSIS VAR CANADENSIS	1 14		1 13			1 40	1 22	1 17	1 33
PRENANTHES SP. #1	2 83	2 67	2 100	2 50	2 86	2 100	2 78	2 67	1 100
PROSARTES LANUGINOSUM	2 6					2 20	1 11		1 33
PRUNUS PENSYLVANICA	4 42	3 33	5 75		3 29	2 40	2 44	4 17	2 100
PRUNUS SEROTINA	4 28		5 50	5 75	1 29	1 20			
PRUNELLA VULGARIS	2 6		1 13				2 11		2 33
PTERIDIUM AQUILINUM	2 19		2 13			2 20	2 56	2 50	2 67
PYCNANTHEMUM MONTANUM	2 14					2 20	2 44	1 17	2 100
QUERCUS ALBA	4 3						4 11		4 33
QUERCUS MONTANA	6 17						6 67	6 67	5 67
QUERCUS RUBRA	7 56		3 25	7 50	4 29	8 100	7 100	7 100	7 100
QUERCUS VELUTINA	2 8	1 33					2 22	2 33	
RANUNCULUS RECURVATUS	2 3				2 14				
RHODODENDRON CALENDULACEUM	3 31		2 38			6 20	3 78	3 67	4 100

Group:	5.	5.1	5.2	5.3	5.4	5.5	5.6	5.6.1	5.6.2
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
RHODODENDRON CATAWBIENSE	6 61		6 75	6 100	3 43	4 20	6 89	6 100	6 67
RHODODENDRON MAXIMUM	4 11		6 13		5 14		2 22	3 17	1 33
RHODODENDRON MINUS	3 33		4 25	2 50		1 60	5 56	6 33	5 100
RIBES CYNOSBATI	2 11		2 13		2 14		2 11		
RIBES GLANDULOSUM	2 3			2 25					
RIBES ROTUNDIFOLIUM	2 19		2 13	1 25	2 14	2 20		2 17	
ROBINIA HISPIDA	1 3		1 13						
ROBINIA PSEUDOACACIA	4 17		3 13	5 50			3 33		3 100
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1 8				1 29	1 20			
RUBUS ARGUTUS	3 17		4 38	4 50			2 11		2 33
RUBUS CANADENSIS	2 39	2 67	3 63	2 25	2 29	2 60	1 11	1 17	
RUDBECKIA LACINIATA	6 3				6 14				
SAMBUCUS RACEMOSA VAR PUBENS	2 6			2 50					
SAXIFRAGA MICRANTHIDIFOLIA	1 3				1 14				
SEDUM TERNATUM	2 3						2 11		2 33
SENECIO AUREUS	1 3		1 13						
SENECIO OBOVATUS*	1 3		1 13						
SILENE VIRGINICA VAR VIRGINICA	1 3					1 20			
SMILAX GLAUCA VAR GLAUCA	1 3	1 33							
SMILAX HERBACEA	1 39	1 33	1 13	1 25	1 43	1 100	1 33	1 33	1 33
SOLIDAGO SP. #1	2 3	2 33							
SOLIDAGO ARGUTA SSP CAROLINIANA	2 19	1 33	1 38		2 14		2 22		2 67
SOLIDAGO CURTISII	2 78	1 100	2 100	2 50	2 57	2 80	1 78	1 67	2 100
SOLIDAGO ERECTA	1 3						1 11	1 17	
SOLIDAGO PATULA VAR PATULA	2 11		2 25		2 29				
SORBUS AMERICANA	2 42		1 63	4 100	1 57	1 20	1 11	1 17	
STACHYS LATIDENS	1 14	2 33				1 40	1 22		1 67
STELLARIA PUBERA	1 3						1 11		1 33
STENANTHIUM GRAMINEUM VAR MICRANTHUM	2 8					2 20	2 22	2 33	
STREPTOPUS ROSEUS	2 8			2 50	2 14				
THALICTRUM CLAVATUM	1 11				1 29	1 40			
THASPIUM BARBINODE	1 8	1 33		1 25	1 14				
THELYPTERIS NOVEBORACENSIS	3 19	2 33	3 25			4 80			
TIARELLA CORDIFOLIA VAR CORDIFOLIA	2 31			1 75	2 43	2 60	2 22	2 17	2 33
TRILLIUM ERECTUM	1 31	1 67		1 75	1 71	1 20			

Group:	5.	5.1	5.2	5.3	5.4	5.5	5.6	5.6.1	5.6.2
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
TRILLIUM UNDULATUM	1 17		1 25				1 44	1 67	
TSUGA CANADENSIS	2 53		2 50	2 25	3 71	2 60	3 67	3 50	3 100
TSUGA CAROLINIANA	1 6		1 13				1 11		1 33
UVULARIA PUBERULA	2 6						2 22	2 33	
VACCINIUM CORYMBOSUM	2 22		3 38		2 14		2 44	2 50	2 33
VACCINIUM ERYTHROCARPUM	2 39		3 38	2 50	1 29	1 60	3 44	2 50	6 33
VACCINIUM PALLIDUM	1 17		1 13			1 40	2 33	2 33	2 33
VACCINIUM SIMULATUM	4 42	1 33	5 75		2 14	4 80	3 33	3 50	
VACCINIUM STAMINEUM	3 31	1 33	4 38	2 25		2 20	3 56	2 50	6 67
VIBURNUM ACERIFOLIUM	2 3						2 11		2 33
VIBURNUM LANTANOIDES	3 8		3 25	3 25					
VIBURNUM NUDUM VAR CASSINOIDES	2 14		2 38			3 20	1 11	1 17	
VIOLA AFFINIS	2 3		2 13						
VIOLA BLANDA	2 47	1 33	1 38	2 75	2 57	2 60	2 33		2 100
VIOLA HASTATA	2 17	2 67				1 60	2 11	2 17	
VIOLA ROTUNDIFOLIA	2 11			2 25	2 29	1 20			
VIOLA SAGITTATA	1 3						1 11		1 33
VIOLA SORORIA	1 8	2 67	1 13						
XANTHORHIZA SIMPLICISSIMA	1 3				1 14				
ZIZIA TRIFOLIATA	1 17			1 25		1 20	2 44	1 17	2 100

Table 4.24. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **High-Elevation Mixed Hardwood Forests** vegetation class and associated community types and sub-types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

5. High-Elevation Mixed Hardwood Forests

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
ACER RUBRUM VAR RUBRUM	40.30	154.63	0.00	194.92	2.46	4.53	7.45	5.99
BETULA ALLEGHANIENSIS	18.66	368.28	7.12	394.05	7.08	13.15	23.14	18.15
FAGUS GRANDIFOLIA	48.09	545.14	0.35	593.58	3.09	8.92	8.58	8.75
KALMIA LATIFOLIA	596.99	862.49	0.00	1459.48	1.31	7.45	3.15	5.30
PICEA RUBENS	20.01	355.64	2.23	377.88	2.27	5.97	4.90	5.43
QUERCUS RUBRA	50.83	139.95	23.31	214.09	10.11	4.96	23.91	14.44
RHODODENDRON CATAWBIENSE	216.11	902.34	0.00	1118.45	2.56	14.17	6.88	10.53
ALL	2248.84	4275.54	39.38	6563.75	36.06	100.00	100.00	100.00

5.1 Fagus/Carex pensylvanica Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
FAGUS GRANDIFOLIA	550.00	5937.50	4.17	6491.67	33.72	96.32	94.60	95.46
ALL	731.94	6026.39	8.33	6766.67	35.48	100.00	100.00	100.00

5.2 Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBURM	22.29	201.15	0.00	223.44	3.09	3.71	15.11	9.41
BETULA ALLEGHANIENSIS	61.46	400.73	4.17	466.35	5.68	7.89	26.07	16.98
ILEX MONTANA	311.46	475.00	0.00	786.46	1.32	9.71	4.33	7.02
KALMIA LATIFOLIA	816.67	1429.17	0.00	2245.83	2.11	11.10	7.35	9.23
PRUNUS PENSYLVANICA	0.00	98.65	0.00	98.65	1.12	2.13	6.05	4.09
PRUNUS SEROTINA	0.00	283.33	0.00	283.33	2.70	3.90	9.95	6.92
RHODODENDRON CATAWBIENSE	321.88	1634.37	0.00	1956.25	3.81	15.87	12.38	14.12
VACCINIUM SIMULATUM	517.08	628.23	0.00	1145.31	0.93	21.57	4.82	13.20
ALL	3498.54	6048.75	5.42	9552.71	24.34	100.00	100.00	100.00

5.3 Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	145.83	131.25	0.00	277.08	1.09	4.68	3.33	4.01
ACER SPICATUM	725.00	354.17	0.00	1079.17	1.18	17.59	3.30	10.45
BETULA ALLEGHANIENSIS	12.50	729.17	8.33	750.00	12.03	9.79	34.99	22.39
PICEA RUBENS	50.00	2529.17	0.00	2579.17	3.05	14.00	7.64	10.82
QUERCUS RUBRA	12.50	81.25	12.50	106.25	4.60	1.37	11.53	6.45
RHODODENDRON CATAWBIENSE	529.17	2047.92	0.00	2577.08	6.86	24.18	15.10	19.64
RUBUS ARGUTUS	556.25	0.00	0.00	556.25	0.01	10.64	0.04	5.34
SORBUS AMERICANA	33.33	193.75	0.00	227.08	2.51	1.96	6.27	4.12
ALL	2656.25	7068.75	27.08	9752.08	39.03	99.99	100.00	100.00

5.4 Betula alleghaniensis/Ageratina-Aster acuminatus Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
AESCULUS FLAVA	0.00	66.96	17.86	84.82	6.24	8.66	15.59	12.12
BETULA ALLEGHANIENSIS	16.19	947.92	27.08	991.19	22.19	49.40	67.61	58.50
PICEA RUBENS	21.07	246.73	0.00	267.80	3.72	15.74	7.78	11.76
ALL	266.79	1521.79	49.70	1838.27	35.09	100.00	100.00	100.00

5.5 Quercus rubra-Picea/Carex pensylvanica Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	155.13	245.64	0.00	400.77	6.10	13.74	12.12	12.93
PICEA RUBENS	32.05	84.36	13.59	130.00	5.78	7.60	10.33	8.96
QUERCUS RUBRA	80.00	256.15	83.85	420.00	35.55	16.76	70.89	43.83
VACCINIUM SIMULATUM	203.33	80.00	0.00	283.33	0.13	11.35	0.33	5.84
ALL	1082.05	1311.03	100.77	2493.85	50.87	100.00	100.01	100.00

5.6 Quercus rubra/Kalmia Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	55.20	294.91	0.00	350.10	3.59	6.70	9.19	7.95
BETULA LENTA	5.61	72.22	1.85	79.69	2.16	1.52	6.48	4.00
KALMIA LATIFOLIA	1660.19	2170.19	0.00	3830.37	3.37	19.36	6.03	12.69
QUERCUS MONTANA	16.72	74.26	0.00	90.98	3.40	1.21	10.41	5.81
QUERCUS RUBRA	153.32	371.76	40.00	565.08	17.89	9.41	47.58	28.49
RHODODENDRON CALENDULACEUM	582.56	73.52	0.00	656.08	0.17	9.28	0.61	4.94
RHODODENDRON CATAWBIENSE	341.30	1176.48	0.00	1517.78	3.58	28.66	9.16	18.91
RHODODENDRON MINUS	282.93	89.81	0.00	372.74	0.16	7.58	0.51	4.04
ALL	3652.36	4663.06	43.24	8358.66	37.86	100.01	99.99	100.00

5.6.1 Quercus rubra/Kalmia-Rhododendron catawbiense sub-type

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	53.33	422.22	0.00	475.56	5.28	9.31	13.44	11.38
KALMIA LATIFOLIA	2379.17	3190.00	0.00	5569.17	4.96	25.58	8.72	17.15
QUERCUS MONTANA	16.67	76.67	0.00	93.33	3.46	1.20	9.77	5.49
QUERCUS RUBRA	98.33	269.44	50.28	418.06	19.66	7.12	47.11	27.12
RHODODENDRON CATAWBIENSE	245.28	1416.11	0.00	1661.39	4.56	31.26	11.11	21.18
ALL	3731.11	5799.45	53.06	9583.61	41.98	100.00	99.99	100.00

5.6.2 Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
BETULA LENTA	16.84	172.22	0.00	189.06	4.33	3.60	14.42	9.01
QUERCUS MONTANA	16.84	69.44	0.00	86.28	3.28	1.23	11.70	6.47
QUERCUS RUBRA	263.30	576.39	19.44	859.13	14.35	13.98	48.51	31.24
RHODODENDRON CALENDULACEUM	1438.80	163.89	0.00	1602.69	0.40	21.89	1.43	11.66
RHODODENDRON CATAWBIENSE	533.33	697.22	0.00	1230.56	1.61	23.47	5.28	14.37
RHODODENDRON MINUS	609.89	208.33	0.00	818.22	0.36	17.14	1.17	9.15
ALL	3494.87	2390.28	23.61	5908.75	29.63	100.01	99.98	100.00

Table 4.25. Vertical structure of woody species in the **High-Elevation Mixed Hardwood Forests** vegetation class and associated community types and sub-types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥ 1 in a stratum are shown.

5. High-Elevation Mixed Hardwood Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	3	2	
ACER SPICATUM	1	1			
AESCULUS FLAVA	1				
AMELANCHIER LAEVIS	1	1	1		
BETULA ALLEGHANIENSIS	1	2	4	2	
BETULA LENTA	1	1	1		
CASTANEA DENTATA	1	1			
FAGUS GRANDIFOLIA	1	1	1		
ILEX MONTANA	1	1			
KALMIA LATIFOLIA	1	1			
PICEA RUBENS	1	2	2	1	
PRUNUS SEROTINA	1	1	1		
QUERCUS RUBRA	1	1	3	3	
RHODODENDRON CATAWBIENSE	1	3	1		
RHODODENDRON MINUS	1	1			
VACCINIUM SIMULATUM	1	1			

5.1 Fagus/Carex pensylvanica Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
AESCULUS FLAVA	1	1	1	1	
FAGUS GRANDIFOLIA	1	6	6	3	

5.2 Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	4	4	1	
AMELANCHIER LAEVIS	1	2	3	1	
BETULA ALLEGHANIENSIS	1	3	4	1	
ILEX MONTANA	1	3	1		
KALMIA LATIFOLIA	1	2			
PICEA RUBENS	1	1			
PIERIS FLORIBUNDA	1	1			
PRUNUS PENSYLVANICA	1	2	2		
PRUNUS SEROTINA	1	1	3	2	
RHODODENDRON CATAWBIENSE	1	4	1		
RHODODENDRON MINUS	1	1			
RUBUS CANADENSIS	1	1			
VACCINIUM ERYTHROCARPUM	1	1			
VACCINIUM SIMULATUM	1	4			
VACCINIUM STAMINEUM	1	1			

5.3 Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ABIES FRASERI	1	3			
ACER PENSYLVANICUM	1	2	2		
ACER SACCHARUM VAR SACCHARUM	1	1	2	2	
ACER SPICATUM	1	5	4		
AMELANCHIER LAEVIS	1	2	1	1	
BETULA ALLEGHANIENSIS	1	4	7	3	
BETULA LENTA	1	1	1		
CORNUS ALTERNIFOLIA	1	1			
FAGUS GRANDIFOLIA	1	1	2		
ILEX MONTANA	1	1			
PIERIS FLORIBUNDA	1	3			
PRUNUS SEROTINA	1	1	2	2	
QUERCUS RUBRA	1	1	4	4	
RHODODENDRON CATAWBIENSE	1	6	3		
ROBINIA PSEUDOACACIA	1	1	2	2	
RUBUS ARGUTUS	1	1			
SORBUS AMERICANA	1	2	4	1	
VIBURNUM LANTANOIDES	1	1			

5.4 Betula alleghaniensis/Ageratina-Aster acuminatus Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ABIES FRASERI	1	1			
ACER PENSYLVANICUM	1	1			
ACER SACCHARUM VAR SACCHARUM	1	1			
ACER SPICATUM	1	1	1		
AESCULUS FLAVA	1	1	2	1	
BETULA ALLEGHANIENSIS	1	2	8	6	
FAGUS GRANDIFOLIA	1	1	1	1	
PICEA RUBENS	1	3	4	2	
RHODODENDRON CATAWBIENSE	1	1			
TSUGA CANADENSIS	1	2	1		

5.5 Quercus rubra-Picea/Carex pensylvanica Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	5	6	
AMELANCHIER LAEVIS	1	2	2		
BETULA ALLEGHANIENSIS	1	1	1	1	
CASTANEA DENTATA	1	1			
CRATAEGUS MACROSPERMA	1	1			
FAGUS GRANDIFOLIA	1	1	1		
ILEX MONTANA	1	2			
PICEA RUBENS	1	3	3	3	
QUERCUS RUBRA	2	1	6	8	
RUBUS CANADENSIS	1	1			
VACCINIUM SIMULATUM	1	2			

5.6 Quercus rubra/Kalmia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1		
ACER RUBRUM VAR RUBRUM	1	1	5	3	
AMELANCHIER LAEVIS	1	1	2		
BETULA LENTA	1	1	3	2	
CASTANEA DENTATA	1	3	2		
KALMIA LATIFOLIA	1	4			
PICEA RUBENS	1	2	2		
QUERCUS MONTANA	1	1	3	3	
QUERCUS RUBRA	1	2	7	5	
RHODODENDRON CALENDULACEUM	1	2			
RHODODENDRON CATAWBIENSE	1	5	3		
RHODODENDRON MINUS	1	3			
VACCINIUM SIMULATUM	1	1			
VACCINIUM STAMINEUM	1	1			

5.6.1 Quercus rubra/Kalmia-Rhododendron catawbiense Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	1		
ACER RUBRUM VAR RUBRUM	1	2	6	5	
AMELANCHIER LAEVIS	1	1	1	1	
BETULA ALLEGHANIENSIS	1	1	1	1	
BETULA LENTA	1	1	2	1	
CASTANEA DENTATA	1	3	2		
KALMIA LATIFOLIA	1	4			
PICEA RUBENS	1	2	2		
QUERCUS MONTANA	1	1	3	3	
QUERCUS RUBRA	1	1	7	6	
RHODODENDRON CALENDULACEUM	1	1			
RHODODENDRON CATAWBIENSE	1	6	3		
RHODODENDRON MINUS	1	2			
VACCINIUM SIMULATUM	1	1			

5.6.2 Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	2		
AMELANCHIER LAEVIS	1	1	3		
BETULA LENTA	1	2	5	3	
CASTANEA DENTATA	1	3	1		
KALMIA LATIFOLIA	1	3			
PICEA RUBENS	1	1	1		
PINUS PUNGENS	1	1	2		
QUERCUS ALBA	1	1	1		
QUERCUS MONTANA	1	1	3	2	
QUERCUS RUBRA	1	3	7	4	
RHODODENDRON CALENDULACEUM	1	3			
RHODODENDRON CATAWBIENSE	1	4	1		
RHODODENDRON MINUS	1	5			
ROBINIA PSEUDOACACIA	1	1	1	1	
TSUGA CANADENSIS	1	1			
VACCINIUM STAMINEUM	3	3			

Table 4.26. Average site information for the **High-Elevation Mixed Hardwood Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 4.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**GMS**=garnet-mica schist, **M**=migmatite, **MG**=mica gneiss), Landform types (representing micro-scale topographic units) (**C**=coves, **R**=ridge, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**US**=upper-slopes).

5. High-Elevation Mixed Hardwood Forests

	Group								
	5.	5.1	5.2	5.3	5.4	5.5	5.6	5.6.1	5.6.2
Site Characteristics:									
Elevation (m)	1650	1747	1692	1748	1609	1648	1571	1584	1546
Slope (o)	20	20	20	24	23	18	19	18	22
Aspect (o)	NW	E	W-N	N-E,W	NW,E	SW-W	NE-W	NE-W	W
Parent material	GMS,MG		MG	GMS,MG	MG	GMS	GMS,MG	GMS	MG
Soil depth (cm)	35.2	45.1	32.5	28.7	35.0	27.5	40.4	45.3	30.5
Surface Substrate (%):									
Moss/Lichen	8	3	7	10	9	14	6	6	5
Wood	5	2	4	5	3	4	7	7	7
Rock	11	8	10	11	10	20	10	9	13
Organic Matter	79	90	82	78	72	76	80	82	77
Water	0	0	0	0	2	0	0	0	0
Topographic Characteristics:									
Relative slope (%)	67	82	59	82	35	77	82	80	86
LFI	0.11	0.04	0.12	0.02	0.18	0.13	0.09	0.07	0.13
TSI	0.01	-0.06	-0.00	-0.04	0.02	-0.01	-0.02	-0.03	-0.00
Landform type	SS	SS	SS	R,SS	SS	C,SS	SS	SS	SS
Topographic position	US	US	US	US	US	US	US	US	US

4.5.6 VEGETATION CLASS: 6. **Spruce-Fir Forests**

The **Spruce-Fir Forests** vegetation class is restricted to high-elevation regions of the Southern Appalachian Mountains. This group was formerly dominated by two coniferous species, *Abies fraseri* and *Picea rubens*, with *Abies* typically dominating higher-elevation sites than *Picea*. However, *Abies* abundance has been severely diminished in recent years by the introduced Balsam Woolly Adelgid (Busing & Clebsch 1988, White & Cogbill 1992). This vegetation class is typically found in association with the **High-Elevation Mixed Hardwood Forests** vegetation class (Figures 4.2-4.7), with the latter usually distributed on lower-slope positions than **Spruce-Fir Forests** (White *et al.* 1993). In Shining Rock this class is presently restricted to a small portion of the upper-slopes and sheltered ridgelines on the central, high-elevation ridge (<0.5% of area mapped; Appendices 2, 5), although it probably had a much broader distribution prior to the logging and fires of the early part of the century (USFS *unpub. data*).

COMMUNITY TYPE: [Picea/Dennstaedtia Forest] (6.1)

Synonymy

Red Spruce--Fraser Fir Forest (Schafale & Weakley 1990), Viburnum-Vaccinium-Dryopteris site type of Spruce Site Type (Crandell 1953), sub-type of north slopes and flats Red Spruce Forest (Whittaker 1956), Spruce-fir forest (Ramseur 1960), Spruce Forests (McLeod 1988), Spruce Forest (White *et al.* 1993), Spruce-Fir Forest (White *et al.* 1993).

Listed species

Abies fraseri.

Physiognomy

This community type is floristically and structurally simple. Large-diameter, mostly 40-60 cm, *Picea rubens* form a tall (26 m mean height), dense, monospecific canopy

(Tables 4.27, 4.28, 4.29). Beneath this is a 1.5 to 2.5 m tall thicket of *Abies fraseri* saplings, with *Picea* and *Pieris floribunda* also present. This stratum has very patchy distribution, mostly inhabiting areas beneath canopy openings. The *Abies* thickets are absent beneath the enclosed canopy and *Dennstaedtia punctilobula* forms a dense fern glade in association with *Ageratina altissima* var. *roanensis* and *Aster acuminatus* var. *acuminatus*. There are also scattered patches of bare ground with only sparse vascular species distribution. Some sites have large-sized *Picea* logs strewn across the floor.

Habitat and Distribution

This community type has limited distribution, restricted to the upper-slopes and sheltered broad ridgelines between Flower and Shining Rock Knobs (Appendix 5). The two sites sampled have elevations of 1715 and 1728 m and slopes of 21° and 16°. One site is underlain by mica gneiss and the other migmatite (Table 4.30).

The soils are moderately coarse-textured and infertile, with low base saturation, Mn and pH levels (Tables 4.4, 4.5). Like many of the high-elevation types in Shining Rock this community type has high levels of Al and Fe.

Distinguishing Features

This is the only tall forest community type dominated by *Picea* and the only group where *Abies fraseri* is a dominate species. The **[Picea/Dennstaedtia Forest]** has by far the highest density of ≥40 cm sized stems of any type or sub-type in the study (Tables 4.8, 4.12, 4.16, 4.20, 4.24, 4.28, 4.32, 4.36, 4.40, 4.44, 4.48). Moreover, the density of large diameter stems is such that this community type has the second highest basal area (52.03m^2) of any community type in this study.

The simple structure and composition of this community type is reflected by its low species richness levels (Table 4.6). Slow decay rates, acidic leaf litter, year-round shade from the *Picea* canopy (White *et al.* 1993) and dense *Abies* thickets may account for limited species diversity in this type.

Succession and Disturbance

Logging records indicate that the *Picea* forests once dominated much of the entire central ridge and adjacent upper-slopes of Shining Rock. These forests were heavily logged in the early twentieth century and were also burned in 1925 and 1942. Large accumulations of spruce slash caused very intense burning in the 1925 fire (USFS *unpub. data*). These former spruce forests inhabited a wider range of landforms than the present **Spruce-Fir Forests** community type. Descriptions by Crandell (1958) in the Smoky Mountains provide some insight to the possible range of these former **Spruce-Fir Forests**. Crandell (1958) observed that changes in understory composition correlated with changes in landform type, which suggests that the present **[Picea/Dennstaedtia Forest]** represents only one of several **Spruce-Fir Forests** community types formerly present in the Shining Rock landscape. Comparisons of disturbance records and recent aerial photographs showing the distribution of the present **Spruce-Fir Forests** suggest that the present **[Picea/Dennstaedtia Forest]** exists in areas that were either not burned in 1925 or were adjacent to land pastured for the previous 45 years (USFS *unpub. data*) where fuel loadings would have been minimal.

The presence of dead *Picea* stems in the canopy and on the ground, and the abundance of this species in the understory, indicates the ability of this community type to be self maintaining. Although logging and fire have destroyed evidence for determining the historical importance of *Abies fraseri* in the canopy, the lack of dead *Abies* canopy trees in the present community suggests that, at least in recent history, this species has not been an important canopy element. The elevational range of the **[Picea/Dennstaedtia Forest]** at Shining Rock may fall below that required for *Abies* dominance. However, *Abies* is maintained as a shrub/small-tree species in this type. The chances of this species reaching the canopy are few, due to either adelgid invasion, changing understory conditions or because of the ability of *Picea* to out-persist *Abies* in the suppressed sapling stage (Busing & Wu 1990).

The *Abies* thickets and *Dennstaedtia* clumps in the lower-strata of the **[Picea/ Dennstaedtia Forest]** move across the forest floor in a cyclic pattern following the dynamics of the canopy. As the canopy opens, following the death of a *Picea* tree, understory conditions become drier with increased light levels. *Abies* seedlings take advantage of the high-light conditions and can establish and release more quickly than *Picea* seedlings (White *et al.* 1985). *Abies* grow to form dense thickets in areas once dominated by ferns. As the canopy closes over, the majority of *Abies* seedlings die, whereas *Picea* stems survive because of their ability to withstand suppression in the understory (White *et al.* 1985, Busing & Wu 1990). As tree sapling numbers diminish the *Dennstaedtia* cover will slowly reestablish.

Although the **[Picea/Dennstaedtia Forest]** has the potential to be self-maintaining, the close proximity of much of the **[Picea/Dennstaedtia Forest]** population to the concentration of trail heads and campsites at the Shining Rock Gap threatens the future integrity of this type. Campsite establishment in the understory of some stands adjacent to the Gap has already caused substantial damage, altering understory conditions and reducing the ability of *Picea* seedlings to establish and survive.

Discussion

The **<u>Spruce-Fir</u> <u>Forests</u>** are one of the most well-known and probably the best described high-elevation Southern Appalachian vegetation class. The dynamics, composition and structure of these forests have been studied extensively (e.g., Crandell 1958, White *et al.* 1985, Busing *et al.* 1988, White & Cogbill 1992). This enables us to compare specific characteristics of the **[Picea/Dennstaedtia Forest]** of Shining Rock with other Southern Appalachian **<u>Spruce-Fir</u> <u>Forests</u>**. White & Cogbill (1992) suggest that basal area measurements of between 25 and $40m^2$/ha are typical for 40- to 80-year-old stands on sites previously logged. These measurements are lower than the $52m^2$/ha quantified for **[Picea/Dennstaedtia Forest]** stands of similar age (Table 4.28). The density of >2.5 cm sized stems is also much lower (654/ha) in this community type than the average values of 1000-2500/ha reported by White & Cogbill (1992). Such differences reflect the dominance of large-canopy sized trees in the Shining Rock stands and their relatively even-aged structure.

Although *Betula alleghaniensis* is typically an important, subdominant canopy component in Southern Appalachian **Spruce-Fir Forests** (Cain 1935, Braun 1950, Oosting & Billings 1951, Whittaker 1956, Crandell 1958, McLeod 1988, P. White *pers. comm.*), this species is virtually absent from the **[Picea/Dennstaedtia Forest]** stands at Shining Rock. *Betula alleghaniensis* is shade intolerant (White *et al.* 1985) and its establishment in this community type may have been inhibited by uniformly low light levels in the understory created by the even-aged *Picea* canopy. *Betula* absence may also be an artifact of the small numbers of stands sampled in this community type, or perhaps the present elevational distribution of Shining Rock **Spruce-Fir Forests**.

White *et al.* (1993) describe changes in canopy composition of **Spruce-Fir Forests** along the elevation gradient. At lowest elevations at the **Spruce-Fir Forests**-hardwood transition zone, *Picea* and hardwood species, such as *Betula alleghaniensis* codominate the canopy. Mid-elevation **Spruce-Fir Forests** are dominated by *Picea* and above this zone *Abies* abundance in the canopy increases with increasing elevation (White *et al.* 1993). Based on historic information and the composition of the present forests, I suggest that the lower-elevation *Picea*-hardwood zone was eliminated by logging and fire and that the surviving **Spruce-Fir Forests** represent mid-elevation *Picea*-dominated stands.

Table 4.27. Average cover class and constancy of species present in the **Spruce-Fir Forests** vegetation class. The vegetation class is represented by its abbreviation code. For full name see Table 4.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. Homoteneity is the mean constancy of the prevalent species.

Group:	6.	
Number of plots:	2	
Homoteneity:	0.839	
	Cov/Con	
Species		
ABIES FRASERI*	6	100
ACER PENSYLVANICUM	2	100
ACER SPICATUM	2	50
AESCULUS FLAVA	1	50
AGERATINA ALTISSIMA VAR ROANENSIS	3	100
AMELANCHIER LAEVIS	2	100
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	1	50
ANEMONELLA THALICTROIDES	1	50
ARISAEMA TRIPHYLLUM	2	50
ASTER ACUMINATUS VAR ACUMINATUS	3	100
ASTER CHLOROLEPIS	1	50
ATHYRIUM ASPLENIOIDES	2	100
BETULA ALLEGHANIENSIS	1	100
BRACHYELYTRUM SEPTENTRIONALES	1	50
CAREX AESTIVALIS	1	50
CAREX COMMUNIS	1	50
CAREX DIGITALIS	1	50
CAREX FLEXUOSA	2	100
CAREX INTUMESCENS	1	50
CAREX PENSYLVANICA	2	100
CIRCAEA ALPINA VAR ALPINA	2	50
DANTHONIA COMPRESSA	2	100
DENNSTAEDTIA PUNCTILOBULA	6	100
DRYOPTERIS CAMPYLOPTERA	2	100
FAGUS GRANDIFOLIA	2	100
IMPATIENS PALLIDA	1	50
LUZULA ACUMINATA	1	50
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	2	50
PICEA RUBENS	8	100
PIERIS FLORIBUNDA	5	100
POA ALSODES	1	50
PRENANTHES SP. #1	1	100
PRUNELLA VULGARIS	1	50
RHODODENDRON CATAWBIENSE	2	100
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1	50
RUBUS CANADENSIS	2	50
SORBUS AMERICANA	2	100
TRILLIUM ERECTUM	1	50
TRILLIUM UNDULATUM	1	50
TSUGA CANADENSIS	3	100
VACCINIUM ERYTHROCARPUM	2	100
VACCINIUM SIMULATUM	2	50
VIOLA BLANDA	1	100

Table 4.28. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Spruce-Fir Forests** vegetation class. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

6. Spruce-Fir Forests

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ABIES FRASERI	670.00	96.25	0.00	766.25	0.24	36.14	0.45	18.30
PICEA RUBENS	655.00	302.50	170.00	1127.50	49.80	47.53	95.60	71.56
PIERIS FLORIBUNDA	251.25	0.00	0.00	251.25	0.01	10.65	0.02	5.33
ALL	1618.75	483.75	170.00	2272.50	52.03	100.02	100.00	100.01

Table 4.29. Vertical structure of woody species in the **Spruce-Fir Forests** vegetation class. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

6. Spruce-Fir Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ABIES FRASERI	5	6			
ACER SPICATUM	1	1			
AMELANCHIER LAEVIS	1	1	1		
PICEA RUBENS	4	5	1	8	
PIERIS FLORIBUNDA	3	4			
TSUGA CANADENSIS	1	1	1	1	

Table 4.30. Average site information for the **Spruce-Fir Forests** vegetation class. The vegetation class is represented by its abbreviation code. For full community type name see Table 4.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**M**=migmatite, **MG**=mica gneiss), Landform types (representing micro-scale topographic units) (**SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**US**=upper-slopes).

6. Spruce-Fir Forests

	Group
	6.
Site Characteristics:	
Elevation (m)	1722
Slope (o)	19
Aspect (o)	E,W
Parent material	M,MG
Soil depth (cm)	45.9
Surface Substrate (%):	
Moss/Lichen	3
Wood	8
Rock	2
Organic Matter	86
Water	1
Topographic Characteristics:	
Relative Slope (%)	14
LFI	0.07
TSI	-0.02
Landform type	SS
Topographic position	US

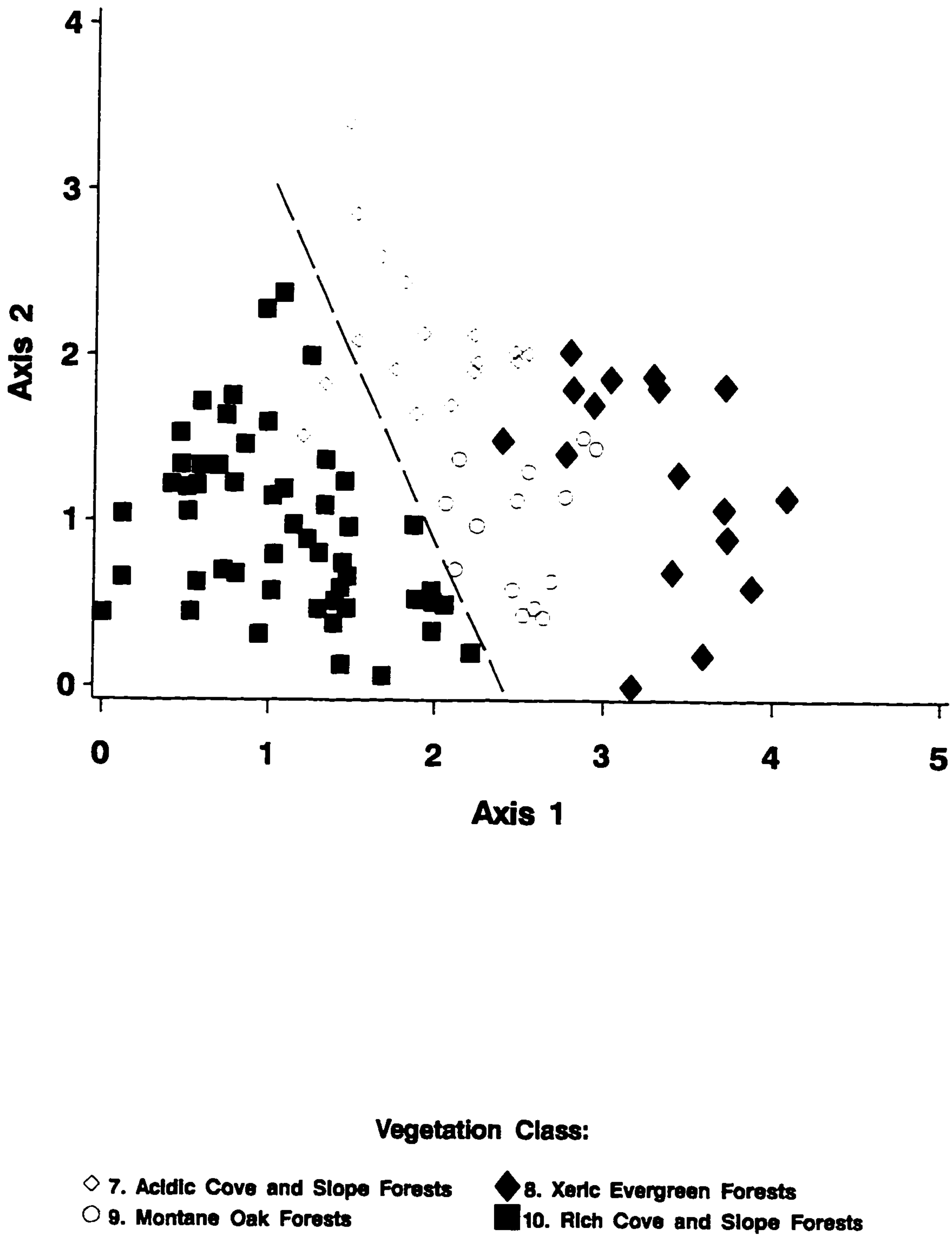
4.5.7 VEGETATION CLASS: 7. Acidic Cove and Slope Forests

The **Acidic Cove and Slope Forests** are widespread throughout the Southern Appalachian Mountains, occurring in "narrow gorges, steep ravines and low gentle ridges within coves" at low and moderate elevations (Schafale and Weakley 1990). The **Acidic Cove and Slope Forests** vegetation class is characterized by the presence of an evergreen shrub layer, typically dominated or codominated by *Rhododendron maximum*. This class generally also has very low species diversity (Table 4.6).

Acidic Cove and Slope Forests inhabit the mid- and lower-elevation valleys of Shining Rock (representing 15% of the vegetation mapped; Appendices 2, 5), in association with the **Montane Oak Forests**, the **Rich Cove and Slope Forests** and the **Xeric Evergreen Forests**. A series of ordinations was performed to clarify habitat differences between these four classes. The four vegetation classes separate along gradients of soil nutrients, topographic position and distance to high-rainfall sources (Figures 4.8, 4.9). The **Rich Cove and Slope Forests** inhabit more fertile soils, with higher pH, Mn, Ca and lower Fe values. Both the **Acidic Cove and Slope Forests** and the **Rich Cove and Slope Forests** typically occur on moist, concave lower-slope sites, generally closer to high-rainfall sources than the **Montane Oak Forests** and the **Xeric Evergreen Forests**. The latter two classes are separated by soil nutrients and topographic shape, with the **Montane Oak Forests** occurring on moister, less convex and more fertile sites than the latter class. To clarify community type relationships, stands were fragmented along the Mn-Fe soil nutrient gradient and the **Acidic Cove and Slope Forests**, the **Montane Oak Forests** and the **Xeric Evergreen Forests** were analyzed separately from the **Rich Cove and Slope Forests** stands. The **Rich Cove and Slope Forests** ordinations are discussed in the **Rich Cove and Slope Forests** section on p 430.

The ordination of the **Acidic Cove and Slope Forests**, the **Montane Oak Forests** and the **Xeric Evergreen Forests** separated classes along gradients of soil nutrients and topographic position (Figures 4.10, 4.11). The **Montane Oak Forests** inhabit more fertile (high Mn and pH), mid- and lower-slope sites than the other two classes. Within this class the **Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest** is situated on drier (higher solar radiation), more fertile sites than the **Quercus montana/ Oxydendrum/Kalmia Forest**. The **Xeric Evergreen Forests** and the **Acidic Cove and Slope Forests** are separated from each other by solar radiation, topographic shape, topographic position, distance to high-rainfall sources and soil nutrients (Mg and cation exchange capacity; Figures 4.10, 4.11). The former class typically inhabits areas further away from high-rainfall source areas, situated on drier (solar radiation, TMI), infertile (lower Mg and cation exchange capacity), convex, upper-slopes. Within the **Xeric Evergreen Forests** class, the **Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest** inhabits drier sites further away from high-rainfall sources. The other two types in this class are separated by site position, shape, moisture and soil nutrient status, with the **Quercus montana-Quercus rubra/Kalmia Forest** inhabiting dry (high solar radiation), infertile (lower cation exchange capacity, Mg and Mn), convex, upper-slopes and ridgelines. In the **Acidic Cove and Slope Forests**, the **Tsuga canadensis-Betula lenta/ Rhododendron maximum Forest** inhabits more concave (TSI, profile and section curvature), moister (TMI), lower-slope sites than the other two types. The remaining two types are separated by distance to rainfall source, elevation and Mn levels, with the **Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest** inhabiting less fertile (Mn), higher-elevation sites with higher rainfall than the **Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest**.

Figure 4.8. DCA ordination diagram showing the distribution of the **Acidic Cove and Slope Forests**, the **Montane Oak Forests**, the **Rich Cove and Slope Forests** and the **Xeric Evergreen Forests** on the two major compositional gradients. The dashed line shows separation of stands for future reordinations.


4
3
2
1
0
Axis 2
0
1
2
3
4
5
Axis 1
Vegetation Class:
7. Acidic Cove and Slope Forests
8. Xeric Evergreen Forests
9. Montane Oak Forests
10. Rich Cove and Slope Forests

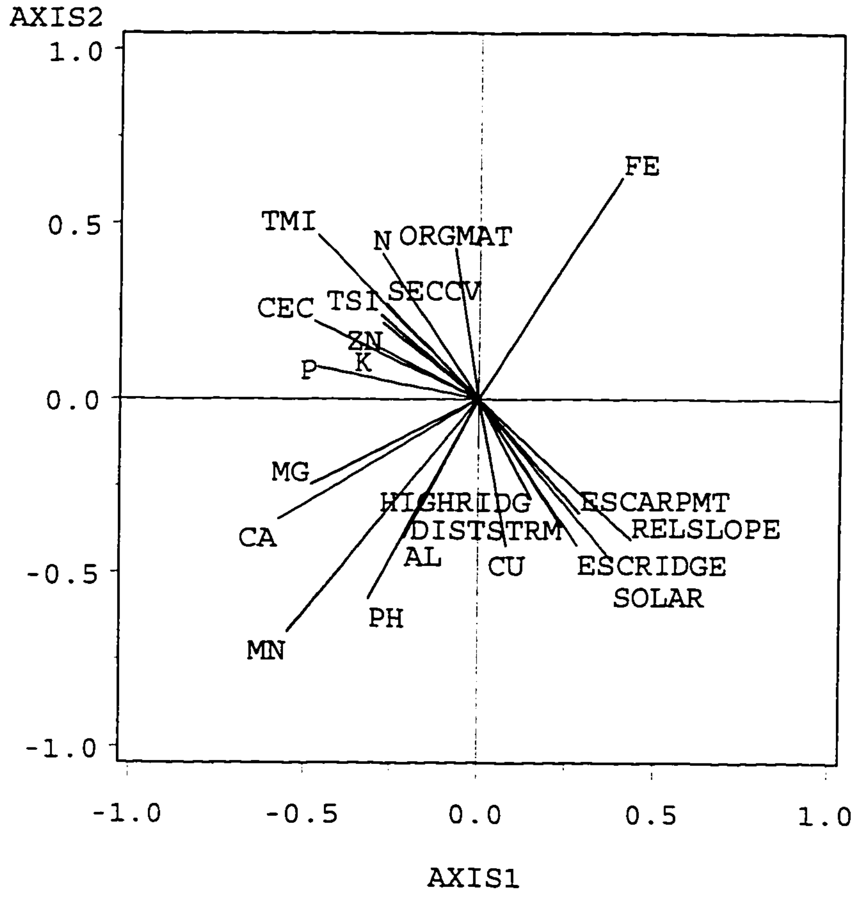
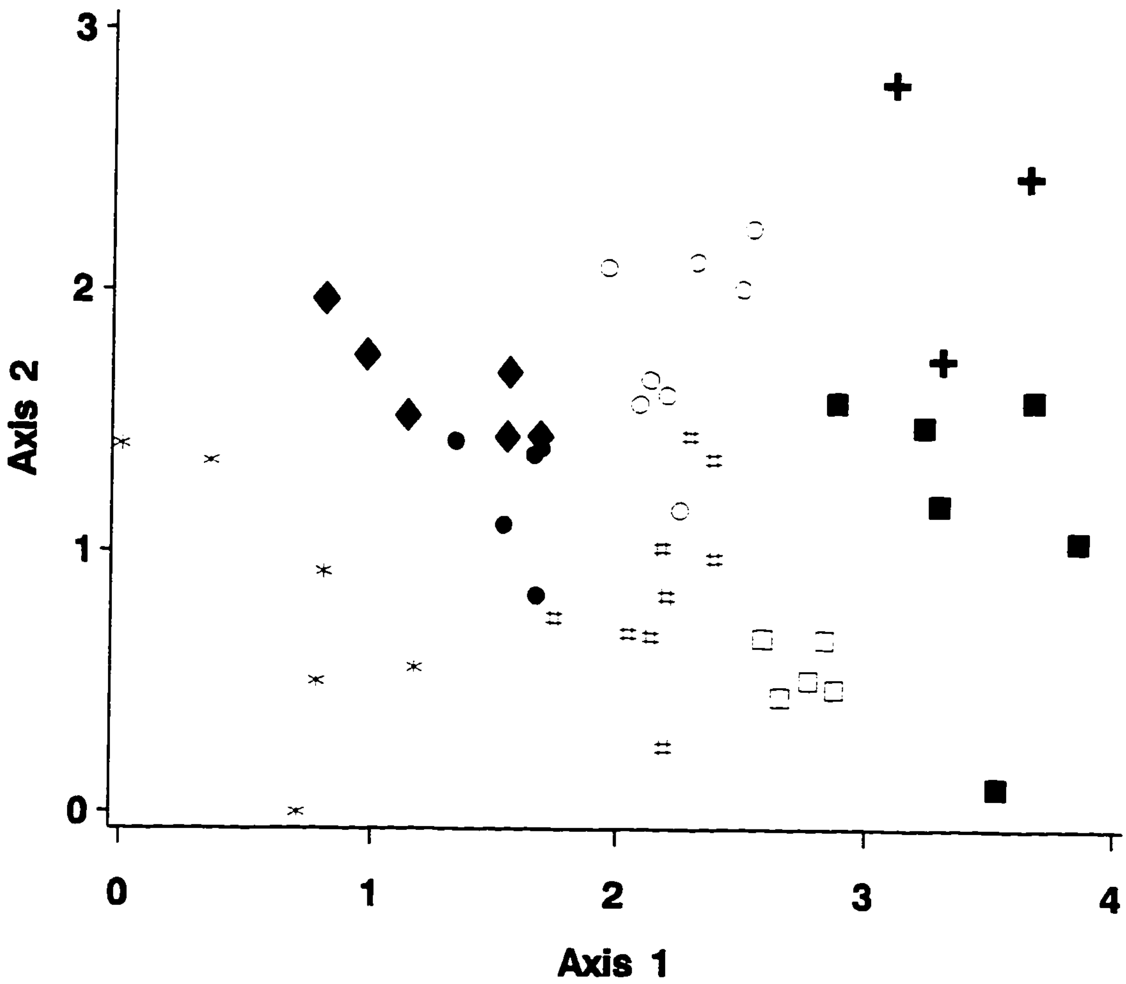


Figure 4.9. Vector diagram for DCA ordination of the **Acidic Cove and Slope Forests**, the **Montane Oak Forests**, the **Rich Cove and Slope Forests** and the **Xeric Evergreen Forests** showing association between species composition and major environmental gradients. DISTRIDG=distance to ridge, DISTSTRM=distance downslope to cove, ESCARPMT=average distance to escarpment region, HIGHRIDG=distance to nearest high-elevation area, ESCRIDGE=ESCARPMTxHIGHRIDG, RELSLOPE=relative slope position, with increasing values corresponding to higher position, SECCV=section curvature. Increasing TMI values correspond to increasing site moisture potential. Low TSI values represent convex upper-slopes while high values represent concave lower- slopes.

Figure 4.10. DCA ordination diagram showing the distribution of the **Acidic Cove and Slope Forests**, the **Montane Oak Forests** and the **Xeric Evergreen Forests** on the two major compositional gradients.



Community type:

- ✳ 7.1 Tsuga canadensis – Betula lenta/Rhododendron maximum Forest
- ● 7.2 Tsuga canadensis – Quercus rubra/Rhododendron maximum Forest
- ◆ 7.3 Betula lenta – Magnolia fraseri/Rhododendron maximum – Hamamelis Forest
- ✚ 8.1 Quercus montana – Quercus rubra/Kalmia Forest
- ○ 8.2 Pinus pungens – Quercus montana/Kalmia Forest
- ■ 8.3 Pinus pungens – Pinus rigida – Quercus montana/Kalmia Forest
- # 9.1 Quercus montana/Oxydendrum/Kalmia Forest
- □ 9.2 Quercus montana – Quercus rubra/Rhododendron calendulaceum Forest

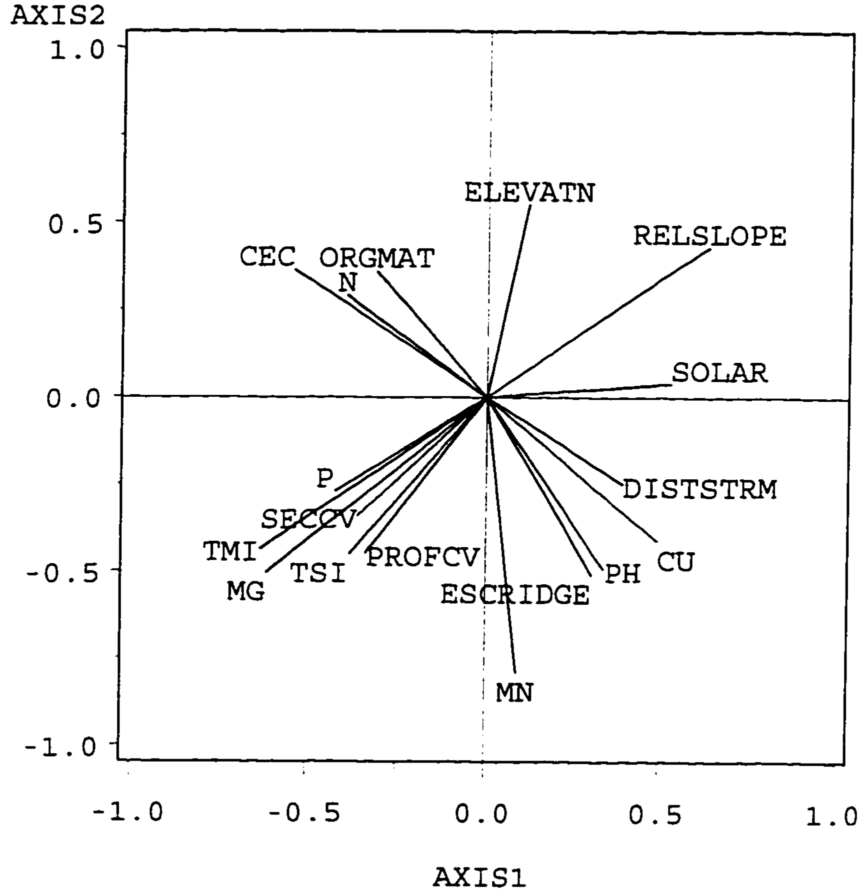


Figure 4.11 Vector diagram for DCA ordination of the **Acidic Cove and Slope Forests, Montane Oak Forests** and **Xeric Evergreen Forests** showing association between species composition and major environmental gradients. DISTSTRM=distance downslope to cove, ESCRIDGE=average distance to escarpment region (ESCARPMT) x distance to nearest high-elevation area (HIGHRIDG), RELSLOPE=relative slope position, with increasing values corresponding to higher position, PROFCV=profile curvature, SECCV= section curvature. Increasing TMI values correspond to increasing site moisture potential. Low TSI values represent convex upper-slopes whereas high values represent concave lower-slopes.

COMMUNITY TYPE: Tsuga canadensis-Betula lenta/Rhododendron maximum Forest (7.1)

Synonymy

Acidic Cove Forest (Schafale & Weakley 1990), Canada Hemlock forest (Schafale & Weakley 1990), Hemlock Forest-Rhododendron type (Oosting & Bourdeau 1955), Tsuga canadensis-Betula alleghaniensis variant of the Cove Forests p.p., Eastern Hemlock Forest (Whittaker 1956), Hemlock Forest p.p. (Racine & Hardin 1975), Cove hemlock forests (Pittillo & Smathers 1979), Yellow Birch-Hemlock type (Golden 1974), High Cove (Rohrer 1983), the Black and Craggy Mountains north-facing slope and gorge variant of Eastern Hemlock forests (McLeod 1988), Hemlock White Pine subtype II p.p. (Patterson 1994), *Tsuga canadensis/Rhododendron maximum* Forest (Chapter 3), *Tsuga canadensis/ Rhododendron maximum* Forest (Chapter 5), *Tsuga canadensis-Betula lenta/ Rhododendron maximum* Forest (Chapter 5).

Constant species

Acer pensylvanicum, *Betula lenta*, *Rhododendron maximum*, *Tsuga canadensis*.

Listed species

Carex manhartii.

Physiognomy

Large *Tsuga canadensis* (diameters mostly between 45 and 65 cm) and *Betula lenta* form a tall, dense canopy (26 m mean height; Tables 4.31, 4.32, 4.33). *B. alleghaniensis* is a canopy codominant at higher-elevation sites and those along sheltered draws. In some sites, both *Betula* species dominate the canopy with *Tsuga* present in the strata below. *Rhododendron maximum* forms a variably dense, but distinctive shrub stratum with stems mostly 2.5 - 5 cm in size. Vascular species are sparsely distributed on the forest floor. Moss covered rocks are scattered across some sites (Table 4.34).

Habitat and Distribution

This community type inhabits a broad range of elevations (994 to 1394 meters) occurring in sheltered, northwest-to-northeast-facing, lower sideslopes and creek margins (Figures 4.10, 4.11, Table 4.34). Sites vary in slope steepness (7-37° range, mean of 26°), reflecting topographic differences between the two landform types inhabited. The **Tsuga canadensis-Betula lenta/Rhododendron maximum Forest** is distributed throughout the lower-elevation valleys to the west and north of the central high-elevation ridge, present in the Little East Fork of the Pigeon River and on the lower reaches of streams north of Cold Mountain. Geology is only known for 50% of the sites, with 66% of these underlain by mica gneiss.

The soils of this type are more fertile than other **Acidic Cove and Slope Forests** types, with higher B, Ca, cation exchange capacity, Fe, Mg, Mn and pH levels (Figures 4.10, 4.11, Tables 4.4, 4.5). Higher fertility probably reflects the influence of occasional surface flooding and downslope nutrient movement. The **Tsuga canadensis-Betula lenta/Rhododendron maximum Forest** has coarse-textured soils that are similar to those of the **Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest**.

Distinguishing Features

The **Tsuga canadensis-Betula lenta/Rhododendron maximum Forest** has the highest mean elevational distribution of the three types in the **Acidic Cove and Slope** vegetation class (Table 4.34).

Succession and Disturbance

Cut stumps in several sites provide evidence for past logging activities, while rough age estimates for canopy-sized *Tsuga canadensis* (ranging between 60 and 115 years old) suggests that trees were selectively left in some sites. Although evidence for fire was only noted in one site, historic records suggest that 66% of stands burned in 1925 (USFS *unpub. data*). The presence of *Tsuga* and absence of both *Betula* species throughout the smaller stem size-classes suggests that *Betula* is successional in this community type and that *Tsuga* will eventually dominate the canopy alone (Table 4.32).

COMMUNITY TYPE: Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest (7.2)

Synonymy

Acidic Cove Forest (Schafale & Weakley 1990), Canada Hemlock forest p.p. (Schafale & Weakley 1990), Hemlock Forest-Rhododendron type (Oosting & Bourdeau 1955), Eastern Hemlock Forest (Whittaker 1956), Hemlock Forest (Racine & Hardin 1975), Hemlock-Red Maple forest (Golden 1981), the Black and Craggy Mountains north-facing slope and gorge variant of Eastern Hemlock forests p.p. (McLeod 1988), Hemlock White Pine subtype II p.p. (Patterson 1994), Tsuga canadensis/Rhododendron maximum Forest p.p. (Chattooga Ecological Classification Team, draft 1995), *Tsuga canadensis/Rhododendron maximum* Forest p.p. (Chapter 3), *Tsuga canadensis/Rhododendron maximum* Forest p.p. (Chapter 5).

Constant species

Acer rubrum var. *rubrum*, *Betula lenta*, *Conopholis americana*, *Halesia tetraptera* var. *monticola*, *Quercus rubra*, *Rhododendron maximum*, *Tsuga canadensis*.

Physiognomy

Large, mostly 48-60 cm diameter *Tsuga canadensis* and 45-50 cm *Quercus rubra* dominate the canopy (23 m mean height) in combination with smaller-diameter *Acer rubrum* (Tables 4.31, 4.32, 4.33). The dominance of these species varies by site. *Q. montana* and *Nyssa sylvatica* are also present in some stands. *Tsuga* is the major subcanopy and understory species. Below, large-stemmed *Rhododendron maximum* (mostly 2.5 to 10 cm in diameter) form a dense, 6 to 8 m tall shrub layer, with *Kalmia latifolia* present as a consistent, but minor component. *Conopholis americana* is the only consistent vascular inhabitant of the forest floor. This stratum is densely covered by a thick litter layer (Tables 4.31, 4.34).

Habitat and Distribution

This community type is scattered throughout the lower-elevation valleys of Shining Rock; sites are found on the northern slopes of Crawford Creek, Shining Creek Gap and the lower reaches of the Little East Fork of the Pigeon River. Sites average 1184 m in elevation (SD 78 m) and vary greatly in slope (9-35° range, mean of 22°, SD 9.3°; Table 4.34). Most sites are north- and south-to-southwest-facing and are situated on several lower-slope landforms, including sideslopes, lower-slope ridgelines and a creek margin.

The soils of the **Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest** are coarse-textured and have the highest sand and clay content of any **Acidic Cove and Slope Forests** type (Table 4.4). This community type has deeper, generally less fertile soils than the other two types in this class with higher levels of Al, Cu and lower cation exchange capacity, K, Mg, N, P and organic matter (Figures 4.10, 4.11, Tables 4.4, 4.5, 4.34). 80% of sites are underlain by mica gneiss bedrock.

Distinguishing Features

The **Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest** has lowest species richness at all spatial scales of any community type described in this study (Table 4.6). Such low richness levels reflect the structural simplicity and dominance by a limited range of species in this type. Moreover, species richness may be inhibited by dense year-round shading in the mid- and lower-strata by evergreen *Tsuga canadensis* and *Rhododendron maximum*, acidic soils, the existence of a deep, acidic litter layer (Oosting & Billings 1939) and reduced soil moisture beneath *R. maximum* (Clinton & Vose 1996).

Succession and Disturbance

A few blackened stems provide evidence for past fires in 60 % of sites in this type. The 1925 fire swept through most sites, while records suggest that only one stand was burned in 1942 (USFS *unpub. data*). Large-diameter, cut chestnut stumps present in 80% of sites suggest that this species was once at least a consistent minor canopy component.

High *Tsuga* numbers in the smaller-size classes, and the absence of small-diameter *Quercus rubra* and *Betula lenta*, suggests that *Tsuga* will assume sole dominance of the canopy in the future (Table 4.32). Such a prediction points to the future convergence of the canopies in the **Tsuga canadensis-Betula lenta/Rhododendron maximum Forest** and the **Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest**, but site moisture differences between these types will maintain the subtle mid- and lower-strata compositional differences.

COMMUNITY TYPE: Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest (7.3)

Synonymy

Acidic Cove Forest (Schafale & Weakley 1990), Eastern Hemlock Forest p.p. (Whittaker 1956).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Amelanchier laevis*, *Betula lenta*, *Dennstaedtia punctilobula*, *Halesia tetraptera* var. *monticola*, *Hamamelis virginiana*, *Kalmia latifolia*, *Magnolia fraseri*, *Polystichum acrostichoides*, *Quercus rubra*, *Rhododendron maximum*, *Robinia pseudo-acacia*, *Smilax rotundifolia*.

Listed species

Carex lucorum var. *austrolucorum*, *Houstonia longifolia* var. *glabra*.

Physiognomy

Large, mostly 40-88 cm diameter *Betula lenta* and *Acer rubrum* are present throughout all sites as sub-dominant canopy species (24 m mean height; Tables 4.31, 4.32, 4.33). Dominant canopy species vary between sites. *Magnolia fraseri* and large-diameter *Quercus rubra* (55-70 cm size) have more consistent cover than *Q. montana*, *B. alleghaniensis*, *Liriodendron tulipifera* and *Tsuga canadensis*. *Halesia* and *Hamamelis* are the major understory species with more limited *Amelanchier* and *Acer pensylvanicum* cover. *Rhododendron maximum*, (stems mostly 2.5 to 10 cm) forms a variably dense shrub layer with *Kalmia latifolia* and *Smilax rotundifolia* present with consistent but low abundance. Two ferns, *Dennstaedtia punctilobula* and *Polystichum acrostichoides* are the only consistent forest floor species.

Species dominance varies with topographic position. Stands on sideslopes are dominated by variations of *Quercus* species, *Betula lenta*, *Magnolia fraseri* and *Acer rubrum* and have a dense *Rhododendron* shrub stratum. The two *Betula* species dominate the canopy of steep, lower-slopes adjacent to the river with a *Rhododendron* shrub layer and a thick carpet of *Leucothoe fontanesiana* present. In contrast, *Liriodendron*, *B. lenta* and *Tsuga* are the major canopy species on a riverflat site with *Ilex montana* shrubs scattered above the *Leucothoe* carpet.

Habitat and Distribution

The **Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest** is restricted to the southern, higher-rainfall portion of the Wilderness nearest the Escarpment (Figures 12,13). Sites range in elevation from 985 to 1327 m (average of 1190 m, SD 131 m) and are mostly north-facing (Table 4.34). Slope angle varies (6-43°, average of 31°), partly reflecting differences in the landforms types inhabited. This type mostly occurs on mid- and lower-slopes in small draws, steep river banks and an alluvial flat. This type inhabits, on average, steeper slopes than the other two **Acidic Cove and Slope Forests** types. This type also contrasts by its inhabitance of all three major geologic types (30% on garnet-mica schist, 30% mica gneiss and 15% migmatite and 15% unknown).

The soils have high silt content and are finer textured than other types in this vegetation class. The **Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest** also has lowest Al, base saturation, Fe, Mn, S and pH and highest N, organic matter levels of the three types in this vegetation class (Figures 4.10, 4.11, Tables 4.4, 4.5). This type has the second lowest soil density of any community type in this study.

Distinguishing Features

This type has higher species richness than the other two community types in this vegetation class (Table 4.6). Previous Southern Appalachian studies have shown that in general diversity is positively correlated with pH and soil fertility (McLeod 1988, Newell & Peet 1996, Chapters 3 & 5,), however, the **Betula lenta-Magnolia fraseri/ Rhododendron maximum-Hamamelis Forest** has the lowest pH levels in the **Acidic Cove and Slope Forests** vegetation class. High diversity probably reflects the absence of dense, year-round canopy shading, more variable shrub density and the absence of the thick, acidic leaf litter common in the *Tsuga canadensis-Rhododendron maximum*-dominated types. Sites adjacent to creek margins have higher floor richness, possibly reflecting the influence of downstream nutrient flows. Diversity levels in the **Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest** are, however, still lower than those in the **Spruce-Fir Forests** and the **Xeric Evergreen Forests**, the other low-diversity vegetation classes (Table 4.6).

Succession and Disturbance

Live sprouts and cut stumps provide evidence for past chestnut presence in 33% of sites. One stump measured 45 cm in diameter, suggesting that chestnut was probably part of the canopy in at least some sites. All stands in this community type were logged (USFS *unpub. data*), however, a 77 cm diameter *Tsuga*, approximately aged 240 years old and a 66 cm diameter *Quercus montana* (the rotten center prevented coring) in two sideslope sites, suggests that logging must have been selective at some sites. All sites were burned in both major fires (USFS *unpub. data*).

Summary data indicates that the composition of the canopy will change in the future, with *Halesia* becoming dominant (Table 4.32). Abundant *Magnolia fraseri* saplings assures the presence of this species in the canopy. However, limited *Acer rubrum* and *Betula lenta* sapling numbers and absence of *Quercus rubra* saplings suggest that these species will not be part of the future canopy.

Discussion

The three **Acidic Cove and Slope Forests** types can be distinguished from one another by geographic location and topographic characteristics and these are reflected by differences in species composition. The **Tsuga canadensis-Quercus rubra/ Rhododendron maximum Forest** inhabits warmer, dryer, lower-elevation sites in less protected valleys than the other two **Acidic Cove and Slope Forests** types (Table 4.34). The former type represents, to some extent, a transition to **Montane Oak Forests**. The dry conditions are reflected by the presence of *Kalmia* and *Quercus rubra* in this type. The **Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest** has a more restricted geographic distribution than the other two types, present only in the wetter, southern-end of the Shining Rock.

The absence of *Tsuga canadensis* from the canopy of the **Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest** separates this forest from the other two **Acidic Cove and Slope Forests** types. The former type was burned in both major fires, while the other two types were only burned in 1925. Differences in the disturbance history may account for the *Tsuga* absence in the **Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest**. Greater abundance of successional species and extent of projected changes in canopy composition suggests that this type suffered greater damage than the other two **Acidic Cove and Slope Forests** types. The successional nature of this type may also explain why the **Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest** does not resemble any previously described Southern Appalachian community.

Although forests dominated by *Tsuga canadensis* have been documented extensively throughout the Southern Appalachians (e.g., Whittaker 1956, McLeod 1988, Schafale & Weakley 1990, Chapters 3 & 5), few studies have quantified the composition and structure of these forests (but see Oosting & Bourdeau 1955, McLeod 1988, Chapters 3 & 5). In comparison to the old-growth **Tsuga canadensis /Rhododendron maximum Forests** at Linville Gorge Wilderness (Chapter 3), the two *Tsuga canadensis-Rhododendron maximum*-dominated types at Shining Rock have lower *Rhododendron maximum* densities, as well as lower *Tsuga* basal area measurements and overall stand basal area. This reflects both the young age of the Shining Rock stands and the presence other species in the canopy (Tables 4.31, 4.32). Although speculative, the addition of these species may relate to past disturbance by logging, higher rainfall or higher soil fertility, corresponding to underlying geologic differences (Tables 4.4, 4.5, see Chapter 3).

Forests dominated by *Tsuga canadensis* and *Rhododendron maximum* are widely distributed throughout the Southern Appalachian Mountains (Schafale & Weakley 1990). However, Pittillo & Smathers (1979) note the near absence of these forests in the Balsam Mountains. Similarly, these forests have limited distribution in Shining Rock with the **Rich Cove and Slope Forests** and **Montane Oak Forests** dominant in the mid- and lower-elevation areas. There seems no clear explanation for this pattern. Disturbance by logging and fire may have reduced former **Acidic Cove and Slope Forests** distribution. Alternatively, soil fertility may be too high, or valleys perhaps are mostly not sheltered enough to support this vegetation class.

Table 4.31. Average cover class and constancy of species present in the **Acidic Cove and Slope Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 4.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	7.	7.1	7.2	7.3
Number of plots:	17	6	5	6
Homteneity:	0.532	0.58	0.667	0.682
	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species				
ACER PENSYLVANICUM	3 76	2 83	3 40	3 100
ACER RUBRUM VAR RUBRUM	5 88	3 67	5 100	5 100
ACER SACCHARUM VAR SACCHARUM	6 6	6 17		
AGERATINA ALTISSIMA VAR ROANENSIS	2 12	1 17		2 17
AMELANCHIER LAEVIS	3 35		1 20	3 83
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	1 6	1 17		
ARALIA RACEMOSA VAR RACEMOSA	1 6	1 17		
ARISTOLOCHIA MACROPHYLLA	2 41	3 67		2 50
ARISAEMA TRIPHYLLUM	1 47	1 67		1 67
ASTER ACUMINATUS VAR ACUMINATUS	1 6			1 17
ASTER CHLOROLEPIS	1 18		1 20	2 33
ASTER DIVARICATUS	1 35	1 67		2 33
ATHYRIUM ASPLENIOIDES	2 29	2 50		2 33
BETULA ALLEGHANIENSIS	5 47	7 67		4 67
BETULA LENTA	6 100	6 100	6 100	6 100
BOTRYCHIUM BITERNATUM	1 6			1 17
CAREX AESTIVALIS	1 18			1 50
CAREX COMMUNIS	2 12			2 33
CAREX DIGITALIS	2 12			2 34
CAREX FLEXUOSA	2 6			2 17
CAREX LUCORUM VAR AUSTROLUCORUM*	2 6			2 17
CAREX MANHARTII*	1 12	1 33		
CAREX PENSYLVANICA	2 6			2 17
CARYA ALBA	5 12	5 17	5 20	
CARYA CORDIFORMIS	2 12		3 20	1 17
CARYA GLABRA	1 6	1 17		
CASTANEA DENTATA	1 6			1 17
CAULOPHYLLUM THALICTROIDES	2 12	2 33		
CHAMAELIRIUM LUTEUM	2 12	2 33		
CHIMAPHILA MACULATA VAR MACULATA	1 18	1 33	1 20	
CLETHRA ACUMINATA	4 18			4 50
CLINTONIA UMBELLULATA	2 6	2 17		
COLLINSONIA CANADENSIS	1 6			1 17
CONOPHOLIS AMERICANA	1 41		1 100	1 33
CORNUS FLORIDA	2 6			2 17
CORYLUS CORNUTA VAR CORNUTA	4 6		4 20	
CYPRIPEDIUM ACAULE	1 6		1 20	
DENNSTAEDTIA PUNCTILOBULA	2 29			2 83
DIERVILLA SESSILIFOLIA	2 6			2 17
DIOSCOREA QUATERNATA	1 24	1 33	2 20	1 17
DRYOPTERIS MARGINALIS	2 12	2 33		

Group:	7.	7.1	7.2	7.3
	Cov/Con	Cov/Con	Cov/Con	Cov/Con
FAGUS GRANDIFOLIA	4 24	4 33	5 20	5 17
FRAXINUS AMERICANA	2 6		2 20	
GALAX URCEOLATA	2 41	2 17	2 40	3 67
GALIUM CIRCAEZANS	1 6	1 17		
GALIUM TRIFLORUM	1 6	1 17		
GOODYERA PUBESCENS	1 35	1 50	2 20	1 33
HALESIA TETRAPTERA VAR MONTICOLA	4 59	6 17	3 80	5 83
HAMAMELIS VIRGINIANA	4 41		2 40	5 83
HIERACIUM PANICULATUM	1 6			1 17
HOUSTONIA LONGIFOLIA VAR GLABRA*	1 12			1 33
HOUSTONIA SERPYLLIFOLIA	1 6			1 17
ILEX MONTANA	4 24	2 17		4 50
KALMIA LATIFOLIA	3 59	1 17	3 80	3 83
LAPORTEA CANADENSIS	1 6	1 17		
LEUCOTHOE FONTANESIANA	6 18			6 50
LEUCOTHOE RECURVA	2 6			2 17
LIRIODENDRON TULIPIFERA	5 24		5 20	5 50
LISTERA SMALLII	1 18	1 17		1 33
LYCOPODIUM OBSCURUM	2 6			2 17
MAGNOLIA ACUMINATA	5 35	7 33	5 40	4 33
MAGNOLIA FRASERI	5 41		6 40	5 83
MEDEOLA VIRGINIANA	1 29		2 40	1 50
MONARDA CLINOPODIA	1 6	1 17		
MONOTROPA UNIFLORA	1 29	1 50	1 40	
NYSSA SYLVATICA	5 18		7 40	2 17
OSTRYA VIRGINIANA VAR VIRGINIANA	6 6	6 17		
OXYDENDRUM ARBOREUM	5 29	4 33	5 60	
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	1 6	1 17		
PICEA RUBENS	5 12	7 17	2 20	
PLATANTHERA CLAVELLATA	1 6	1 17		
POLYGONATUM BIFLORUM	2 18	2 50		
POLYPODIUM APPALACHIANUM	1 12			1 33
POLYPODIUM VIRGINIANUM	2 12	2 33		
POLYSTICHUM ACROSTICHOIDES	1 59	2 67	1 20	1 83
PRENANTHES SP. #1	1 18			1 50
PROSARTES LANUGINOSUM	2 12	2 17		1 17
PRUNUS PENSYLVANICA	1 24	1 33	1 20	1 17
PRUNUS SEROTINA	1 18		1 40	1 17
PTERIDIUM AQUILINUM	2 6			2 17
PYRULARIA PUBERA	2 6		2 20	
QUERCUS ALBA	1 6			1 17
QUERCUS COCCINEA VAR COCCINEA	4 6		4 20	
QUERCUS MONTANA	5 41		6 60	4 67
QUERCUS RUBRA	4 82	2 50	6 100	4 100
RHODODENDRON CALENDULACEUM	1 6		1 20	
RHODODENDRON MAXIMUM	7 100	6 100	8 100	6 100
RHODODENDRON MINUS	2 24	3 33	2 40	
ROBINIA PSEUDOACACIA	3 53	3 33	4 40	2 83
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1 6			1 17
RUBUS ARGUTUS	2 6			2 17
RUBUS CANADENSIS	2 6			2 17
SANICULA CANADENSIS VAR CANADENSIS	1 6	1 17		
SASSAFRAS ALBIDUM	2 6			2 17
SMILAX GLAUCA VAR GLAUCA	1 12			1 33
SMILAX ROTUNDIFOLIA	2 53	2 17	2 60	2 83

Group:	7.		7.1		7.2		7.3	
	Cov/Con		Cov/Con		Cov/Con		Cov/Con	
SOLIDAGO ARGUTA SSP CAROLINIANA	1	12					1	33
SOLIDAGO CURTISII	1	35	1	33	1	20	1	50
THASPIUM BARBINODE	2	6	2	17				
THELYPTERIS NOVEBORACENSIS	2	6			2	20		
TILIA AMERICANA VAR HETEROPHYLLA	5	18	5	50				
TRILLIUM ERECTUM	1	6	1	17				
TRILLIUM UNDULATUM	1	12	1	17			1	17
TSUGA CANADENSIS	6	88	7	100	7	100	4	67
VACCINIUM PALLIDUM	1	12					1	33
VACCINIUM SIMULATUM	2	6					2	17
VACCINIUM STAMINEUM	1	6					1	17
VIBURNUM ACERIFOLIUM	2	6	2	17				
VIBURNUM LANTANOIDES	2	6					2	17
VIOLA AFFINIS	1	6					1	17
VIOLA BLANDA	2	18	2	50				
VIOLA HASTATA	1	12			1	40		
VIOLA ROTUNDIFOLIA	2	41	2	50			1	67
VITIS AESTIVALIS VAR BICOLOR	2	6	2	17				

Table 4.32. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Acidic Cove and Slope Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

7. Acidic Cove and Slope Forests

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	3.68	87.32	3.82	94.82	2.60	2.03	6.92	4.48
BETULA ALLEGHANIENSIS	0.98	154.41	0.00	155.39	2.57	2.34	5.76	4.05
BETULA LENTA	10.29	149.12	7.84	167.26	5.40	3.86	13.16	8.51
QUERCUS RUBRA	0.00	43.04	8.43	51.47	3.56	1.10	7.97	4.53
RHODODENDRON MAXIMUM	569.02	2848.29	0.00	3417.31	7.30	52.43	15.68	34.06
TSUGA CANADENSIS	33.77	388.04	26.47	448.28	13.19	14.54	26.52	20.53
ALL	1149.85	4283.96	58.19	5492.00	45.01	99.99	100.00	100.00

7.1 Tsuga canadensis-Betula lenta/Rhododendron maximum Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
BETULA ALLEGHANIENSIS	0.00	336.11	0.00	336.11	6.39	4.70	13.09	8.90
BETULA LENTA	0.00	143.06	4.17	147.22	4.73	4.05	8.78	6.41
MAGNOLIA ACUMINATA	0.00	0.00	12.50	12.50	4.06	0.43	8.21	4.32
RHODODENDRON MAXIMUM	730.56	2140.28	0.00	2870.83	4.48	52.53	8.51	30.52
TILIA AMERICANA VAR HETEROPHYLLA	0.00	45.83	0.00	45.83	2.82	1.71	6.34	4.02
TSUGA CANADENSIS	61.11	650.00	36.11	747.22	21.31	25.87	43.28	34.57
ALL	883.33	3659.72	52.78	4595.83	49.61	99.99	100.00	100.00

7.2 Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	3.33	113.67	8.00	125.00	4.80	2.53	11.92	7.23
BETULA LENTA	0.00	120.00	3.33	123.33	4.68	3.73	8.68	6.20
QUERCUS RUBRA	0.00	41.33	13.67	55.00	5.16	1.40	10.56	5.98
RHODODENDRON MAXIMUM	349.67	3551.33	0.00	3901.00	9.82	63.30	20.25	41.78
TSUGA CANADENSIS	34.00	511.00	41.67	586.67	16.91	17.44	30.46	23.95
ALL	520.33	4708.33	82.00	5310.67	50.85	99.99	99.99	100.00

7.3 Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	7.64	136.01	4.17	147.82	2.65	2.97	7.45	5.21
BETULA LENTA	29.17	179.46	15.28	223.91	6.65	3.79	21.27	12.54
HALESIA TETRAPTERA VAR MONTICOLA	113.89	331.65	0.00	445.54	1.22	7.10	4.70	5.90
HAMAMELIS VIRGINIANA	334.72	192.36	0.00	527.08	0.93	8.39	2.87	5.63
MAGNOLIA FRASERI	58.33	86.81	2.78	147.92	2.17	3.30	6.10	4.70
QUERCUS RUBRA	0.00	79.17	12.50	91.67	5.46	1.53	12.74	7.14
RHODODENDRON MAXIMUM	590.28	2970.44	0.00	3560.71	8.03	43.26	19.05	31.16
SMILAX ROTUNDIFOLIA	480.56	2.08	0.00	482.64	0.04	8.04	0.12	4.08
ALL	1940.97	4554.56	43.75	6539.29	35.55	99.99	100.00	100.00

Table 4.33. Vertical structure of woody species in the **Acidic Cove and Slope Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

7. Acidic Cove and Slope Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	3	3	
BETULA ALLEGHANIENSIS	1	1	2	2	
BETULA LENTA	1	1	5	6	
HALESIA TETRAPTERA	1	1	2	1	
KALMIA LATIFOLIA	1	1			
LEUCOTHOE FONTANESIANA	1				
LIRIODENDRON TULIPIFERA	1	1	1	1	
MAGNOLIA ACUMINATA	1	1	2	2	
MAGNOLIA FRASERI	1	1	2	2	
OXYDENDRUM ARBOREUM	1	1	1	1	
QUERCUS MONTANA	1	1	2	2	
QUERCUS RUBRA	1	1	3	3	
RHODODENDRON MAXIMUM	1	6	3		
ROBINIA PSEUDOACACIA	1	1	1	1	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	1	
TSUGA CANADENSIS	1	3	5	4	

7.1 Tsuga canadensis-Betula lenta/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	1	1	
ACER SACCHARUM VAR SACCHARUM	1	1	1	1	
BETULA ALLEGHANIENSIS	1	1	4	4	
BETULA LENTA	1	1	6	6	
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1	1	
OSTRYA VIRGINIANA VAR VIRGINIANA	1	1	1		
PICEA RUBENS	1	1	1		
QUERCUS RUBRA	1	1	1	1	
RHODODENDRON MAXIMUM	1	6	2		
TILIA AMERICANA VAR HETEROPHYLLA	1	1	3	3	
TSUGA CANADENSIS	1	4	7	6	

7.2 Tsuga candensis-Quercus rubra/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	3	4	
BETULA LENTA	1	1	5	5	
FAGUS GRANDIFOLIA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1	1	
KALMIA LATIFOLIA	1	1			
MAGNOLIA ACUMINATA	1	1	2	2	
MAGNOLIA FRASERI	1	1	2	2	
NYSSA SYLVATICA	1	1	2	2	
OXYDENDRUM ARBOREUM	1	1	2	2	
QUERCUS MONTANA	1	1	2	3	
QUERCUS RUBRA	1	1	4	5	
RHODODENDRON MAXIMUM	1	8	4		
ROBINIA PSEUDOACACIA	1	1	1	1	
TSUGA CANADENSIS	1	4	6	5	

7.3 Betula lenta-Magnolia fraseri/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1	1	
ACER RUBRUM VAR RUBRUM	1	1	5	5	
AMELANCHIER LAEVIS	1	1	1		
BETULA ALLEGHANIENSIS	1	1	2	2	
BETULA LENTA	1	1	5	6	
HALESIA TETRAPTERA VAR MONTICOLA	1	2	3	1	
HAMAMELIS VIRGINIANA	1	3	2		
ILEX MONTANA	1	1	1		
KALMIA LATIFOLIA	1	2			
LEUCOTHOE AXILLARIS	3	2			
MAGNOLIA ACUMINATA	1	1	1	1	
MAGNOLIA FRASERI	1	1	2	2	
QUERCUS MONTANA	1	1	2	3	
QUERCUS RUBRA	1	1	3	3	
RHODODENDRON MAXIMUM	1	6	2		
ROBINIA PSEUDOACACIA	1	1	1	1	
TSUGA CANADENSIS	1	1	2	2	

Table 4.34. Average site information for the **Acidic Cove and Slope Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 4.1 Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**MG**=mica gneiss, **?**=unknown), Landform types (representing micro-scale topographic units) (**R**=ridge, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**LS**=lower-slopes, **MS**=mid-slopes).

7. Acidic Cove and Slope Forests

	Group			
	7.	7.1	7.2	7.3
Site Characteristics:				
Elevation (m)	1194	1207	1184	1190
Slope (o)	27	27	22	31
Aspect (o)		NW-NE	N, S-SW	N
Parent material	?	?	MG	?
Soil depth (cm)	43.9	43.3	50.0	39.7
Surface Substrate (%):				
Moss/Lichen	7	15	1	5
Wood	6	6	6	7
Rock	11	19	2	10
Organic Matter	81	74	91	81
Water	1	3	0	0
Topographic Characteristics:				
Relative slope (%)	27	19	26	36
LFI	0.23	0.22	0.23	0.24
TSI	0.03	0.06	0.02	0.00
Landform type	SS	SS	SS	R, SS
Topographic position	LS	LS	MS, LS	MS, LS

4.5.8 VEGETATION CLASS: 8. <u>Xeric</u> <u>Evergreen</u> <u>Forests</u>

This vegetation class inhabits xeric sites with thin soils and is restricted to lower-elevation areas of the Southern Appalachian Mountains (Schafale & Weakley 1990). The **<u>Xeric</u> <u>Evergreen</u> <u>Forests</u>** class (representing 10% of the vegetation mapped) is not evenly distributed throughout Shining Rock, with two of the three community types virtually restricted to mid- and lower-elevation ridge and off-ridge sites north of Crawford Creek (Figures 1.3, 4.2, 4.3, 4.10, 4.11; Appendices 2, 5). In Shining Rock this class is characterized by the dominance of xerophytic *Pinus* (*Pinus pungens, P. rigida*) and *Quercus* species (*Quercus montana*) and a dense evergreen shrub stratum, typically dominated by *Kalmia latifolia*.

COMMUNITY TYPE: Quercus montana-Quercus rubra/Kalmia Forest (8.1)

Synonymy

Chestnut Oak Forest (Schafale & Weakley 1990), Chestnut Oak-Chestnut Heath (Whittaker 1956), Scarlet Oak Forests, Red Maple Forests, Chestnut Oak Forests p.p. (McLeod 1988), Chestnut Oak Forest (Patterson 1994), *Quercus montana-Quercus coccinea/Kalmia* Forest p.p. (Chapter 3), *Quercus rubra-Quercus coccinea/Kalmia* Forest p.p. (Chapter 5).

Constant species

Acer rubrum var. *rubrum, Galax urceolata, Kalmia latifolia, Quercus montana, Quercus rubra, Rhododendron maximum, Smilax rotundifolia.*

Listed species

Luzula multiflora var. *congesta*.

Physiognomy

This community type varies greatly in stature (13-27 m canopy height range, 21 m mean) with stands stunted on more exposed sites. Large, mostly 40-63 cm diameter *Quercus montana* dominate the canopy, in association with *Q. rubra* and *Acer rubrum* (Tables 4.35, 4.36, 4.37). There is no subcanopy in stunted stands, while *Nyssa sylvatica* and *Oxydendrum arboreum* form a subcanopy in taller forms of this type. Small-stemmed *Kalmia latifolia* (diameters mostly 1 - 2.5 cm) typically form an extremely dense, 2 to 3 m tall shrub stratum with 5 to 8 m tall clumps of *Rhododendron maximum* (stems 2.5-10 cm in diameter) scattered throughout. However, *Rhododendron* dominates the shrub stratum in two north-facing stands at the northern-end of the Wilderness, with *Kalmia* less abundant. *Smilax rotundifolia* is scattered throughout the shrub layer at all sites. *Galax urceolata* is also present at all sites with generally low cover, only forming extensive patches in drier ridge sites.

Habitat and Distribution

This community type is scattered across Shining Rock at elevations between 1026 and 1448 meters (mean of 1296 m, SD 138 m), typically inhabiting south-to-west-facing, side slopes, ridges and off-ridge sites (Table 4.38, Appendix 5). Sites vary widely in slope angle (mean of 25.5°, SD 13°), reflecting site differences in the landforms types inhabited. The two sites north of Cold Mountain differ in slope aspect and topographic position, inhabiting cooler, north-facing, lower-slope positions, reflecting the comparatively dry conditions present at this end of the Wilderness. Geology is known only for 63% of sites in this type, with three of these sites underlain by garnet-mica schist and one each by migmatite and mica gneiss.

The soils of this group are moderately coarse-textured and less fertile than the other two **Xeric Evergreen Forests** types (Figures 4.12, 4.13, Tables 4.4, 4.5). The **Quercus montana-Quercus rubra/Kalmia Forest** has soils with higher cation exchange capacity, K, Mg, organic matter and Zn and lower base saturation, pH and soil density levels.

Distinguishing Features

This community type has the highest basal area (63.14m^2) of any group in Shining Rock, while stem density (22,174.19 stems/ha) is highest for forest community types in this study (Table 4.36). The almost impenetrable shrub layer and the dominance of small-sized trees in this group account for high stem density, reflecting disturbance by fire in 1942 and logging. The combination of high stem density and presence of large diameter *Quercus montana* and *Q. rubra* account for the high basal area levels present.

Succession and Disturbance

Charred stems provide evidence for recent fire in 75% of plots. Historic records indicate that 80% of sites were burned in 1925, with all of these except one, burned in 1942. Three sites were probably subjected to intense fire in 1942 (USFS *unpub. data*) and today these have particularly dense understories (*pers. obs.*). All sites appear to have been logged (USFS *unpub. data*). Chestnut existence (sprouts and cut stumps) is apparent in 25% of plots, suggesting that this species was a minor canopy component in some stands.

With time, as tree and shrub stems increase in diameter, the density of the **Quercus montana-Quercus rubra/Kalmia Forest** will decrease. Large *Acer rubrum* sapling numbers suggest an increasing abundance of *Acer* in the future canopy of this type (Table 4.36). High numbers of *A. rubrum* saplings and small-sized trees may partially result from canopy openings associated with chestnut death. The limited presence of young *Quercus montana* stems and absence of *Q. rubra* saplings points to the decreasing importance of *Quercus* species in the canopy.

COMMUNITY TYPE: Pinus pungens-Quercus montana/Kalmia Forest (8.2)

Synonymy

Pine--Oak/Heath (Schafale & Weakley 1990), Xeric Pine Forests (Whittaker 1956), Pine Community Type (Cooper & Hardin 1970), Pine Oak Heath (Rohrer 1983), Xeric Pine

Forests (McLeod 1988), *Pinus pungens/Gaylussacia baccata-Leiophyllum* Forest p.p. (Chapter 3), *Pinus pungens/Kalmia* Forest (Chapter 3).

Constant species

Acer rubrum var. *rubrum, Castanea dentata, Epigaea repens, Gaylussacia baccata, Kalmia latifolia, Pinus pungens, Quercus montana, Smilax glauca* var. *glauca.*

Physiognomy

Pinus pungens and *Quercus montana* dominate the canopy (17 m mean height) of this community type (Tables 4.35, 4.36, 4.37). *Acer rubrum* is also present, while the presence of *Q. coccinea* var. *coccinea* varies between sites. There is no distinctive subcanopy. *Kalmia latifolia,* stems typically 1 to 5 cm in size, form a dense, 1.5 to 2.5 m tall shrub layer. Shrub density is patchy, with *Gaylussacia baccata* forming a dense low stratum in *Kalmia* shrub openings. *Epigaea repens* has limited but consistent distribution on the ground, mostly concentrated around small, exposed rock ledges and *Kalmia* openings.

Habitat and Distribution

The **Pinus pungens-Quercus montana/Kalmia Forest** occurs north of Crawford Creek and is restricted to steep (mean of 32°), southwest- and northwest-facing, mid-slope ridge and adjacent off-ridge sites between 1430 and 1516 m elevation (Table 4.38, Appendix 5). The two sites with known geology are underlain by mica gneiss. The soils are moderately coarse-textured, with lower cation exchange capacity, Mg, Na, P and Zn, and higher Al, base saturation, pH and soil density than the other two **Xeric Evergreen Forests** types (Tables 4.4, 4.5). This type has the second highest Al levels of any group described in this study.

Succession and Disturbance

There is evidence for the 1925 fire in all sites while the lack of charred stumps and dense shrub stratum reflects the absence of fire in 1942. All sites have been logged (USFS *unpub. data*). Although there were no cut stumps present on any site (most likely destroyed by fire), live *Castanea* stems are present at all sites, suggesting that *Castanea* was a consistent, but perhaps minor component of this community type.

High *Quercus montana* and *Pinus pungens* sapling numbers in this community type suggests that the present composition of this type will be maintained in the immediate future (Table 4.36). However, work by Barden (1977) suggests that infrequent fires are necessary to maintain fire-adapted *P. pungens*. Periodic fires, will be necessary to sustain the **Pinus pungens-Quercus montana/Kalmia Forest** in its present form.

COMMUNITY TYPE: Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest (8.3)

Synonymy

Pine--Oak/Heath (Schafale & Weakley 1990), Xeric Pine Forests (Whittaker 1956), Pine Community Type (Cooper & Hardin 1970), Pine Oak Heath (Rohrer 1983), Xeric Pine Forests (McLeod 1988), *Pinus rigida-Quercus montana/Fothergilla* Forest p.p. (Chapter 3), *Pinus pungens/Kalmia* Forest p.p. (Chapter 3).

Constant species

Acer rubrum var. *rubrum, Andropogon virginicus* var. *virginicus, Chimaphila maculata* var. *maculata, Coreopsis major* var. *rigida, Kalmia latifolia, Melampyrum lineare, Oxydendrum arboreum, Polygonatum biflorum, Quercus montana, Quercus rubra, Quercus velutina, Robinia pseudo-acacia, Smilax glauca* var. *glauca, Smilax rotundifolia, Solidago arguta* ssp. *caroliniana, Vaccinium stamineum.*

Listed species

Houstonia longifolia var. *glabra, Smilax biltmoreana, Solidago arguta* ssp. *caroliniana.*

Physiognomy

This forest varies greatly in height (10-22 m range, 16 m mean), with stunted forms inhabiting more exposed, ridge sites. *Quercus montana* consistently dominates the canopy of this type (Tables 4.35, 4.36, 4.37). *Pinus pungens* and *P. rigida* abundance varies and is higher on more exposed sites. *Oxydendrum arboreum* and *Q. velutina* dominate the mid-strata with *Carya glabra* and *C. alba* having substantial cover in some sites. Small-sized, mostly 0-5 cm diameter *Kalmia latifolia* form a dense shrub layer with *Smilax glauca* var. *glauca* and *S. rotundifolia* scattered throughout. The ground is dry and rocky, with large areas of lichen-covered rocks often present (30 and 43% surface substrate respectively; Table 4.38). *Melampyrum lineare* dominates the range of high-constancy species on the ground, in conjunction with *Andropogon virginicus* var. *virginicus*, *Chimaphila maculata* var. *maculata*, *Coreopsis major* var. *rigida*, *Polygonatum biflorum* and *Solidago arguta* ssp. *caroliniana*.

Habitat and Distribution

The **Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest**, situated mainly north of Crawford creek, inhabits lower-elevation (mean of 1150 m), lower-slope, east- and southeast-facing, steep (mean slope of 36.5°, SD 9°), off-ridge and ridge sites (Figure 1.4, Table 4.38, Appendix 5). This type inhabits small exposed outcrops, found mostly on the eastern- and northern-most slopes of Shining Rock.

The soils are coarser-textured than the other **Xeric Evergreen Forests** types, with higher sand and lower silt content (Table 4.5). The **Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest** has higher B, Fe and Mn values than the other two **Xeric Evergreen Forests** types (Figures 4.10, 4.11; Table 4.4). Geology is only known for one site and this site is underlain by mica gneiss.

One lower-slope stand above Henderson Creek at the northern-end of Shining Rock, is compositionally different to the typical ridge and off-ridge sites dominated by *Quercus montana* and the xeric pines. This stand is dominated by *Q. montana*, *Carya alba* and *Q. coccinea* with *Pinus rigida* scattered throughout the canopy. *C. alba* and *Amelanchier* are the major mid-stratum species with *Kalmia* and *Vaccinium corymbosum* forming an open shrub layer. The forest floor is dry, and sparsely scattered with a diverse range of forest floor species.

Distinguishing Features

The **Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest** has the highest species richness levels of the three **Xeric Evergreen Forests** types (Table 4.6), reflecting the greater number of highly constant species, lower shrub and overall stem density and greater forest floor diversity. At the 400m^2 scale, diversity is similar to the **Rich Cove and Slope Forests** vegetation class. The levels of diversity within this community type may be augmented by the *Quercus montana-Carya* stand described above, however the high numbers of constant species in this group do reflect the constancy of this diversity.

Succession and Disturbance

Records suggests that 50% of sites withstood intensive fire in 1925 and none were burned in 1942 (USFS *unpub. data*). The logging history of sites in this type is unknown.

Chestnut stumps/logs were absent from this type. Live sprouts are present in a small percentage of sites, suggesting that *Castanea dentata* was probably only a minor component of the **Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest**.

The dominant canopy species in the **Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest** are all represented in the small-stem size classes, suggesting that the canopy will be self-sustaining (Table 4.36). However, *Pinus pungens* and *P. rigida* are fire-adapted species which require at least infrequent fires for reproduction (Zobel 1969, Barden 1977) Existing *Pinus* saplings (mostly *P. pungens*) are all present in the most xeric, rocky stands, perhaps corresponding to Zobel's (1969) hypothesis that *P. pungens* can maintain itself on extremely xeric sites. These three sites, however, were also burned in 1925. Periodic fires, will be necessary to maintain these two species across the full range of conditions inhabited by this community type.

Discussion

The **Xeric Evergreen Forests** are not evenly distributed throughout the Shining Rock landscape. Only the oak-dominated **Quercus montana-Quercus rubra/Kalmia Forest** is present with any abundance in the southern half of the Wilderness, inhabiting south-facing slopes intensely burned in 1942. In the northern half of Shining Rock, north of Cold Mountain, this type inhabits cooler northwest-to-north-facing slopes. In contrast, the two xeric *Pinus* community types are abundant only in the northern half of the Wilderness where they are restricted to infertile, dry and rocky, mid- and low-elevation ridgelines and associated upper-slopes. All three types described here correspond to previous descriptions of Southern Appalachian Mountains xeric *Pinus*- and xeric *Quercus*-dominated communities (e.g., see Whittaker 1956, Cooper & Hardin 1970, Rohrer 1983, McLeod 1988, Schafale & Weakley 1990, Chapter 3).

The sub-dominance of *Rhododendron* in the shrub layer and the absence of xeric *Pinus* species sets the **Quercus montana-Quercus rubra/Kalmia Forest** apart from the other **Xeric Evergreen Forests** types (Tables 4.34, 4.35) and suggests that this community type inhabits less xeric, higher-rainfall areas. This type is widely scattered throughout Shining Rock in contrast to the other two types, which each have only one stand present south of Crawford Creek (Figure 1.4, Appendix 5). The **Quercus montana-Quercus rubra/Kalmia Forest** occupies significantly deeper soils enabling greater soil moisture retention than the other two types. *Pinus pungens* and *P. rigida* are typically associated with infertile soils and dry sites (e.g., Racine 1966, Zobel 1969), however, the absence of these species from the **Quercus montana-Quercus rubra/Kalmia Forest**, the most infertile **Xeric Evergreen Forests** type, suggests that in Shining Rock *Pinus* has a stronger association with site moisture and rainfall patterns rather than soil fertility.

Subtle compositional and topographic differences separate the two *Pinus*-dominated types. The **Pinus pungens-Quercus montana/Kalmia Forest** inhabits higher-elevation sites more centrally located in Shining Rock. The ridgelines inhabited by this type are southwest and northwest in orientation and have a mid-slope position. In contrast the **Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest** inhabits more xeric, lower-elevation, upper-slope, east- to southeast-facing ridgelines located along the drier, northern- and eastern-edges of the Wilderness. The presence of several lower-elevational species, including *Carya alba*, *C. glabra*, *Oxydendrum arboreum*, *Quercus velutina*, reflects the close proximity of this type to lower-elevation landscapes.

The presence of stands from two of the three community types in this vegetation class on moister, lower-slope sites in the northern-most part of the Wilderness illustrates the rainfall gradient present across Shining Rock. Moreover, this pattern of distribution suggests that in dry regions, xeric, infertile stands inhabit sites occupied by more mesic community types in the wetter, more southern portion of the Wilderness. The **Quercus montana-Quercus rubra/Kalmia Forest** stands north of Cold Mountain, which are dominated by *Rhododendron*, inhabit cooler, lower-slope sites than typical stands in this type. Slope orientation and position of the *Rhododendron* stands resemble sites in the wetter, more southerly portion of the Shining Rock inhabited by the **Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest** and the **Betula lenta-Robinia pseudo-acacia/Ageratina Forest**. This suggests that the *Rhododendron* variant of the **Quercus montana-Quercus rubra/Kalmia Forest** may replace the former community type in drier regions of Shining Rock. The **Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest** stand with a canopy of *Quercus montana*, *Carya alba* and *Q. coccinea* and scattered *Pinus rigida*, inhabits mid- and lower-slopes above Henderson Creek. Such sites would be inhabited by the **Quercus rubra-Carya glabra/Cornus florida Forest** in more southern areas of Shining Rock.

Table 4.35. Average cover class and constancy of species present in the **Xeric Evergreen Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 4.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	8.	8.1	8.2	8.3
Number of plots:	17	3	8	6
Homoteneity:	0.519	0.571	0.70	0.683
	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species				
ACER PENSYLVANICUM	2 47	1 63	3 67	1 17
ACER RUBRUM VAR RUBRUM	5 100	6 100	5 100	3 100
AGERATINA ALTISSIMA VAR ROANENSIS	1 6	1 13		
AGROSTIS PERENNANS	1 18	1 13		1 33
AMELANCHIER LAEVIS	3 47	3 50	1 33	4 50
AMPHICARPAEA BRACTEATA	1 6			1 17
ANDROPOGON VIRGINICUS VAR VIRGINICUS	2 35			2 100
ANTENNARIA PLANTAGINIFOLIA	2 6			2 17
AQUILEGIA CANADENSIS	1 6			1 17
ARALIA RACEMOSA VAR RACEMOSA	1 6	1 13		
ARISTOLOCHIA MACROPHYLLA	1 12	1 13		1 17
ASCLEPIAS TUBEROSA	2 6			2 17
ASPLENIUM PLATYNEURON VAR PLATYNEURON	2 6			2 17
ASTER ACUMINATUS VAR ACUMINATUS	1 6	1 13		
ASTER CHLOROLEPIS	1 6	1 13		
ASTER DIVARICATUS	1 6	1 13		
ASTER LATERIFLORUS VAR LATERIFLORUS	2 6			2 17
ASTER PATENS VAR PATENS	1 18			1 50
ASTER PATERNUS	2 12			2 33
ATHYRIUM ASPLENIOIDES	1 6	1 13		
AUREOLARIA LAEVIGATA	2 24			2 67
BETULA LENTA	3 59	4 63	4 33	3 67
CAMPANULA DIVARICATA	2 6			2 17
CAREX AESTIVALIS	2 6	2 13		
CAREX COMMUNIS	2 6	2 13		
CAREX LAXIFLORA VAR LAXIFLORA	1 6	1 13		
CAREX NIGROMARGINATA	1 6	1 13		
CAREX PENSYLVANICA	2 6			2 17
CAREX UMBELLATA	1 6		1 33	
CARYA ALBA	3 29	2 25		5 50
CARYA GLABRA	3 24			3 67
CASTANEA DENTATA	4 59	4 63	4 100	4 33
CASTANEA PUMILA VAR PUMILA	4 6	4 13		
CEANOTHUS AMERICANUS VAR AMERICANUS	2 6			2 17
CHAMAELIRIUM LUTEUM	1 24	1 25		1 33
CHIMAPHILA MACULATA VAR MACULATA	1 59	1 50		1 100
CLETHRA ACUMINATA	3 24	2 38	4 33	
CLITORIA MARIANA	1 18			1 50
CONOPHOLIS AMERICANA	1 29	1 38		2 33

Group:	8.	8.1	8.2	8.3
	Cov/Con	Cov/Con	Cov/Con	Cov/Con
COREOPSIS MAJOR VAR RIGIDA	2 35			2 100
CORNUS FLORIDA	3 12	4 13		1 17
DANTHONIA COMPRESSA	1 24	1 38		2 17
DANTHONIA SERICEA	2 18			2 50
DENNSTAEDTIA PUNCTILOBULA	1 6			1 17
DESMODIUM NUDIFLORUM	2 12			2 33
DICHANTHELIUM BOSCII	2 12	1 13		2 17
DICHANTHELIUM COMMUTATUM	1 18			1 50
DICHANTHELIUM DEPAUPERATUM	1 12			1 33
DICHANTHELIUM DICHOTOMUM VAR DICHOTOMUM	2 12			2 33
DIOSCOREA QUATERNATA	1 12	1 25		
DIPHASIASTRUM DIGITATUM	1 6		1 33	
DRYOPTERIS MARGINALIS	1 6	1 13		
EPIGAEA REPENS	2 53	2 38	2 100	3 50
EUPATORIUM PURPUREUM	1 6	1 13		
EUPHORBIA COROLLATA	1 24			1 67
FAGUS GRANDIFOLIA	1 6	1 13		
FRAXINUS AMERICANA	2 6			2 17
GALAX URCEOLATA	3 71	3 88	1 67	2 50
GALIUM CIRCAEZANS VAR CIRCAEZANS	1 6			1 17
GAYLUSSACIA BACCATA	4 29		4 100	5 33
GENTIANA DECORA	1 18	1 25	1 33	
GOODYERA PUBESCENS	1 24	1 50		
HALESIA TETRAPTERA VAR MONTICOLA	4 6	4 13		
HAMAMELIS VIRGINIANA	4 6	4 13		
HELIANTHUS STRUMOSUS	2 6			2 17
HEUCHERA AMERICANA	2 6			2 17
HIERACIUM VENOSUM	1 18			1 50
HOUSTONIA LONGIFOLIA VAR GLABRA*	2 12			2 33
HOUSTONIA PURPUREA VAR PURPUREA	1 12	1 13		1 17
HYPERICUM SP. #1	1 6	1 13		
HYPERICUM PUNCTATUM	1 6			1 17
HYPERICUM STRAGULUM	1 6			1 17
ILEX MONTANA	4 29	4 63		
KALMIA LATIFOLIA	7 100	7 100	8 100	6 100
LESPEDEZA CUNEATA	2 6			2 17
LESPEDEZA REPENS	1 12			1 33
LEUCOTHOE RECURVA	3 24	3 25	6 33	2 17
LIRIODENDRON TULIPIFERA	1 6			1 17
LISTERA SMALLII	1 18	1 38		
LUZULA MULTIFLORA VAR CONGESTA*	2 6	2 13		
LYONIA LIGUSTRINA VAR LIGUSTRINA	2 29	2 38	2 33	4 17
LYSIMACHIA QUADRIFOLIA	1 6	1 13		
MAGNOLIA ACUMINATA	1 18	1 25		2 17
MAGNOLIA FRASERI	2 18	2 38		
MAIANTHEMUM RACEMOSUM	1 18	1 13		2 33
MEDEOLA VIRGINIANA	1 6	1 13		
MELAMPYRUM LINEARE	3 53	2 25	2 67	4 83
MONOTROPA UNIFLORA	1 6	1 13		
NYSSA SYLVATICA	5 29	5 38		5 33
OXYDENDRUM ARBOREUM	5 53	6 38		5 100
PARTHENIUM INTEGRIFOLIUM VAR INTEGRIFOLIUM	1 6			1 17
PIERIS FLORIBUNDA	2 6		2 33	
PINUS PUNGENS	7 41		7 100	7 67
PINUS RIGIDA	6 24			6 67
PINUS STROBUS	1 6			1 17
PINUS VIRGINIANA	1 6		1 33	

Group:	8.		8.1		8.2		8.3	
	Cov/Con		Cov/Con		Cov/Con		Cov/Con	
POLYGONATUM BIFLORUM VAR BIFLORUM	1	41	1	13	1	33	1	83
POLYPODIUM APPALACHIANUM	2	12	1	13			2	17
POLYPODIUM VIRGINIANUM	1	12	1	13	1	33		
POLYSTICHUM ACROSTICHOIDES	1	12	1	25				
POTENTILLA CANADENSIS VAR CANADENSIS	2	12					2	33
PRENANTHES SP. #1	1	12	1	25				
PRUNUS PENSYLVANICA	1	6					1	17
PRUNUS SEROTINA	1	6	1	13				
PTERIDIUM AQUILINUM	2	29			2	67	2	50
PYCNANTHEMUM PYCNANTHEMOIDES VAR PYCNANTHEMOIDES	1	6					1	17
PYCNANTHEMUM PYCNANTHEMOIDES VAR VIRIDIFOLIUM	1	6	1	13				
PYRULARIA PUBERA	2	18	2	13			2	33
QUERCUS ALBA	4	12	5	13	2	33		
QUERCUS COCCINEA VAR COCCINEA	4	41	4	13	4	67	5	67
QUERCUS MONTANA	6	100	7	100	6	100	6	100
QUERCUS RUBRA	5	82	6	88	4	33	4	100
QUERCUS VELUTINA	4	29					4	83
RHODODENDRON CALENDULACEUM	3	12	2	13	4	33		
RHODODENDRON CATAWBIENSE	6	6			6	33		
RHODODENDRON MAXIMUM	6	53	6	88	3	33	4	17
RHODODENDRON MINUS	3	12	1	13			5	17
ROBINIA PSEUDOACACIA	2	59	2	38	1	33	3	100
RUBUS ARGUTUS	1	6	1	13				
RUBUS CANADENSIS	2	6					2	17
RUBUS FLAGELLARIS	2	6					2	17
SASSAFRAS ALBIDUM	2	35	2	25			2	67
SILENE VIRGINICA VAR VIRGINICA	1	6					1	17
SMILAX BILTMOREANA*	1	6					1	17
SMILAX GLAUCA VAR GLAUCA	2	82	1	63	2	100	3	100
SMILAX HERBACEA	1	6	1	13				
SMILAX ROTUNDIFOLIA	2	71	2	88			2	83
SOLIDAGO ARGUTA SSP CAROLINIANA	2	47	1	38			2	83
SOLIDAGO CURTISII	1	6	1	13				
SORGHASTRUM NUTANS	1	12					1	33
TIARELLA CORDIFOLIA VAR CORDIFOLIA	2	6	2	13				
TSUGA CANADENSIS	3	35	2	38			3	50
TSUGA CAROLINIANA	4	12			5	33	2	17
UVULARIA PUBERULA	1	18	1	25			1	17
VACCINIUM CORYMBOSUM	3	18			2	67	6	17
VACCINIUM PALLIDUM	2	53	1	50	2	33	4	67
VACCINIUM SIMULATUM	1	24	1	50				
VACCINIUM STAMINEUM	3	47	2	25	2	33	3	83
VIOLA BLANDA	2	6					2	17
VIOLA HASTATA	2	12	2	25				
VITIS AESTIVALIS VAR AESTIVALIS	2	12					2	33

Table 4.36. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Xeric Evergreen Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

8. Xeric Evergreen Forests

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	44.61	752.80	0.00	797.40	4.45	2.59	6.05	4.32
KALMIA LATIFOLIA	6733.33	2381.37	0.00	9114.71	4.83	48.54	10.85	29.70
PINUS PUNGENS	29.41	384.80	7.35	421.57	9.71	7.64	25.00	16.32
PINUS RIGIDA	5.88	119.12	1.47	126.47	3.15	1.31	7.30	4.30
QUERCUS MONTANA	43.63	569.17	11.72	624.51	11.02	3.35	20.36	11.86
QUERCUS RUBRA	15.20	249.65	4.71	269.56	6.83	1.37	9.60	5.49
RHODODENDRON MAXIMUM	341.67	1517.19	0.00	1858.86	5.39	15.60	10.97	13.29
ALL	9340.20	6674.85	25.25	16040.30	50.13	100.00	100.00	100.00

8.1 Quercus montana-Quercus rubra/Kalmia Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	57.29	1554.90	0.00	1612.19	9.23	4.76	12.34	8.55
KALMIA LATIFOLIA	8878.13	2885.42	0.00	11763.54	5.86	44.53	12.95	28.74
QUERCUS MONTANA	8.33	935.52	20.73	964.58	17.10	2.74	24.59	13.67
QUERCUS RUBRA	0.00	478.42	10.02	488.44	13.57	1.63	18.08	9.85
RHODODENDRON MAXIMUM	551.04	3211.54	0.00	3762.58	11.39	31.63	23.20	27.42
SMILAX ROTUNDIFOLIA	1821.88	0.00	0.00	1821.88	0.04	8.53	0.10	4.32
ALL	12073.96	10069.48	30.75	22174.19	63.14	100.00	100.00	100.00

8.2 Pinus pungens-Quercus montana/Kalmia Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
KALMIA LATIFOLIA	7875.00	5280.56	0.00	13155.56	10.19	75.31	22.42	48.87
PINUS PUNGENS	83.33	938.89	0.00	1022.22	28.11	5.57	57.80	31.69
QUERCUS MONTANA	138.89	208.33	0.00	347.22	4.47	1.99	9.46	5.72
ALL	10930.56	6822.22	0.00	17752.78	47.26	100.00	99.99	99.99

8.3 Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
CARYA ALBA	66.67	155.56	0.00	222.22	0.80	6.17	3.43	4.80
KALMIA LATIFOLIA	3302.78	259.72	0.00	3562.50	0.79	40.50	2.27	21.39
PINUS PUNGENS	41.67	620.83	20.83	683.33	13.47	18.85	41.92	30.39
PINUS RIGIDA	16.67	337.50	4.17	358.33	8.92	3.71	20.67	12.19
QUERCUS MONTANA	43.06	261.11	5.56	309.72	6.19	4.85	20.17	12.51
ALL	4900.00	2075.00	30.56	7005.56	34.22	100.00	99.99	100.01

Table 4.37. Vertical structure of woody species in the **Xeric Evergreen Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

8. Xeric Evergreen Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	4	2	
AMELANCHIER LAEVIS	1	1	1		
BETULA LENTA	1	1	1		
CASTANEA DENTATA	1	2	1		
KALMIA LATIFOLIA	2	7			
NYSSA SYLVATICA	1	1	1		
OXYDENDRUM ARBOREUM	1	1	2	1	
PINUS PUNGENS	1	1	3	2	
PINUS RIGIDA	1	1	1	1	
QUERCUS COCCINEA VAR COCCINEA	1	1	1	1	
QUERCUS MONTANA	1	2	6	4	
QUERCUS RUBRA	1	1	3	3	
QUERCUS VELUTINA	1	1			
RHODODENDRON MAXIMUM	1	3	1		
SMILAX GLAUCA VAR GLAUCA	1	1			
SMILAX ROTUNDIFOLIA	1	1			

8.1 Quercus montana-Quercus rubra/Kalmia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	3		
CASTANEA DENTATA	1	4			
KALMIA LATIFOLIA	3	8			
LEUCOTHOE RECURVA	2	2			
PINUS PUNGENS	1	1	7	6	
QUERCUS COCCINEA VAR COCCINEA	1	1	2	2	
QUERCUS MONTANA	1	1	6	4	
RHODODENDRON CALENDULACEUM	1	1			
RHODODENDRON CATAWBIENSE	1	2			
SMILAX GLAUCA VAR GLAUCA	1	1			
TSUGA CAROLINIANA	1	1	1		

8.2 Pinus pungens-Quercus montana/Kalmia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	6	5	
BETULA LENTA	1	1	1	2	
CASTANEA DENTATA	1	2	1		
ILEX MONTANA	1	1	1		
KALMIA LATIFOLIA	1	8			
NYSSA SYLVATICA	1	1	1		
OXYDENDRUM ARBOREUM	1	1	2	2	
QUERCUS MONTANA	1	1	6	5	
QUERCUS RUBRA	1	1	5	5	
RHODODENDRON MAXIMUM	1	5	2		
SMILAX ROTUNDIFOLIA	1	1			

8.3 Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	1		
AMELANCHIER LAEVIS	1	1	2		
CARYA ALBA	1	2	2	1	
CASTANEA DENTATA	1	1			
KALMIA LATIFOLIA	1	5			
NYSSA SYLVATICA	1	1	2		
OXYDENDRUM ARBOREUM	1	2	4	1	
PINUS PUNGENS	1	1	5	2	
PINUS RIGIDA	1	2	4	2	
QUERCUS COCCINEA VAR COCCINEA	1	2	2	1	
QUERCUS MONTANA	1	3	5	3	
QUERCUS RUBRA	1	2	2	1	
QUERCUS VELUTINA	1	2	1		
RHODODENDRON MINUS	1	1			
ROBINIA PSEUDOACACIA	1	1			
SMILAX GLAUCA VAR GLAUCA	1	2			
SMILAX ROTUNDIFOLIA	1	2			

Table 4.38. Average site information for the **Xeric Evergreen Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 4.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (?=unknown), Landform types (representing micro-scale topographic units) (SS=sideslopes) and Topographic position (representing macro-scale topographic units) (LS=lower-slopes, MS=mid-slopes).

8. Xeric Evergreen Forests

	Group			
	8.	8.1	8.2	8.3
Site Characteristics:				
Elevation (m)	1275	1471	1296	1150
Slope (o)	30	32	26	37
Aspect (o)	S-SW	S-W	SW,NW	E,SE
Parent material	?	?	?	?
Soil depth (cm)	29.4	37.4	21.2	20.5
Surface Substrate (%):				
Moss/Lichen	15	9	5	31
Wood	4	2	5	4
Rock	20	11	7	43
Organic Matter	72	80	85	51
Water	0	0	0	0
Topographic Characteristics:				
Relative slope (%)	67	88	56	70
LFI	0.19	0.15	0.19	0.21
TSI	-0.03	-0.06	-0.03	-0.03
Landform type	SS	SS	SS	SS
Topographic position	LS,MS	LS	MS	LS

4.5.9 VEGETATION CLASS: 9. **Montane Oak Forests**

Montane Oak Forests are widely distributed throughout the Southern Appalachian Mountains. In Shining Rock this vegetation class dominates the mid- and-lower-elevation areas in conjunction with the **Rich Cove and Slope Forests** class. These two classes are separated by topographic position and soil nutrients with the former inhabiting typically less fertile sites with higher slope position (Figures 4.10, 4.11). **Montane Oak Forests** account for 11% of the sites sampled in this study and 16% of the vegetation mapped (Appendices 2, 5).

The **Montane Oak Forests** are characterized by *Quercus*-dominated canopies (typically *Quercus rubra*, *Q. montana*), a broad number of low-cover, but highly consistent forest floor species and dominance of deciduous species. High-elevation forests in Shining Rock dominated by *Q. rubra* have been included in the **High-Elevation Mixed Hardwood Forests** vegetation class because of their closer floristic and environmental associations with high-elevation forests (Figures 4.2-4.5). The **Montane Oak Forests** in Shining Rock have moderately high species richness at larger scales in comparison to other vegetation classes identified in this study (Table 4.6).

COMMUNITY TYPE: Quercus montana/Oxydendrum/Kalmia Forest (9.1)

Synonymy

Chestnut Oak Forest p.p. (Schafale & Weakley 1990), Montane Oak--Hickory Forest p.p. (Schafale & Weakley 1990), Chestnut Oak-Chestnut Forest (Whittaker 1956), Chestnut Oak Forest p.p. (McLeod 1988), Chestnut Oak Forest p.p. (Patterson 1994), *Quercus montana-Quercus velutina/Oxydendrum* Forest p.p. (Chapter 5).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Amelanchier laevis*, *Aureolaria laevigata*, *Betula lenta*, *Castanea dentata*, *Chimaphila maculata* var. *maculata*, *Conopholis* *americana*, *Gentiana decora*, *Goodyera pubescens*, *Halesia tetraptera* var. *monticola*, *Kalmia latifolia*, *Magnolia acuminata*, *Medeola virginiana*, *Oxydendrum arboreum*, *Polystichum acrostichoides*, *Quercus montana*, *Quercus rubra*, *Rhododendron calendulaceum*, *Rhododendron maximum*, *Robinia pseudo-acacia*, *Smilax rotundifolia*, *Solidago curtisii*, *Tsuga canadensis*, *Uvularia puberula* var. *puberula*, *Viburnum acerifolium*, *Zizia trifoliata*.

Listed species

Abies fraseri, *Carex lucorum* var. *austrolucorum*.

Physiognomy

Although large-diameter *Quercus montana* (40-67 cm in size) and *Acer rubrum* are typically the most abundant canopy species (mean height 24.6 m, SD 4.2) in this community type, species dominance varies between sites (Tables 4.39, 4.40, 4.41). At some sites *Q. rubra* codominates with *Q. montana*, whereas in moister sites *Betula lenta* is more prevalent. The subcanopy is dominated by *Oxydendrum arboreum* with *Halesia tetraptera* also present. *Tsuga canadensis* is scattered throughout the lower strata, varying in abundance by site. *Kalmia* is typically the major shrub species, forming a moderately dense stratum in some sites, while sparsely distributed in others where *Castanea dentata* and *Cornus florida* are more abundant. The ground stratum is dry and sparsely covered by a variety of species including; *Aureolaria laevigata*, *Chimaphila maculata* var. *maculata*, *Conopholis americana*, *Gentiana decora*, *Goodyera pubescens*, *Medeola virginiana*, *Polystichum acrostichoides*, *Smilax rotundifolia*, *Solidago curtisii*, *Uvularia puberula*, and *Zizia trifoliata*.

Habitat and Distribution

The **Quercus montana/Oxydendrum/Kalmia Forest** occurs north of Shining Rock at low-to-moderate-elevations (mean 1205 m, range 1077-1351 m, SD 91 m), on moderately steep (mean slope of 25°, SD 5.5°), open mid-slopes and lower-slope ridges

(Table 4.42). Sites west of the central ridge in the Wilderness have southwest-to-northwest aspects (mostly northwest), while those east of this ridge have north-to-northeast aspects. Stands are underlain by both garnet-mica schist (56% of sites) and mica gneiss (33%) with the geology of 11% unknown.

The **Quercus montana/Oxydendrum/Kalmia Forest** has finer-textured, less fertile soils than the other **Montane Oak Forests** type. Soils have higher silt and clay content (Table 4.5) and lower Al, base saturation, Cu and pH and higher Fe levels (Figures 4.10, 4.11, Table 4.4).

Distinguishing Features

The dominance of *Quercus montana* and *Kalmia* give the **Quercus montana/ Oxydendrum/Kalmia Forest** some superficial floristic similarities with the **Quercus montana-Quercus rubra/Kalmia Forest**, in the **Xeric Evergreen Forests** vegetation class, however, the two groups exhibit broad differences (Tables 4.35, 4.39). While both types inhabit similar mean elevations, the **Quercus montana/Oxydendrum/Kalmia Forest** occurs on moister, lower-slope sites than the **Quercus montana-Quercus rubra/Kalmia Forest**. This is reflected by the much broader range of less xeric species present in the **Quercus montana/Oxydendrum/Kalmia Forest**, higher forest floor diversity and much lower shrub densities.

Succession and Disturbance

Records suggest that only one of the nine sites in this type was burned in the two major fires. All sites were logged (USFS *unpub. data*) and this is reflected by the canopy of mostly young trees, although plot 441 contained a 67 cm diameter *Quercus montana* over 140 years in age. Chestnut sprouts are present in 88% of sites in this type. Large, cut chestnut stumps (a 95 cm diameter stump in plot 304, 120 cm in plot 399, 145 cm in plot 402) indicate the presence and probable past (co)dominance of this species with *Q. montana* in the canopy. The abundance of small *Acer rubrum* stems and presence of this species in the canopy suggests that *Acer* has probably replaced *Castanea dentata* in this community. The subdominance of *Betula lenta* and *Oxydendrum*, found to replace chestnut in the Smoky Mountains (Woods & Shanks 1959) and other Southern Appalachian forests (Keever 1953), may also relate to chestnut death.

Extremely high *Halesia* and abundant *Acer rubrum* sapling numbers, suggest that the future canopy of this community type will dominated by these two species (Table 4.40). However, there is some *Quercus rubra* regeneration, indicating the continuing presence of this species as at least a minor canopy species.

COMMUNITY TYPE: Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest (9.2)

Synonymy

Montane Oak--Hickory Forest (Schafale & Weakley 1990), Chestnut Oak-Chestnut Forest p.p. (Whittaker 1956), lower elevation variant of Red Oak-Chestnut Forest p.p. (Whittaker 1956), *Quercus montana-Quercus rubra/Cornus florida* Forest (Chapter 5).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Amelanchier laevis*, *Aristolochia macrophylla*, *Aster divaricatus*, *Carex digitalis*, *Carya alba*, *Carya glabra*, *Castanea dentata*, *Chimaphila maculata* var. *maculata*, *Conopholis americana*, *Cornus florida*, *Dichanthelium dichotomum* var. *dichotomum*, *Dioscorea quaternata*, *Gentiana decora*, *Halesia tetraptera* var. *monticola*, *Hieracium paniculatum*, *Houstonia purpurea* var. *purpurea*, *Kalmia latifolia*, *Luzula multiflora* var. *congesta*, *Lysimachia quadrifolia*, *Magnolia acuminata*, *Maianthemum racemosum*, *Nyssa sylvatica*, *Oxydendrum arboreum*, *Pedicularis canadensis*, *Poa cuspidata*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Potentilla canadensis* var. *canadensis*, *Prenanthes* species, *Pycanthemum montanum*, *Quercus alba*, *Quercus montana*, *Quercus rubra*, *Rhododendron calendulaceum*, *Robinia pseudo-acacia*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Solidago arguta* ssp. *caroliniana*, *Solidago curtisii*, *Uvularia puberula* var. *puberula*, *Vaccinium pallidum*, *Vaccinium stamineum*, *Viburnum acerifolium*, *Zizia trifoliata*.

Listed species

Carex lucorum var. *austrolucorum*, *Luzula multiflora* var. *congesta*.

Physiognomy

Large-diameter *Quercus montana* and *Q. rubra* (stems mostly between 47-92 and 42-80 cm in diameter, respectively) codominate the canopy (mean height 23 m, SD 5.9), in association with smaller-sized *Acer rubrum* (Table 4.39, 4.40, 4.41). *Carya glabra* and *Carya alba* are scattered throughout. *Quercus coccinea* abundance varies between sites. *Oxydendrum arboreum* forms a distinctive subcanopy in conjunction with *Acer rubrum*. The shrub stratum is open and contains a diverse range of predominantly deciduous species. *Castanea dentata* is the major shrub species in association with *Rhododendron calendulaceum*, *Kalmia latifolia* and *Nyssa sylvatica* whereas *Cornus florida*, *Halesia tetraptera* and *Robinia pseudo-acacia* are scattered throughout. *Pyrularia pubera* has high, but less consistent cover in this stratum. The forest floor is dry, slightly rocky and open with areas of exposed mineral soil visible. This stratum is inhabited by a diverse range of highly constant, sparsely scattered, low-cover species, including; *Aristolochia macrophylla*, *Aster divaricatus*, *Carex digitalis*, *Chimaphila maculata* var. *maculata*, *Conopholis americana*, *Dichanthelium dichotomum* var. *dichotomum*, *Dioscorea quaternata*, *Gentiana decora*, *Hieracium paniculatum*, *Houstonia purpurea* var. *purpurea*, *Luzula multiflora* var. *congesta*, *Lysimachia quadrifolia*, *Maianthemum racemosum*, *Pedicularis canadensis*, *Poa cuspidata*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Potentilla canadensis* var. *canadensis*, *Prenanthes* species, *Pycanthemum montanum*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Solidago arguta* ssp. *caroliniana*, *Solidago curtisii*, *Uvularia puberula* var. *puberula*, *Vaccinium pallidum* and *Zizia trifoliata*.

Habitat and Distribution

This community type inhabits moderately steep (mean 28°, SD 4.5°), south-to south-west-facing, lower-elevation (elevational range 1072-1254 m, mean 1161 m, SD 71 m) slopes and ridgelines (Table 4.42). This type is present south of Stairs Mountain and is restricted to the peripheral western and eastern-most slopes of the Wilderness (Appendix 5). Sites are underlain by mica gneiss, with the geology of one unknown.

The **Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest** soils are moderately coarse-textured (Tables 4.4, 4.5). The **Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest** has highest Al, density and Zn and lowest B, Ca, cation exchange capacity, K, Mg, Mn, P, S and organic matter levels in comparison to the other **Montane Oak Forests** community types (Figures 4.10, 4.11).

Distinguishing Features

This is the only type in the study where *Castanea dentata* is a dominant species. The high homoteneity of this community type reflects the consistency of species throughout stands classified in this group (Table 4.39). The **Quercus montana-Quercus rubra/ Rhododendron calendulaceum Forest** has a higher number of high constancy species than the other **Montane Oak Forests** type. The largest tree measured in this study, a 113 cm diameter *Quercus montana* (plot 334), was found in this community type.

Succession and Disturbance

Charcoal in the soil of 80% of sites provides evidence for past fire, while historic records indicate that 60% of sites in this type were burned in each major fire, with only one site burned in both (USFS *unpub. data*). There is also evidence of past logging activities in 80% of the stands. Records suggest that most sites were logged, although information for two sites in unknown (USFS *unpub. data*). Some sites, particularly where *Quercus montana* is abundant, appear to have only been selectively logged.

Chestnut sprouts are present in all sites, with 80% having at least one large-diameter, cut chestnut stump present within the plot boundary. This suggests that *Castanea* *dentata* was previously codominant in the canopy. The presence of high numbers of small-diameter *Acer rubrum* suggests that this species has filled the gaps left by chestnut.

Extremely high *Acer rubrum* sapling numbers and limited *Quercus montana* and *Q. rubra* saplings indicates that *Acer* will assume dominance in the future canopy of this community type with decreasing importance of these *Quercus* species (Table 4.40). However, *Q. coccinea* has higher sapling numbers, suggesting that the presence of *Quercus* may be maintained in the canopy by this species.

Discussion

The **Quercus montana/Oxydendrum/Kalmia Forest** inhabits higher-elevation, less fertile sites than the **Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest**, and this is reflected by the predominance of *Quercus montana*, an evergreen, ericaceous shrub stratum dominated by *Kalmia latifolia* and lower species diversity. The latter type inhabits more fertile, but drier sites than the **Quercus montana/ Oxydendrum/Kalmia Forest**, situated on more exposed landforms. The codominance of *Quercus montana* and *Q. rubra* and abundance of *Rhododendron calendulaceum* and *Castanea dentata* in the **Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest** are at least partly indicative of the more fertile, lower-elevation conditions.

Although **Montane Oak Forests** are common throughout the Southern Appalachians there is only limited quantitative information available for comparisons with the two community types described in this present study. The two **Montane Oak Forests** types is this study correspond closely to descriptions of *Quercus*-dominated communities found elsewhere in the Southern Appalachian region (Whittaker 1956, McLeod 1988, Schafale & Weakley 1990, Chapter 5).

Table 4.39. Average cover class and constancy of species present in the **Montane Oak Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 4.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	9.		9.1		9.2	
Number of plots:	14		9		5	
Homoteneity:	0.691		0.695		0.794	
	Cov	Con	Cov	Con	Cov	Con
Species						
ABIES FRASERI*	1	7	1	11		
ACER PENSYLVANICUM	2	93	2	89	2	100
ACER RUBRUM VAR RUBRUM	7	100	7	100	7	100
ACER SACCHARUM VAR SACCHARUM	2	29	2	33	2	20
AGERATINA ALTISSIMA VAR ROANENSIS	1	7	1	11		
AGROSTIS PERENNANS	1	29	1	22	2	40
AMELANCHIER LAEVIS	2	93	2	89	2	100
AMIANTHIUM MUSCAETOXICUM	1	7	1	11		
AMPHICARPAEA BRACTEATA	1	7			1	20
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	1	14	1	22		
ARALIA RACEMOSA VAR RACEMOSA	1	7	1	11		
ARISTOLOCHIA MACROPHYLLA	2	50	2	33	1	80
ARISAEMA TRIPHYLLUM	1	7			1	20
ASTER CHLOROLEPIS	2	7	2	11		
ASTER CORDIFOLIUS	1	14	1	11	1	20
ASTER DIVARICATUS	1	79	1	67	1	100
ASTER LATERIFLORUS VAR LATERIFLORUS	1	7			1	20
ASTER MACROPHYLLUS	2	29	2	33	2	20
ASTER UNDULATUS	1	21			1	60
AUREOLARIA FLAVA	1	7	1	11		
AUREOLARIA LAEVIGATA	2	71	1	78	2	60
BETULA LENTA	3	71	4	78	1	60
BOTRYCHIUM BITERNATUM	1	14			1	40
BRACHYELYTRUM ERECTUM	1	7			1	20
CAMPANULA DIVARICATA	2	7			2	20
CAREX COMMUNIS	2	21	2	22	2	20
CAREX DIGITALIS	1	64	1	56	2	80
CAREX LUCORUM VAR AUSTROLUCORUM*	3	29	5	22	2	40
CAREX NIGROMARGINATA	2	7	2	11		
CAREX PENSYLVANICA	2	21	3	11	2	40
CAREX SWANII	2	14	2	11	1	20
CAREX VIRESCENS	1	21	1	11	1	40
CARYA ALBA	3	50	1	22	4	100
CARYA GLABRA	4	57	2	33	5	100
CARYA OVATA	4	7	4	11		
CASTANEA DENTATA	4	93	3	89	5	100
CHAMAELIRIUM LUTEUM	1	43	1	56	1	20
CHELONE GLABRA	2	7	2	11		
CHIMAPHILA MACULATA VAR MACULATA	1	93	1	89	1	100
CLEMATIS VIRGINIANA	2	7			2	20
CLETHRA ACUMINATA	1	7	1	11		

Group:	9.	9.1	9.2
	Cov/Con	Cov/Con	Cov/Con
CLINTONIA UMBELLULATA	2 21	2 33	
COLLINSONIA CANADENSIS	1 21	1 22	1 20
CONOPHOLIS AMERICANA	1 86	1 89	2 80
COREOPSIS MAJOR VAR RIGIDA	2 29	2 22	2 40
CORNUS FLORIDA	4 71	4 67	3 80
CYPRIPEDIUM ACAULE	1 7	1 11	
CYPRIPEDIUM PARVIFLORUM VAR PUBESCENS	1 7		1 20
DANTHONIA COMPRESSA	1 43	1 44	2 40
DENNSTAEDTIA PUNCTILOBULA	1 14	1 22	
DESMODIUM NUDIFLORUM	2 14		2 40
DICHANTHELIUM BOSCII	1 57	1 56	2 60
DICHANTHELIUM COMMUTATUM	2 29	1 11	2 60
DICHANTHELIUM DICHOTOMUM VAR DICHOTOMUM	2 36	1 11	2 80
DICHANTHELIUM DICHOTOMUM VAR 5 (=YADKINENSE)	2 7		2 20
DIOSCOREA QUATERNATA	1 79	1 67	1 100
DRYOPTERIS MARGINALIS	2 14	2 22	
EPIGAEA REPENS	2 7		2 20
ERIGERON PULCHELLUS VAR PULCHELLUS	2 21	1 11	2 40
EUONYMUS AMERICANA	1 7	1 11	
EUPHORBIA COROLLATA	1 7		1 20
FAGUS GRANDIFOLIA	3 29	2 33	6 20
FESTUCA SUBVERTICILLATA	2 7	2 11	
FRAXINUS AMERICANA	1 14	1 11	1 20
GALAX URCEOLATA	2 50	2 67	2 20
GALEARIS SPECTABILIS	2 7	2 11	
GALIUM CIRCAEZANS VAR CIRCAEZANS	1 29	1 11	1 60
GALIUM LATIFOLIUM	2 14	2 11	2 20
GENTIANA DECORA	1 86	1 89	1 80
GOODYERA PUBESCENS	1 79	1 100	2 40
HALESIA TETRAPTERA VAR MONTICOLA	4 93	4 89	3 100
HAMAMELIS VIRGINIANA	3 14	3 22	
HELIANTHUS STRUMOSUS	2 14		2 40
HIERACIUM PANICULATUM	1 64	1 44	2 100
HIERACIUM VENOSUM	1 7		1 20
HOUSTONIA PURPUREA VAR PURPUREA	2 64	2 44	2 100
HUPERZIA LUCIDULA	1 7	1 11	
HYPOXIS HIRSUTA	2 7		2 20
ILEX MONTANA	4 7	4 11	
KALMIA LATIFOLIA	4 93	5 89	4 100
LEUCOTHOE RECURVA	2 29	2 44	
LIGUSTICUM CANADENSE	2 14	2 11	1 20
LINDERA BENZOIN	2 7	2 11	
LIPARIS LILIIFOLIA	1 7	1 11	
LIRIODENDRON TULIPIFERA	3 57	3 56	3 60
LISTERA SMALLII	1 7	1 11	
LUZULA ACUMINATA	1 14	1 22	
LUZULA MULTIFLORA VAR CONGESTA*	2 36		2 100
LYONIA LIGUSTRINA VAR LIGUSTRINA	2 36	2 33	2 40
LYSIMACHIA QUADRIFOLIA	2 64	2 44	2 100
MAGNOLIA ACUMINATA	3 93	3 100	2 80
MAGNOLIA FRASERI	1 50	1 44	2 60
MAIANTHEMUM RACEMOSUM	2 50	1 22	2 100
MEDEOLA VIRGINIANA	2 64	2 89	1 20
MELAMPYRUM LINEARE	2 57	2 67	2 40
MELANTHIUM PARVIFLORUM	1 7	1 11	
MELANTHIUM VIRGINICUM	1 21	1 11	2 40

Group:	9.	9.1	9.2
	Cov/Con	Cov/Con	Cov/Con
MONOTROPA HYPOPITHYS	1 7		1 20
MONOTROPA UNIFLORA	1 21	1 22	1 20
NYSSA SYLVATICA	4 64	4 56	4 80
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	2 14	2 22	
OSTRYA VIRGINIANA VAR VIRGINIANA	4 7	4 11	
OXYDENDRUM ARBOREUM	6 100	6 100	5 100
PEDICULARIS CANADENSIS	2 29		2 80
PINUS STROBUS	1 7	1 11	
POA ALSODES	2 7		2 20
POA AUTUMNALIS	1 14	1 22	
POA CUSPIDATA	2 29		2 80
POLYGONATUM BIFLORUM VAR BIFLORUM	1 57	1 44	1 80
POLYPODIUM APPALACHIANUM	1 7	1 11	
POLYSTICHUM ACROSTICHOIDES	2 79	2 78	2 80
PORTERANTHUS TRIFOLIATUS	1 7		1 20
POTENTILLA CANADENSIS VAR CANADENSIS	2 36		2 100
PRENANTHES SP. #1	2 71	2 56	2 100
PROSARTES LANUGINOSUM	1 43	1 44	1 40
PRUNUS PENSYLVANICA	1 21	1 11	1 40
PRUNUS SEROTINA	1 43	1 44	1 40
PTERIDIUM AQUILINUM	2 21	2 11	2 40
PYCNANTHEMUM MONTANUM	2 50	2 22	2 100
PYRULARIA PUBERA	3 36	2 22	4 60
QUERCUS ALBA	2 36	1 11	2 80
QUERCUS COCCINEA VAR COCCINEA	4 29	1 11	5 60
QUERCUS MONTANA	6 100	7 100	6 100
QUERCUS RUBRA	6 93	5 100	6 80
QUERCUS VELUTINA	1 21	1 11	2 40
RANUNCULUS RECURVATUS	1 7		1 20
RHODODENDRON CALENDULACEUM	3 86	2 78	4 100
RHODODENDRON MAXIMUM	3 64	3 89	5 20
RHODODENDRON MINUS	2 14	2 22	
ROBINIA PSEUDOACACIA	3 86	2 78	3 100
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1 7		1 20
SASSAFRAS ALBIDUM	2 50	2 56	3 40
SILENE STELLATA	1 7	1 11	
SMILAX GLAUCA VAR GLAUCA	2 57	1 33	2 100
SMILAX HERBACEA	1 36	1 22	1 60
SMILAX ROTUNDIFOLIA	2 93	2 89	2 100
SOLIDAGO ARGUTA VAR CAROLINIANA	2 57	1 33	2 100
SOLIDAGO CURTISII	2 93	1 89	2 100
SOLIDAGO ERECTA	1 14	1 22	
SPHENOPHOLIS NITIDA	2 7		2 20
THELYPTERIS NOVEBORACENSIS	3 29	3 44	
TOXICODENDRON RADICANS	2 7		2 20
TSUGA CANADENSIS	4 86	4 100	3 60
UVULARIA PERFOLIATA	1 21	2 22	1 20
UVULARIA PUBERULA VAR PUBERULA	2 93	2 89	2 100
VACCINIUM CORYMBOSUM	2 36	2 33	2 40
VACCINIUM PALLIDUM	2 50	1 33	2 80
VACCINIUM SIMULATUM	1 7		1 20
VACCINIUM STAMINEUM	2 36	2 11	2 80
VIBURNUM ACERIFOLIUM	2 86	2 78	1 100
VICIA CAROLINIANA	2 7		2 20
VIOLA BLANDA	1 21	1 22	1 20
VIOLA HASTATA	2 57	2 56	2 60

Group:	9.	9.1	9.2
	Cov/Con	Cov/Con	Cov/Con
VIOLA ROTUNDIFOLIA	1 14	1 22	
VIOLA SORORIA	1 14	1 11	1 20
VITIS AESTIVALIS VAR AESTIVALIS	2 14	2 11	2 20
VITIS AESTIVALIS VAR BICOLOR	2 14	2 11	1 20
VITIS VULPINA	2 7	2 11	
ZIZIA TRIFOLIATA	2 86	1 78	2 100

Table 4.40. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Montane Oak Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

9. Montane Oak Forests

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	115.43	468.36	3.27	587.06	5.98	14.43	16.37	15.40
HALESIA TETRAPTERA VAR MONTICOLA	128.22	82.29	1.19	211.70	1.15	5.91	3.36	4.63
KALMIA LATIFOLIA	497.57	1375.31	0.00	1872.88	3.18	24.67	5.99	15.33
OXYDENDRUM ARBOREUM	45.04	144.12	0.00	189.15	2.64	4.72	7.28	6.00
QUERCUS MONTANA	3.87	62.81	22.99	89.66	9.08	2.05	22.09	12.07
QUERCUS RUBRA	11.13	75.01	22.99	109.13	8.45	2.91	22.07	12.49
RHODODENDRON MAXIMUM	51.85	204.35	0.00	256.20	0.78	7.48	2.39	4.94
ALL	1876.23	2895.14	59.66	4831.03	38.46	100.00	100.00	100.00

9.1 Quercus montana/Oxydendrum/Kalmia Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RURBUM	47.86	347.04	5.09	399.99	5.72	9.81	15.84	12.82
HALESIA TETRAPTERA VAR MONTICOLA	145.64	112.41	1.85	259.90	1.64	7.71	4.94	6.32
KALMIA LATIFOLIA	502.31	2007.65	0.00	2509.96	4.72	29.06	8.74	18.90
OXYDENDRUM ARBOREUM	40.43	169.91	0.00	210.33	3.15	5.35	8.64	6.99
QUERCUS MONTANA	3.24	81.39	24.07	108.70	8.08	2.42	19.65	11.03
QUERCUS RUBRA	12.22	99.91	20.37	132.50	8.15	3.53	22.49	13.01
RHODODENDRON MAXIMUM	76.39	287.96	0.00	364.35	1.11	10.83	3.50	7.17
ALL	1661.74	3489.59	61.57	5212.91	38.00	99.99	100.00	99.99

9.2 Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	237.05	686.73	0.00	923.78	6.45	22.73	17.33	20.03
CARYA GLABRA	15.38	120.96	0.00	136.35	3.60	3.20	8.88	6.04
KALMIA LATIFOLIA	489.04	237.12	0.00	726.15	0.40	16.76	1.03	8.90
OXYDENDRUM ARBOREUM	53.33	97.69	0.00	151.03	1.70	3.57	4.83	4.20
QUERCUS COCCINEA VAR COCCINEA	23.33	50.00	5.00	78.33	3.14	1.62	9.17	5.39
QUERCUS MONTANA	5.00	29.36	21.03	55.38	10.88	1.38	26.47	13.93
QUERCUS RUBRA	9.17	30.19	27.69	67.05	9.00	1.80	21.32	11.56
RHODODENDRON CALENDULACEUM	236.92	134.42	0.00	371.35	0.20	8.58	0.48	4.53
ALL	2262.31	1825.13	56.22	4143.65	39.28	100.00	100.00	100.00

Table 4.41. Vertical structure of woody species in the **Montane Oak Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

9. Montane Oak Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	6	5	
BETULA LENTA	1	1	2	1	
CARYA GLABRA	1	1	1	1	
CASTANEA DENTATA	1	2			
CORNUS FLORIDA	1	2	1		
HALESIA TETRAPTERA VAR MONTICOLA	1	2	2	1	
KALMIA LATIFOLIA	1	4			
NYSSA SYLVATICA	1	1	1		
OXYDENDRUM ARBOREUM	1	2	4	3	
QUERCUS COCCINEA VAR COCCINEA	1	1	1	1	
QUERCUS MONTANA	1	1	6	6	
QUERCUS RUBRA	1	1	4	4	
RHODODENDRON CALENDULACEUM	1	2			
RHODODENDRON MAXIMUM	1	2			
ROBINIA PSEUDOACACIA	1	1	1	1	
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	2	1		

9.1 Quercus montana/Oxydendrum/Kalmia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	2	6	6	
BETULA LENTA	1	1	3	2	
CASTANEA DENTATA	1	1			
CORNUS FLORIDA	1	1	1		
HALESIA TETRAPTERA VAR MONTICOLA	1	2	2	2	
KALMIA LATIFOLIA	1	4			
LIRIODENDRON TULIPIFERA	1	1	1		
MAGNOLIA ACUMINATA	1	1			
NYSSA SYLVATICA	1	1	1		
OXYDENDRUM ARBOREUM	1	2	4	3	
QUERCUS MONTANA	1	1	6	6	
QUERCUS RUBRA	1	1	5	5	
RHODODENDRON CALENDULACEUM	1	1			
RHODODENDRON MAXIMUM	1	2			
ROBINIA PSEUDOACACIA	1	1	1	1	
TSUGA CANADENSIS	1	3	2		

9.2 Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	6	5	
AMELANCHIER LAEVIS	1	1	1		
CARYA ALBA	1	1	2	2	
CARYA GLABRA	1	1	3	3	
CASTANEA DENTATA	1	4			
CORNUS FLORIDA	1	2			
FAGUS GRANDIFOLIA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	2			
KALMIA LATIFOLIA	1	4			
LIRIODENDRON TULIPIFERA	1	1			
NYSSA SYLVATICA	1	2	1		
OXYDENDRUM ARBOREUM	1	1	4	3	
PYRULARIA PUBERA	1	1			
QUERCUS COCCINEA VAR COCCINEA	1	1	3	3	
QUERCUS MONTANA	1	1	5	5	
QUERCUS RUBRA	1	1	3	3	
RHODODENDRON CALENDULACEUM	1	3			
RHODODENDRON MAXIMUM	1	1			
ROBINIA PSEUDOACACIA	1	1			
SMILAX ROTUNDIFOLIA	1	2			
TSUGA CANADENSIS	1	1			

Table 4.42. Average site information for the **Montane Oak Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 4.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**GMS**=garnet-mica schist, **MG**=mica gneiss, ?=unknown), Landform types (representing micro-scale topographic units) (**R**=ridge, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**LS**=lower-slopes, **MS**=mid-slopes).

9. Montane Oak Forests

	Group		
	9.	9.1	9.2
Site Characteristics:			
Elevation (m)	1190	1205	1162
Slope (o)	26	25	28
Aspect (o)	E-SW	SW-NW,NE	S-SW
Parent material	MG	GMS,MG	MG
Soil depth (cm)	40.2	43.2	34.4
Surface Substrate (%):			
Moss/Lichen	3	3	2
Wood	5	5	5
Rock	5	5	6
Organic Matter	86	87	84
Water	0	0	0
Topographic Characteristics:			
Relative slope (%)	58	60	55
LFI	0.19	0.17	0.24
TSI	-0.01	-0.03	0.01
Landform type	SS	SS	R,SS
Topographic position	LS,MS	LS,MS	LS,MS

4.5.10 VEGETATION CLASS: 10. Rich Cove and Slope Forests

The **Rich Cove and Slope Forests** vegetation class is well known throughout the Southern Appalachian Mountains for its diversity of tree species and herbaceous flora (Schafale and Weakley 1990). In Shining Rock this class codominates the mid- and lower-elevations in association with the **Montane Oak Forests**, typically inhabiting more fertile, lower-slope sites than the latter class (Figures 4.2, 4.3, 4.8, 4.9). This class represents 33% of the sites sampled and 35% of the area mapped (Appendices 2, 5). The **Rich Cove and Slope Forests** are mostly underlain by garnet-mica schist and mica gneiss however, this reflects the spatial distribution of parent material types in Shining Rock rather than an specific association with geologic type, with migmatite restricted to high-elevation areas of this landscape.

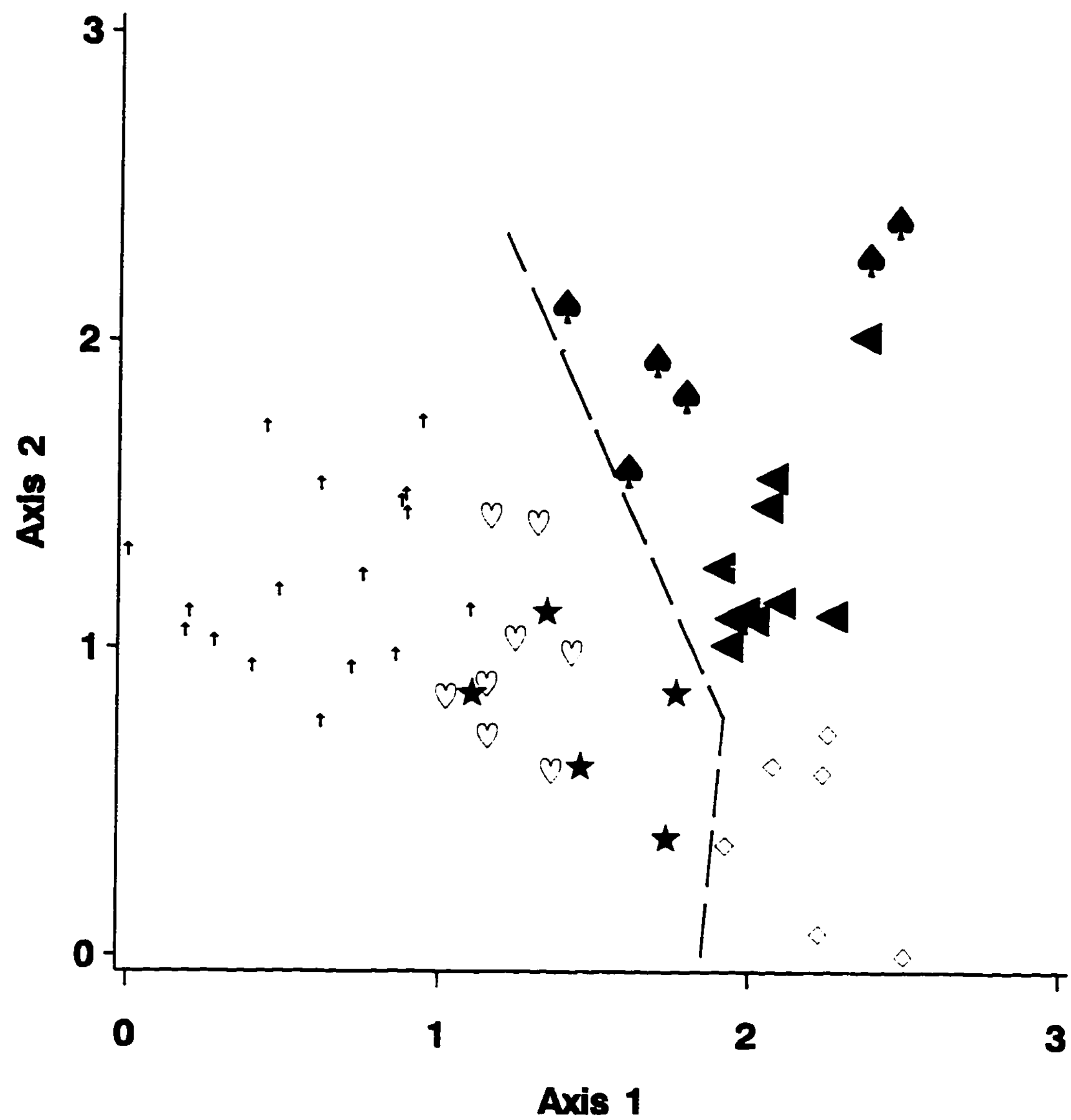
At Shining Rock the dominant tree species in this vegetation class include *Acer saccharum* var. *saccharum*, *Aesculus flava*, *Betula lenta*, *Carya glabra*, *Halesia tetraptera*, *Liriodendron tulipifera*, *Quercus rubra* and *Tilia americana* var. *heterophylla*. This vegetation class typically has high species at the larger spatial scales (Table 4.6).

Within the **Rich Cove and Slope Forests** vegetation class, individual community types are separated from each other along gradients of elevation, soil fertility, and distance to high-rainfall sources (Figures 4.12, 4.13). The **Liriodendron/Halesia Forest**, the **Quercus rubra-Carya glabra/Cornus florida Forest** and the **Quercus rubra-Halesia/Acer saccharum Forest** inhabit lower-elevation, finer-textured sites than the three remaining types. The **Quercus rubra-Carya glabra/Cornus florida Forest** and the **Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest** occur on more fertile soils (higher Mn, pH, lower Fe, N and organic matter) than the other four types. The **Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest** also has much higher P levels than the other types in this vegetation class (Table 4.4). The three high-elevation community types separate well from one another along soil fertility, site moisture and distance to Escarpment rainfall source gradients. The **Quercus rubra-Aesculus-Robinia**

pseudo-acacia/Ageratina Forest inhabits fertile, high-elevation, upper-slope sites furthest from the Escarpment rainfall source. At the opposing end of these gradients, the **Betula lenta-Robinia pseudo-acacia/Ageratina Forest** inhabits high-rainfall, moist (TMI), lower-slope sites and has siltier, more organic and infertile soils (highest Fe, N and lower pH) than other types in this class. Separation between the three remaining types is indistinct and these were reordinated separately in an attempt to clarify site differences.

Elevation, distance to rainfall source, slope position and soil nutrients separate the **Quercus rubra-Carya glabra/Cornus florida Forest**, the **Liriodendron/Halesia Forest**, and the **Quercus rubra-Halesia/Acer saccharum Forest** from one another (Figures 4.14, 4.15). The **Quercus rubra-Carya glabra/Cornus florida Forest** stands cover the broadest range of slope positions and elevations. Sites within this type tend to have more fertile (higher Mn) soils and be positioned further away from rainfall sources than stands in the two remaining types. The **Quercus rubra-Halesia/Acer saccharum Forest** sites are drier (TMI), less protected, higher in slope position and nearer rainfall-source areas than the **Liriodendron/Halesia Forest** stands.

Figure 4.12. DCA ordination diagram showing the distribution of the **Rich Cove and Slope Forests** class on the two major compositional gradients. Stands to the left of the dashed line were reordinated separately.



Community type:

- † 10.1 Quercus rubra – Carya glabra/Cornus florida Forest
- ♡ 10.2 Liriodendron/Halesia Forest
- ★ 10.3 Quercus rubra – Halesia/Acer saccharum Forest
- ◇ 10.4 Betula lenta – Robinia pseudo acacia/Ageratina Forest
- ◀ 10.5 Tilia – Betula lenta Forest
- ♠ 10.6 Quercus rubra – Aesculus – Robinia pseudo acacia/Ageratina Forest

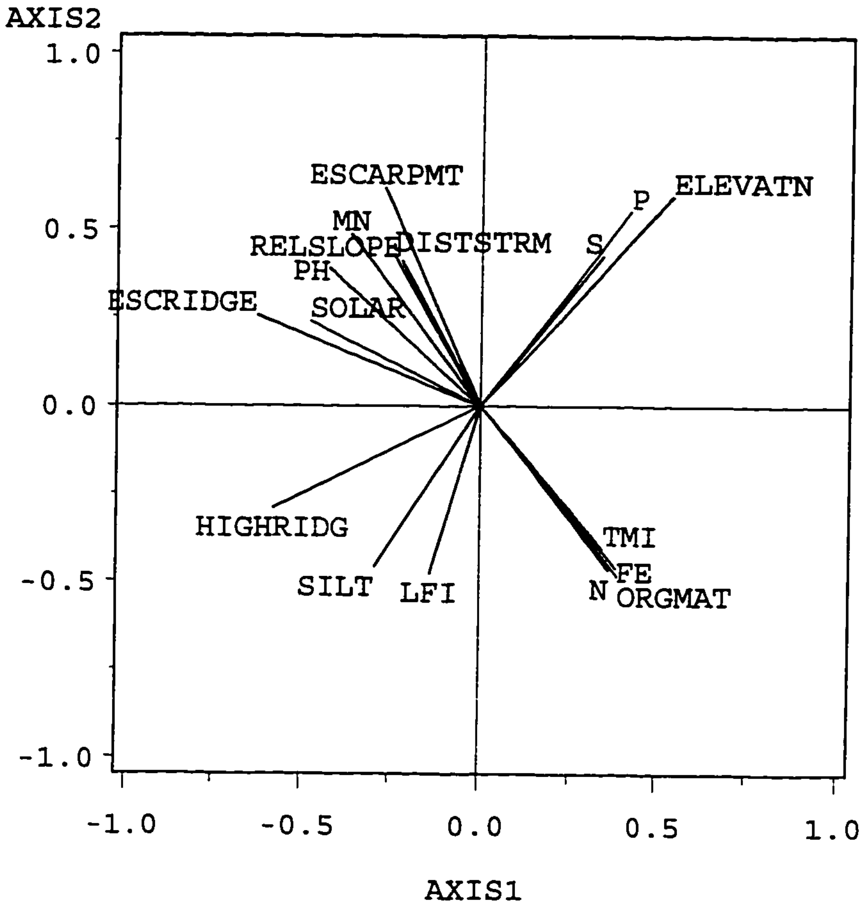
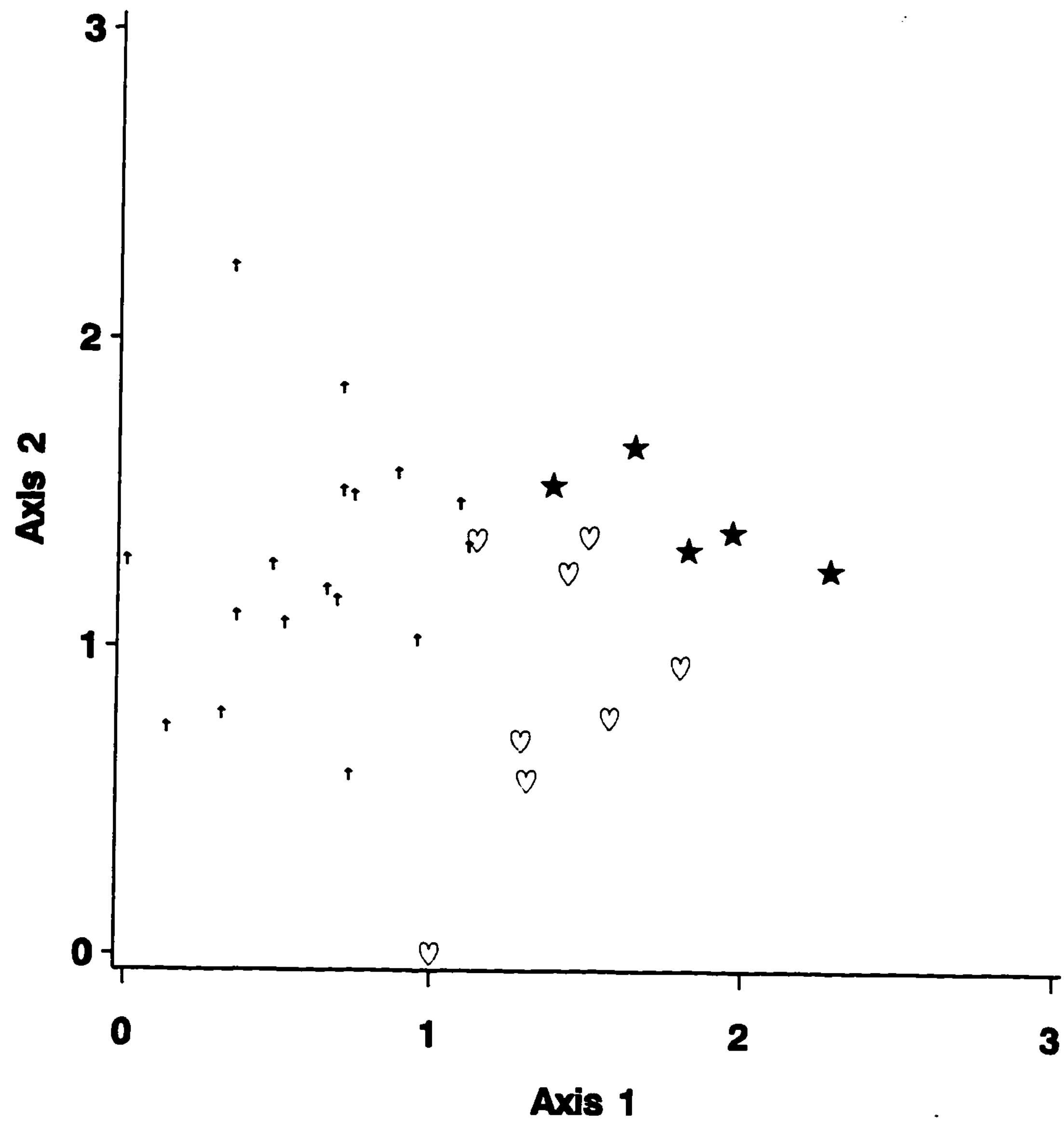


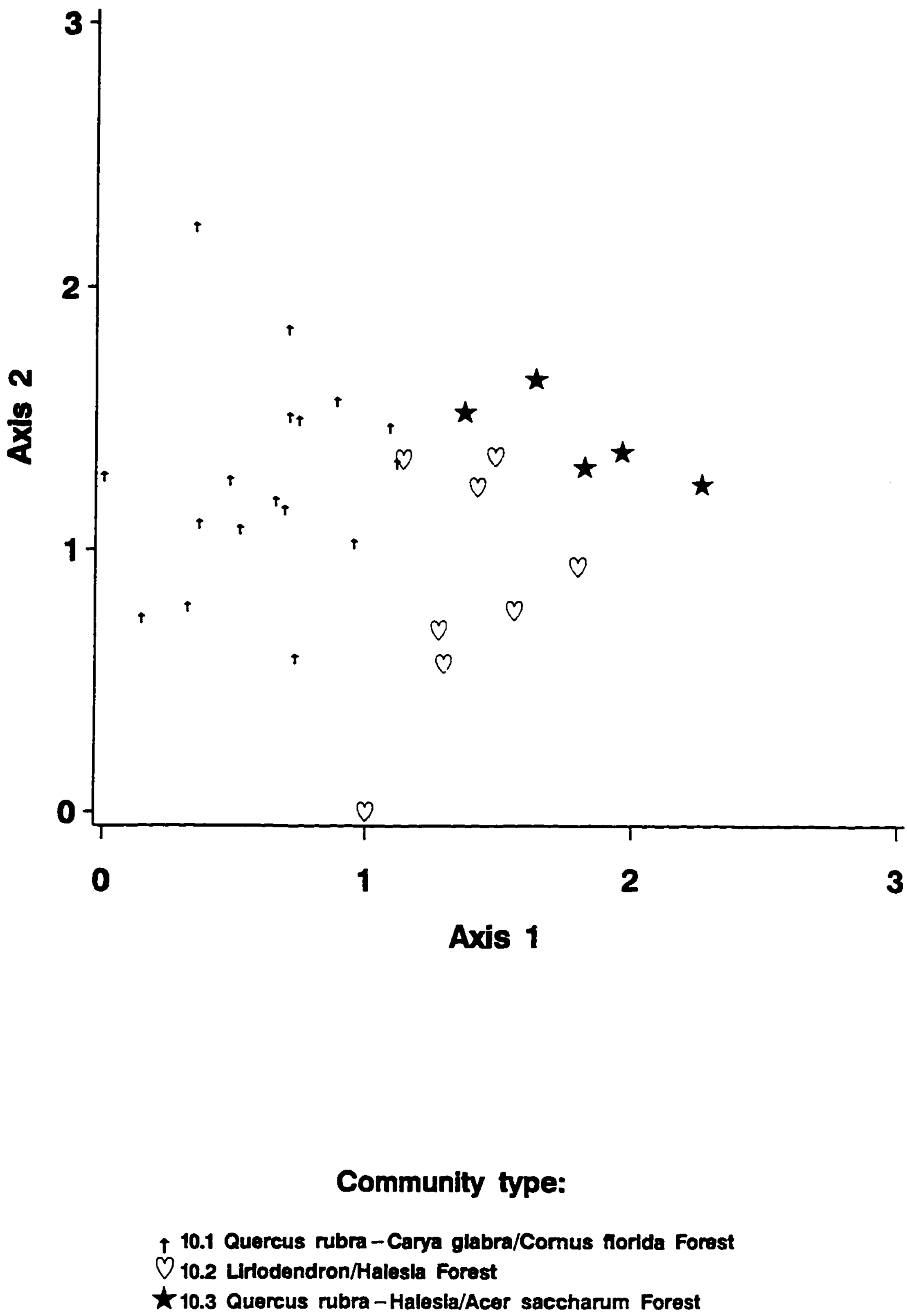
Figure 4.13. Vector diagram for DCA ordination of the **Rich Cove and Slope Forests** class showing association between species composition and major environmental gradients. DISTSTRM=distance downslope to cove, ESCARPMT=average distance to Escarpment region, HIGHRIDG=distance to nearest high-elevation area, ESCRIDGE=ESCARPMT xHIGHRIDG, RELSLOPE=relative slope position, with increasing values corresponding to higher position. Small LFI values represent unprotected upper-slopes progressing through to high values representing sheltered, lower-slopes and coves. Small TMI values represent low site moisture potential while large values represent high site moisture.



Community type:

† 10.1 Quercus rubra – Carya glabra/Cornus florida Forest
♡ 10.2 Liriodendron/Halesia Forest
★ 10.3 Quercus rubra – Halesia/Acer saccharum Forest

Figure 4.14. DCA ordination diagram showing the distribution of the **Quercus rubra-Carya glabra/Cornus florida Forest**, the **Liriodendron/Halesia Forest**, and the **Quercus rubra-Halesia/Acer saccharum Forest** in the <u>Rich Cove</u> **and** <u>Slope Forests</u> class on the two major compositional gradients.



3
2
1
0
Axis 2
0
1
2
3
Axis 1
Community type:
10.1 Quercus rubra – Carya glabra/Cornus florida Forest
10.2 Liriodendron/Halesia Forest
10.3 Quercus rubra – Halesia/Acer saccharum Forest

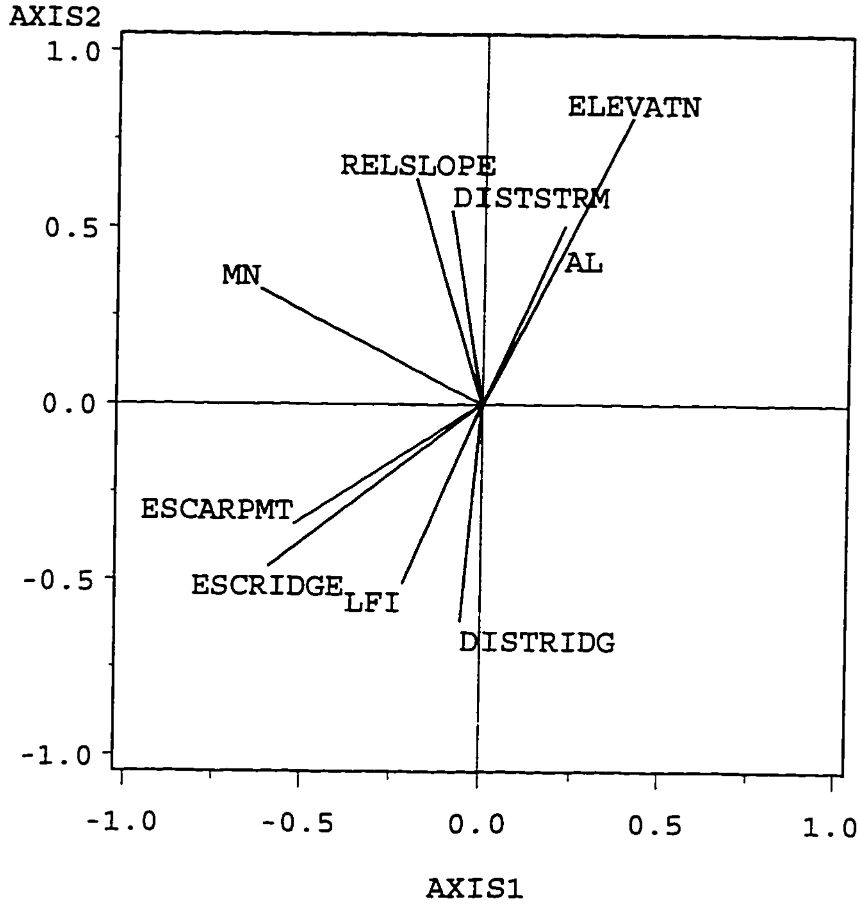


Figure 4.15. Vector diagram for DCA ordination of the **Quercus rubra-Carya glabra/ Cornus florida Forest**, the **Liriodendron/Halesia Forest**, and the **Quercus rubra-Halesia/Acer saccharum Forest** in the **Rich Cove and Slope Forests** class showing association between species composition and major environmental gradients. DISTRIDG =distance to ridge, DISTSTRM=distance downslope to cove, ESCARPMT=mean distance to Escarpment region, ESCRIDGE=ESCARPMTx distance to nearest high-elevation area (HIGHRIDG), RELSLOPE=relative slope position, with increasing values corresponding to higher position. Small LFI values=unprotected upper-slopes, high values= sheltered, lower-slopes and coves. Increasing TMI values represent greater site moisture potential.

COMMUNITY TYPE: Quercus rubra-Carya glabra/Cornus florida Forest (10.1)

Synonymy

Montane Oak--Hickory Forest (Schafale & Weakley 1990), Red Oak-Pignut Hickory Forest (Whittaker 1956), Mixed Oak-Hickory Type p.p. (Cooper & Hardin 1970).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Amelanchier laevis*, *Aristolochia macrophylla*, *Arisaema triphylla*, *Aster divaricatus*, *Betula lenta*, *Carex digitalis*, *Carya glabra*, *Castanea dentata*, *Collinsonia canadensis*, *Conopholis americana*, *Cornus florida*, *Dioscorea quaternata*, *Fraxinus americana*, *Galium circaezans*, *Halesia tetraptera* var. *monticola*, *Houstonia purpurea* var. *purpurea*, *Lysimachia quadrifolia*, *Magnolia acuminata*, *Maianthemum racemosum*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Potentilla canadensis* var. *canadensis*, *Prenanthes* species, *Prosartes lanuginosum*, *Pycanthemum montanum*, *Quercus montana*, *Quercus rubra*, *Robinia pseudo-acacia*, *Smilax herbacea*, *Smilax rotundifolia*, *Solidago curtisii*, *Zizia trifoliata*.

Listed species

Carex lucorum var. *austrolucorum*, *Carex manhartii*, *Carex woodii*, *Luzula multiflora* var. *congesta*, *Panax quinquefolius*.

Physiognomy

The canopy (mean height 28 m, SD 4.2 m) of this community type is dominated by three species, large-diameter *Quercus rubra* (stems mostly 40 to 63 cm), *Acer rubrum* and *Carya glabra*. *Q. montana* is also abundant in most sites. The presence of *Liriodendron* and *Carya alba* varies between sites (Tables 4.43, 4.44, 4.45). *Acer rubrum* dominates the lower strata in conjunction with *Halesia tetraptera*. The shrub stratum is open and dominated by *Cornus florida* in association with *Acer pensylvanicum* and lower levels of

Acer saccharum and *Castanea dentata*. The forest floor is a little rocky and moderately lush, covered in a diverse range of sparsely distributed species. Species with high constancy include; *Aristolochia macrophylla, Arisaema triphylla, Aster divaricatus, Carex digitalis, Collinsonia canadensis, Conopholis americana, Dioscorea quaternata, Galium circaezans, Houstonia purpurea* var. *purpurea, Lysimachia quadrifolia, Maianthemum racemosum, Polygonatum biflorum* var. *biflorum, Polystichum acrostichoides, Potentilla canadensis* var. *canadensis, Prenanthes* species, *Prosartes lanuginosum, Pycanthemum montanum, Smilax herbacea, Smilax rotundifolia, Solidago curtisii* and *Zizia trifoliata*. The diversity of this stratum is also augmented by a range of species restricted to a limited number of sites.

Compositional variation within this community type reflects the presence of two sub-types.

Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type (10.1.1)
Synonymy: Basic Oak--Hickory Forest p.p. (Schafale & Weakley 1990), Mixed Oak, Yellow Poplar, Hickory Forest (McLeod 1988), Mesic Oak-Hickory Forest (Patterson 1994), *Carya alba-Quercus alba/Cornus florida/Polystichum* Forest p.p. (Chapter 5).

Quercus rubra and *Liriodendron tulipifera* codominate the canopy with *Carya glabra* and *Acer rubrum* also abundant (Tables 4.43, 4.44, 4.45). While *Q. rubra* is consistently the canopy (co)dominant throughout this sub-type, the abundance of the other canopy species varies. *Liriodendron* typically dominates toeslopes and alluvial stands, sometimes in association with *Carya glabra*. However, the former species has limited distribution in the slope and lower-ridge stands where *Magnolia acuminata* and *Q. rubra* are abundant along with variable levels of *Carya alba* and *Carya glabra*. In all sites *Halesia* dominates the subcanopy and the tiers below, with a scattered *Cornus florida* and *Hamamelis virginiana* shrub layer. The forest floor is lush and inhabited by a dense, but very diverse range of species. *Thelypteris noveboracensis* is the most abundant of these with *Potentilla canadensis* var. *canadensis* also common. *Carex lucorum* var. *austrolucorum* has high, but less consistent cover. The broad range of low-cover, highly constant species includes; *Aristolochia macrophylla*, *Arisaema triphyllum*, *Aster divaricatus*, *Aster undulatus*, *Carex digitalis*, *Collinsonia canadensis*, *Conopholis americana*, *Dichanthelium boscii*, *Dioscorea quaternata*, *Erigeron pulchellus* var. *pulchellus*, *Galium circaezans*, *Houstonia purpurea* var. *purpurea*, *Lysimachia quadrifolia*, *Maianthemum racemosum*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Prosartes lanuginosum*, *Pycnanthemum montanum*, *Smilax herbacea*, *Smilax rotundifolia*, *Solidago curtisii*, *Viola hastata*, *Viola sororia* and *Zizia trifoliata*.

Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanica sub-type (10.1.2)
Synonymy: Mesic Oak-Hickory Forest p.p. (Patterson 1994).

Large-diameter *Quercus rubra* form the canopy of this sub-type in association with *Carya glabra* (Tables 4.43, 4.44, 4.45). *Q. montana* is less abundant, while *Carya alba* is present only in some sites. *Carya glabra* has greater abundance than *Q. rubra* on some dry, southeast-facing slopes, while *Betula lenta* dominates two west- and north-facing sites. *Acer rubrum* is the major subcanopy species with an understory of *Acer saccharum* var. *saccharum*, *Cornus florida* and *Halesia tetraptera*. The latter three species form a distinctive shrub stratum in association with *Acer pensylvanica* and scattered *Smilax rotundifolia*. *Aristolochia macrophylla* dominates the forest floor which is typically inhabited by a diverse range of highly consistent, low-cover species, including; *Arisaema triphyllum*, *Carex digitalis*, *Conopholis americana*, *Dioscorea quaternata*, *Galium circaezans*, *Goodyera pubescens*, *Houstonia purpurea* var. *purpurea*, *Lysimachia quadrifolia*, *Maianthemum racemosum*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Prosartes lanuginosum*, *Pycnanthemum montanum*, *Smilax herbacea*, *Solidago curtisii*, *Uvularia perfoliata* and *Zizia trifoliata*.

Habitat and Distribution

The **Quercus rubra-Carya glabra/Cornus florida Forest** is distributed across a broad range of elevations, inhabiting mid- and lower-slopes, toe slopes and alluvial terraces

(Figures 4.12-4.15, Table 4.46). The two sub-types in this community type differ in soil characteristics (fertility, texture and depth), slope position, orientation and elevation. The ***Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type*** occurs south of Stairs Mountain, inhabiting lower-elevation (945 to 1174 m range, 1061 m average), lower-slopes, lower-slope ridges, toeslopes and alluvial terraces (Table 4.46). Sites vary in slope with respect to landform type (4-35° range, mean of 17°, SD 12°) and are mostly south-to-southwest-facing. The ***Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type*** has deep, fine-textured, infertile soils in comparison to the other sub-type, with lowest sand and clay and highest silt content of any **Rich Cove and Slope Forests** type or sub-type (Tables 4.4, 4.5). Stands are mostly underlain by mica gneiss.

The ***Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanica sub-type*** is distributed north of Shining Rock Gap on east-to-southwest-facing mid-slopes (19-38° slope range, 29° average, SD 6°) at elevations between 1006 and 1590 meters (mean of 1255 m, SD 166 m; Table 4.46). The two steepest sites have high rock surface substrate, in contrast to other sites in this sub-type. Thirty percent of sites are underlain by mica gneiss, 20% by garnet-mica schist and 50% have unknown geology. The soils are moderately coarse-textured, with highest Cu and Mn levels in the **Rich Cove and Slope Forests** class (Tables 4.4, 4.5). The high fertility of soils in this sub-type is reflected by having highest Mn values of any group in this study and pH levels surpassed only by the **Liriodendron/ Halesia Forest**.

Distinguishing Features

At the community type-level, the **Quercus rubra-Carya glabra/Cornus florida Forest** shares highest richness levels all spatial scales $\geq 0.1 m^2$ with the **Liriodendron/ Halesia Forest**, in comparison to all other forest community types in this study (Table 4.6). However, at the sub-type-level, the ***Quercus rubra-Liriodendron-Carya glabra/***

Hamamelis-Cornus florida sub-type has the highest diversity of any type or sub-type in this study at all but the three smallest scales. High numbers of forest floor species at least partly account for this diversity.

The ***Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanica sub-type*** has highest density of ≥40 cm stems (mostly all *Quercus rubra*) of any community type or sub-type in the four mid- and low-elevation vegetation classes (Tables 4.30, 4.34, 4.38, 4.42). However, the density of stems in this size class is much lower than those found in the **Quercus rubra-Picea/Carex pensylvanica Forest** in the **High-Elevation Mixed Hardwood Forests** vegetation class (Table 4.24).

The ***Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type*** is one of two forest groups in Shining Rock (co)dominated by *Liriodendron*. The other, the **Liriodendron/Halesia Forest** is the second type described in the **Rich Cove and Slope Forests** class. These two groups have marked compositional and environmental similarities, with both inhabiting lower-slopes, toeslopes and alluvial flats across a very similar elevational range (Tables 4.43, 4.44, 4.45). However, the ***Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type*** also inhabits lower-slope ridgelines and occurs on finer-textured, drier sites with higher Al, Cu and Mn than the **Liriodendron/Halesia Forest** (Figures 4.8, 4.9, Tables 4.4, 4.5). Site moisture differences between the two groups also relate to site orientation, with former sub-type occurring on dryer south-to-southwest-facing sites and the latter type inhabiting moister, northeast-to-east- and westerly-facing positions. These differences are reflected by *Liriodendron tulipifera* and *Quercus rubra* dominance, with higher *Liriodendron* abundances and lower *Quercus* levels in the more fertile, moister **Liriodendron/Halesia Forest**. The opposite pattern is visible in the dryer, less fertile ***Quercus rubra-Liriodendron-Carya glabra/ Hamamelis-Cornus florida sub-type***. The abundance of *Carya glabra* in the latter type also reflects the drier site conditions.

Succession and Disturbance

The presence of charcoal in the soil reflects past disturbance by fire in

41% of sites in this type, while historic records suggest that 41% of stands were burned in 1925 and 29% in 1942. All stands have been logged, with 43% of the stands in the ***Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type*** cleared for cultivation or pasture (USFS *unpub. data*).

Chestnut sprouts have high constancy in this type, concentrated mostly in the ***Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanica sub-type.*** Fifty percent of the sites in this sub-type contain more than one large-diameter chestnut stump, with four present within one 0.1 ha site (stump diameters of 48 cm, 75 cm, 80 cm, 100 cm). However, although sprouts are less abundant in the ***Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type***, each site contains at least one stump and/or log, (the largest stump measuring 140 cm in diameter; plot 332), suggesting that perhaps the disturbance regime following the chestnut demise has inhibited resprouting. Alternatively, this species may have historically been less abundant, or perhaps stands were dominated by a few, very large chestnut trees.

Summary stem information suggests that *Acer rubrum* will be a major species in the future canopy of both sub-types in this community type (Table 4.44). In the ***Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type***, extremely high *Halesia* saplings numbers suggest that this species will become the canopy dominant, with present canopy dominants, *Carya glabra*, *Liriodendron* and *Q. rubra* persisting only as minor components. In contrast, summary data suggests that *Acer saccharum* will become the dominant canopy species in the ***Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanica sub-type*** (Table 4.44). Sapling densities also indicate that *Q. rubra* will be maintained in the canopy of this sub-type with greater densities than the previous sub-type.

COMMUNITY TYPE: Liriodendron/Halesia Forest (10.2)

Synonymy

Rich Cove Forest (Schafale & Weakley 1990), Cove Hardwoods Forest (Whittaker 1956), Successional Hardwood Forest p.p. (Racine & Hardin 1975), Cove Hardwoods (Pittillo & Smathers 1979), Upper Cove Hardwoods (Lorimer 1980), Yellow Poplar (Callaway *et al.* 1987), Oak, Mixed Mesic Forest (McLeod 1988), Cove Forest p.p. (Patterson 1994), Liriodendron tulipifera-Tilia americana var. heterophylla-Aesculus flava-Fagus grandifolia/Tiarella Forest p.p. (Chattooga Ecological Classification Team, draft 1995), [*Liriodendron-Carya glabra* Forest] (Chapter 3).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Aesculus flava*, *Aristolochia macrophylla*, *Arisaema triphylla*, *Aster divaricatus*, *Betula lenta*, *Botrychium virginianum*, *Carex digitalis*, *Carex digitalis*, *Carya glabra*, *Caulophyllum thalictroides*, *Cornus florida*, *Dioscorea quaternata*, *Fraxinus americana*, *Galium circaezans*, *Galium triflorum*, *Halesia tetraptera* var. *monticola*, *Liriodendron tulipifera*, *Magnolia acuminata*, *Maianthemum racemosum*, *Medeola virginiana*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Prosartes lanuginosum*, *Quercus rubra*, *Smilax rotundifolia*, *Solidago curtisii*, *Thelypteris noveboracensis*, *Tilia americana* var. *heterophylla*, *Trillium erectum*, *Viola blanda*, *Viola hastata*.

Listed species

Carex lucorum var. *austrolucorum*, *Carex manhartii*, *Luzula multiflora* var. *congesta*, *Panax quinquefolius*.

Physiognomy

Large-diameter *Liriodendron tulipifera* (40 to 67 cm) dominate the tall canopy (mean height 31.4 m, SD 3.6) of this community type (Tables 4.43, 4.44, 4.45). *Betula lenta* is also abundant with the cover of *Acer rubrum*, *Acer saccharum*, *Carya glabra* and *Halesia tetraptera* varying between sites. *Tsuga*, *Robinia* and *Betula alleghaniensis* are present at some sites. *Halesia* dominates the subcanopy and lower strata. Shrub density varies between sites, but is mostly dominated by *Halesia*, *Cornus florida*, *Acer rubrum* with more limited *Acer pensylvanicum* abundance. The forest floor is lushly covered by a diverse assemblage of species (Table 4.43). *Thelypteris noveboracensis* and *Viola blanda* are the most abundant species with *Aristolochia macrophylla*, *Arisaema triphylla*, *Aster divaricatus*, *Botrychium virginianum*, *Carex digitalis*, *Caulophyllum thalictroides*, *Dioscorea quaternata*, *Galium circaezans*, *G. triflorum*, *Maianthemum racemosum*, *Medeola virginiana*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Prosartes lanuginosum*, *Smilax rotundifolia*, *Solidago curtisii*, *Trillium erectum* and *V. hastata* also present with more limited cover. Dominance of the ground species varies by site with *Thelypteris noveboracensis* and *Dennstaedtia punctilobula* dominating the dryer, mid-slope sites and *V. blanda* most abundant on the alluvial terrace site.

Habitat and Disturbance

This community type ranges from 957 to 1182 m in elevation (mean of 1082 m, SD 75), inhabiting northeast-to-east- and west-facing, lower-slopes, coves, river terraces and toeslopes (7-28° slope range, mean of 18°; Table 4.46). The 80% of stands with known geology occur over mica gneiss. The soils are moderately coarse-textured, high in Ca, Cu and Mn (Tables 4.4, 4.5). The **Liriodendron/Halesia Forest** has highest base saturation, K, Mg and pH and lowest Al values in comparison to the other **Rich Cove and Slope Forests** types. This type has highest pH and base saturation levels of any type or sub-type in the study (Figures 4.14, 4.15).

Distinguishing Features

This type inhabits, on average, lower-elevations than any other type in the study (Tables 4.10, 4.14, 4.18, 4.22, 4.26, 4.30, 4.34, 4.38, 4.42, 4.46, 4.50). The **Liriodendron/ Halesia Forest** is also the tallest forest in this study and only type dominated by *Liriodendron tulipifera*. The size and dominance of *Liriodendron* trees is reflected by the fact that this group has the highest density of stems ≥40 cm of any **Rich Cove and Slope Forests** type (Table 4.44). The **Liriodendron/Halesia Forest** has high species diversity (Table 4.6), with forest floor species accounting for much of this diversity.

Succession and Disturbance

Records suggest that only 33% of sites in the **Liriodendron/Halesia Forest** were burned in both major fires. Three sites were probably cultivated with the remaining sites logged (USFS *unpub. data*). The presence of past human habitation was visible in one site (plot 344). Site fertility probably made these sites prime targets for both logging and cultivation. Sites adjacent to streams may be subject to occasional surface flooding. Chestnut stumps or logs are absent from all stands in this community type.

There are few *Liriodendron* saplings in this type (Table 4.44). *Liriodendron* is a shade intolerant species and requires canopy openings for establishment (Lorimer 1980, McLeod 1988). Such conditions may be periodically created as the present canopy ages and individual trees senesce. Summary data suggests that *Halesia* and *Acer rubrum* will gain dominance of the canopy.

COMMUNITY TYPE: Quercus rubra-Halesia/Acer saccharum Forest (10.3)

Synonymy

Montane Oak--Hickory Forest p.p. (Schafale & Weakley 1990), *Acer saccharum-Halesia* variant of Cove Hardwoods Forest (Whittaker 1956), Cove Hardwoods p.p. (McLeod

1988), *Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris* Forest p.p. (Chapter 5), *Quercus rubra-Halesia/Thelypteris* Forest (Chapter 5).

Constant species

Acer pensylvanicum, Acer rubrum var. *rubrum, Acer saccharum* var. *saccharum, Aesculus flava, Ageratina altissima* var. *roanensis, Arisaema triphylla, Carex digitalis, Carex pensylvanica, Caulophyllum thalictroides, Dichanthelium boscii, Dioscorea quaternata, Halesia tetraptera* var. *monticola, Magnolia acuminata, Magnolia fraseri, Prenanthes* species, *Prunus pensylvanica, Quercus rubra, Robinia pseudo-acacia, Smilax herbacea, Smilax rotundifolia, Solidago curtisii, Thelypteris noveboracensis, Tsuga canadensis, Viola blanda, Viola hastata, Viola rotundifolia.*

Listed species

Allium burdickii, Galium lanceolatum.

Physiognomy

Large *Quercus rubra* (40-48 cm diameter stems) dominate the tall canopy (mean height 28m, SD 6.2 m) of this community type in conjunction with *Acer saccharum* and *Halesia tetraptera* (Tables 4.43, 4.44, 4.45). Although present in the canopy of all plots, *Acer rubrum, Magnolia acuminata* and *Robinia pseudo-acacia* abundance varies between stands. *Tilia, Quercus montana, Fagus* and *Betula lenta* are canopy components in only some sites. *Acer saccharum* and *Halesia* dominate the subcanopy and lower strata, forming a scattered shrub layer in association with *Acer pensylcanicum. Fagus* is present in the understory of some stands. *Carex pensylvanica* is typically the most abundant forest floor species (cover 6), with more limited but abundant cover, provided by *Ageratina altissima* and *Thelypteris noveboracensis*. The abundance of these three species varies with landform position and moisture regime. *Ageratina* dominates the moister, lower-slope sites, whereas *Carex pensylvanica* has overwhelming dominance on the dryer, mid-slope sites. *Thelypteris* is the major species on the dry ridge site. There is a diverse range of highly constant, low-cover species present, including; *Arisaema triphylla, Carex digitalis, Caulophyllum thalictroides, Dichanthelium boscii, Dioscorea quaternata, Prenanthes* species, *Smilax herbacea, Smilax rotundifolia, Solidago curtisii, Viola blanda, V. hastata* and *V. rotundifolia*.

Habitat and Distribution

This community type inhabits a relatively restricted elevational range (1272-1385 m range, mean of 1329 m, SD 43 m), typically occurring on moderately sloped (8-37° range, mean 25°, SD 11°), east- and southwest-facing, mid- to lower-slopes south of Flower Knob (Table 4.46). This type also inhabits a ridge and off-ridge site. 80% of sites are underlain by mica gneiss.

The **Quercus rubra-Halesia/Acer saccharum Forest** has moderately coarse-textured and somewhat infertile soils in comparison to most **Rich Cove and Slope Forests** types. This type has high Al, low base saturation, Ca and Mg and lowest cation exchange capacity, Mn and P of any type in this vegetation class (Tables 4.4, 4.5).

Distinguishing Features

This type has the highest basal area measurements (44.09m^2) of any **Rich Cove and Slope Forests** community type (Table 4.44).

Succession and Disturbance

The relatively young canopy present (*Quercus rubra* generally aged 50 to 70 years) reflects past disturbance. Historic records indicate that all stands were burned in the 1925 fire with 60% burned in 1942. All sites were probably logged (USFS *unpub. data*). An old *Tsuga canadensis* (83 cm diameter aged 110 years; plot 435) reflects the fact that logging was not complete at some sites. Although there are no chestnut sprouts in this type, scattered chestnut logs in off-ridge and ridge sites suggest that this species was at least a minor canopy component of dryer sites.

Extreme abundance of *Halesia* saplings and presence of *Acer saccharum* saplings suggests that with time *Halesia* will dominate the canopy with *Acer* also present (Table 4.44).

COMMUNITY TYPE: Betula lenta-Robinia pseudo-acacia/Ageratina Forest (10.4)

Synonymy

Acidic Cove Forest p.p. (Schafale & Weakley 1990), Montane Alluvial Forest p.p. (Schafale & Weakley 1990), Rich Cove Forest p.p. (Schafale & Weakley 1990), Cove Hardwoods Forest p.p. (Whittaker 1956).

Constant species

Acer pensylvanicum, Acer rubrum var. *rubrum, Acer saccharum* var. *saccharum, Aesculus flava, Ageratina altissima* var. *roanensis, Arisaema triphylla, Aristolochia macrophylla, Betula alleghaniensis, Betula lenta, Polystichum acrostichoides, Prunus pensylvanica, Quercus rubra, Robinia pseudo-acacia, Solidago curtisii, Tsuga canadensis, Viola blanda, Viola rotundifolia.*

Physiognomy

Betula alleghaniensis and *B. lenta* are the major canopy species (27 m mean height, SD 4 m; Tables 4.43, 4.44, 4.45). Both species dominate mid- and lower-slope sites whereas those adjacent to water courses have a canopy dominated solely by *B. alleghaniensis. Robinia* is also present in the canopy with coverage of *Tilia americana* var. *heterophylla, Acer rubrum, Acer saccharum* and *Tsuga canadensis* varying between sites. *Aesculus flava* and *T. canadensis* are the most consistent understory species with *Halesia tetraptera* and *Rhododendron maximum* present in some sites. *Ilex montana* occurs in sites adjacent to streams. Understory density varies between sites, influencing forest floor species distribution. Ground species are widespread in sites with an open understory, but are restricted to small openings in sites with a dense understory. The forest floor is somewhat rocky, and *Ageratina* and *Viola blanda* are typically the most abundant species. *Arisaema triphylla*, *Aristolochia macrophylla*, *Polystichum acrostichoides*, *Solidago curtisii*, and *Viola rotundifolia* are present throughout with low abundance. *Leucothoe fontanesiana* densely carpets the forest floor at sites adjacent to streams.

Habitat and Distribution

The **Betula lenta-Robinia pseudo-acacia/Ageratina Forest** inhabits mid-elevations (elevational range of 1169-1394 m, mean 1295 m, SD 99 m), on relatively infertile, north-to-northeast-facing, mid- to lower-slopes and toeslopes adjacent to creeks (slope ranges from 12 to 34°, 24° mean, SD 9°; Table 4.46). The soils are medium-textured, typically low in Mn and P and have highest Fe, N, organic matter and lowest Al, base saturation, Ca, Cu, density and pH of any **<u>Rich</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** community type (Figures 4.14, 4.15, Tables 4.4, 4.5). The 50% of sites with known geology are mostly underlain by mica gneiss.

Distinguishing Features

The **Betula lenta-Robinia pseudo-acacia/Ageratina Forest** has the lowest species diversity at all scales measured in comparison to all other **<u>Rich</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** types (Table 4.6). The combination of the dense understory, dense *Leucothoe* cover at some sites and less fertile soils probably accounts for lower diversity.

Succession and Disturbance

Records suggest that all stands were burned in 1925 and 66% in 1942. All stands appear to have been logged, with two near areas cleared for a sawmill and switch yard (USFS *unpub. data*). Thirty three percent of all sites have one or two cut chestnut logs in the plot or local environs, indicating that chestnut was a minor component in some sites.

The lack of *Betula lenta* saplings and limited number of *Betula alleghaniensis* saplings suggests that this genus has a successional role in this community type. High

Halesia tetraptera sapling numbers, points to this species dominating the future canopy (Table 4.44).

COMMUNITY TYPE: Tilia-Betula lenta Forest (10.5)

Synonymy

Boulderfield Forest p.p. (Schafale & Weakley 1990), Rich Cove Forest (Schafale & Weakley 1990), Cove Hardwoods Forest (Whittaker 1956), Mixed Mesophytic Forest, Cove segregate (Cooper & Hardin 1970), Cove hardwood forests p.p. (Golden 1981), Basswood-buckeye forest p.p. (Callaway *et al.* 1987), Cove Hardwoods (McLeod 1988), *Acer saccharum-Fagus/Viola blanda* Forest p.p. (Chapter 5), *Liriodendron-Tilia/Asarum canadense* Forest p.p. (Chapter 5).

Constant species

Acer pensylvanicum, *Acer saccharum* var. *saccharum*, *Aesculus flava*, *Ageratina altissima* var. *roanensis*, *Arisaema triphylla*, *Athyrium asplenioides*, *Betula lenta*, *Botrychium virginianum*, *Caulophyllum thalictroides*, *Dioscorea quaternata*, *Galium triflorum*, *Impatiens pallida*, *Laportea canadensis*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Quercus rubra*, *Robinia pseudo-acacia*, *Solidago curtisii*, *Tilia americana* var. *heterophylla*, *Trillium erectum*, *Viola blanda*, *Viola rotundifolia*.

Listed species

Allium burdickii, *Carex manhartii*, *Hypericum mitchellianum*, *Luzula multiflora* var. *congesta*, *Panax quinquefolius*.

Physiognomy

The tall canopy (27 m mean height, SD 5.7 m) is dominated by large-diameter *Tilia americana* var. *heterophylla* in association with *Betula lenta*. *Betula alleghaniensis* has more limited abundance (Tables 4.43, 4.44, 4.45). The presence of *Acer saccharum* and *Aesculus flava* in the canopy varies between sites, but is consistently high in the subcanopy. *Halesia tetraptera* and the liana *Aristolochia macrophylla* are subdominant in the subcanopy at some sites. The highly scattered shrub layer is typically dominated by *Aesculus* and *Acer pensylvanicum*, with *Acer saccharum* less abundant. *Tsuga canadensis* and *Rhododendron maximum* are present in this stratum at some sites. Moss-covered rocks dominate the forest floor (28% rock and 20% moss surface substrate; Table 4.46) with *Ageratina altissima* var. *roanensis*, *Laportea canadensis* and *Viola blanda* dominant. The low-cover, highly-constant species in this stratum, include; *Arisaema triphylla*, *Athyrium asplenioides*, *Botrychium virginianum*, *Caulophyllum thalictroides*, *Dioscorea quaternata*, *Galium triflorum*, *Impatiens pallida*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Solidago curtisii*, *Trillium erectum*, *Viola blanda*, and *V. rotundifolia*.

Habitat and Distribution

This community type inhabits west-to-north-facing, concave lower-slopes and creek margins and western-facing slopes mostly south of Stairs Mountain (Figures 1.3, 4.14, 4.15). Slopes vary in steepness (8-34°, mean of 25°, SD 9.4°), reflecting topographic differences between the two landform types inhabited. Elevations range from 1142-1453 m (mean 1277, SD 109 m). Most sites are underlain by mica gneiss (Table 4.46).

One site (plot 458) is situated on a concave, mid-slope boulderfield. This site is dominated by *Betula alleghaniensis* and *Tilia*, with the liana *Aristolochia macrophylla* also present in the upper strata (all cover of 7). The ground is dominated by 1 to 2 m diameter, moss-covered boulders, with clumps of *Ageratina altissima*, the only dominant vascular species (cover 5), restricted to areas where soil can accumulate at the surface. This site has some resemblance to the *B. alleghaniensis* boulderfields described by Schafale and Weakley (1990) and Pittillo & Smathers (1979).

The **Tilia-Betula lenta Forest** has coarse-textured soils which are high in Fe, Mg and S in comparison to **Rich Cove and Slope Forests** averages (Tables 4.4, 4.5). This type has highest B, Ca, Cu, P and Zn levels in the **Rich Cove and Slope Forests** class. High nutrient status may be augmented by occasional flooding at sites adjacent to creeks.

Distinguishing Features

The **Tilia-Betula lenta Forest** is the only community type where *Tilia americana* var. *heterophylla* is the dominant canopy species. The size of these trees is reflected by the high density of stems ≥40 cm (Table 4.44). However, the low total basal area and the lowest total stem density measurements of any **Rich Cove and Slope Forests** type, emphasizes the openness of the strata below the canopy.

Succession and Disturbance

Records suggest that all stands were burned in the 1925 fire and 40% burned in 1942. All stands have probably been logged (USFS *unpub. data*). Field observations indicate that stands in this type are subjected to small-scale disturbance resulting from surface rock movement and movement by flooding in sites near creeks. Sites adjacent to creeks may have periodic siltation and water saturation during periods of flooding.

Limited *Betula* species saplings points to the future loss of this genera from the canopy (Table 4.44). Summary data indicates that *Tilia* will be maintained in the canopy, with increasing dominance by *Halesia* and *Aesculus*.

COMMUNITY TYPE: Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest (10.6)

Synonymy

Rich Cove Forest (Schafale & Weakley 1990), Cove Hardwoods Forest (Whittaker 1956).

Constant species

Acer pensylvanicum, Acer saccharum var. *saccharum, Aesculus flava, Ageratina altissima* var. *roanensis, Amphicarpaea bracteata, Arisaema triphylla, Aristolochia macrophylla, Aster chlorolepis, Botrychium virginianum, Cimicifuga racemosa, Collinsonia canadensis, Dioscorea quaternata, Fraxinus americana, Impatiens pallida, Maianthemum racemosum, Monarda clinopodia, Polygonatum biflorum* var. *biflorum, Polystichum acrostichoides, Prunus pensylvanica, Quercus rubra, Robinia pseudo-acacia, Sedum ternatum, Smilax herbacea, Solidago curtisii, Stachys latidens, Tradescantia subaspera, Viola blanda.*

Listed species

Panax quinquefolius.

Physiognomy

Quercus rubra, Aesculus flava, Robinia pseudo-acacia and *Prunus pensylvanica* are the four canopy tree species common to all six sites in this type (Tables 4.43, 4.44, 4.45). The mid-strata are extremely open, with only a sparse, scattered shrub layer present. The characteristically tall, dense, lush herbaceous stratum is dominated by between two and four species.

There are two variants of this community type. The first variant is dominated by large-diameter *Quercus rubra* (41-87 cm diameter) and *Aesculus*, with *Prunus pensylvanica, Robinia* and *Acer saccharum* either dominant as canopy, subcanopy or small-tree species (Tables 4.43, 4.44, 4.45). Sites within this variant (4 plots), typically have lush herbaceous cover dominated by *Collinsonia canadensis, Cimicifuga racemosa* and, in some sites, *Monarda clinopodia. Osmunda cinnamomea* dominates this stratum in one steep, rocky site. Woody debris (fallen and cut logs) are often present on the ground.

Robinia, dominates the open canopy of the second variant (plots 380, 388), in association with *Prunus pensylvanica* and *Quercus rubra. Acer saccharum* is present in the canopy of one site and in the small tree stratum of the other. The understory is open with only scattered *Crategus flabellata* shrubs emergent above the herbaceous stratum. This latter stratum is particularly tall (1.2-2 m) and dense, dominated by *Ageratina altissima* (cover of 8) with *Monarda clinopodia* and *Clematis virginiana* also abundant. Throughout sites in both variants *Amphicarpaea bracteata, Aristolochia macrophylla, Arisaema triphylla, Aster chlorolepis, Botrychium virginianum, Dioscorea quaternata, Impatiens pallida, Maianthemum racemosum, Polygonatum biflorum, Polystichum acrostichoides, Sedum ternatum, Smilax herbacea, Solidago curtisii, Stachys latidens, Tradescantia subaspera* and *Viola blanda* have low, but consistent cover.

Habitat and Distribution

This type is restricted to areas surrounding Deep Gap (Figure 1.4). Variant 1 inhabits moderately steep (25° mean slope), upper-sideslopes (Figures 4.2, 4.3) between 1424 and 1580 m on east-to-southeast-facing slopes (Table 4.46) between The Narrows and the *Quercus rubra* dominated ridge north of Deep Gap. Variant 2 extends south from Deep Gap along the broad ridge towards The Narrows, terminating as the ridge rises abruptly and becomes narrow, dry and rocky. This variant also dominates the cove at the head of Crawford Creek, immediately below Deep Gap. All stands are underlain by mica gneiss.

The **Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest** has coarse-textured soils with a high clay component (Table 4.5) and has the lowest silt and highest clay content of any forest community type in this study. Like other **Rich Cove and Slope Forests** types, the soils have high pH and base saturation levels (Table 4.4). In comparison to other types in this class this type has high cation exchange capacity and Mn levels, lowest Cu, K, Mg, Zn, organic matter, and highest P, S, and soil density values.

Distinguishing Features

This type is the third-most species-rich forest community type in the study at all spatial scales except the 0.1 ha scale (Table 4.6). However, this type has a very simple structure, consisting of a canopy and a herbaceous stratum, with each dominated by a limited number of species (Table 4.45). Much of the high diversity is attributable to the widely scattered, low-cover species hidden within the dense herbaceous stratum.

Succession and Disturbance

All stands were burned in 1925, but were not burned in 1945 (USFS *unpub. data*). The abundance of the successional *Robinia pseudo-acacia* and *Prunus pensylvanica* provides some indication for the intensity of past disturbance levels in this type. Cut stumps and logs indicate that variant 1 was logged, while the high levels of *R. pseudo-acacia* in variant 2 may also reflect past heavy logging (Schafale and Weakley 1990). However, although not indicated by historic records, the presence of scattered apple trees at Deep Gap and south along the adjacent ridgeline, provides evidence for past human inhabitance and suggests that variant 2 may have established on abandoned old fields. A similar *Robinia*-dominated gap community at Elk Pasture Gap (1300 m, Haywood Co., near Story Bald) shows evidence of being pastured (D. Danley *pers. comm.*). Cut *Castanea* stumps and logs, and sprouts provide some evidence for the past existence of this species in the second variant.

In variant 1 *Quercus rubra*, *Halesia*, *Fraxinus*, *Robinia pseudo-acacia* and *Aesculus flava* are well represented in the smaller stem size classes, suggesting the future dominance of these species in the canopy (Table 4.44). However, the absence of tree saplings in variant 2 is probably perpetuated by the very dense herbaceous layer present (see Graves 1995). Tree seedling establishment may only be possible when small-scale disturbances create openings in the dense herbaceous layer. The close proximity of the two variants suggests that the future canopy of variant 2 will contain a similar species range to variant 1.

Discussion

The **<u>Rich</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** are widespread throughout Shining Rock. This vegetation class has been widely documented by many authors (e.g., Braun 1950, Whittaker 1956, McLeod 1988, Schafale & Weakley 1990, Chapter 5). However, these studies have mostly briefly overviewed the range of dominant species in this class, and only a few have quantified the composition, structure and site conditions of different community types within this vegetation class (e.g., Whittaker 1956, Lorimer 1980, McLeod 1988, Patterson 1994, Chapters 3 & 5). The results of this present study provide additional quantified information on specific types within the **Rich Cove and Slope Forests** and highlights the compositional breadth of this vegetation class and range of site conditions it inhabits.

The broad elevational range of this vegetation class in Shining Rock corresponds to patterns described by Whittaker (1956), McLeod (1988) (also see Chapter 5). However, in Shining Rock this class is distributed across a wider range of topographic positions than has been previously suggested. While Schafale & Weakley (1990) suggest that **Rich Cove and Slope Forests** are restricted to lower-slopes and coves, this study has documented the presence of the **Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest** on upper-slopes and an adjacent gap and ridgeline. Similarly, I found the existence of a **Rich Cove and Slope Forests** type on upper-slopes and ridgelines at Linville Gorge (Chapter 3). Both the **Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest** and the **Carya glabra/Ageratina Forest** at Linville Gorge inhabit sites previously disturbed by logging (Chapter 3) with some sites in the former probably cultivated. Whereas the high topographic position of the **Carya glabra/Ageratina Forest** most likely reflects underlying bedrock (Chapter 3), explanations for the distribution of the **Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest** are less obvious, but may be the result of past cultivation.

The dominance of *Quercus rubra* in the canopy of several **Rich Cove and Slope Forests** types contrasts to descriptions of **Rich Cove and Slope Forests** elsewhere in the Southern Appalachian Mountains (e.g., Whittaker 1956, Golden 1974, McLeod 1988, Chapters 3 & 5). This may relate to the broader range of topographic positions and the less mesic conditions of sites inhabited by this vegetation class in Shining Rock.

High *Liriodendron*, *Betula* species, *Robinia pseudo-acacia* and *Prunus pensylvanica* cover in the canopies of **Rich Cove and Slope Forests** types reflects the extent of past disturbances and the present transitional state of these forests. Summary stem data suggest that *Halesia* and/or *Acer saccharum* will have a more dominant role in most types in the future (Table 4.44).

Table 4.43. Average cover class and constancy of species present in the **Rich Cove and Slope Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type and sub-type. Each group is represented by its abbreviation code. For full group names see Table 4.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
Number of plots:	52	17	7	10	8	5	6	10	6
Homotenity:	0.568	0.671	0.737	0.685	0.695	0.718	0.715	0.671	0.703
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species									
ACER PENSYLVANICUM	3 85	3 82	2 86	4 80	2 88	4 80	2 100	3 80	4 83
ACER RUBRUM VAR RUBRUM	5 88	6 100	6 100	6 100	5 100	5 100	4 100	4 60	4 67
ACER SACCHARUM VAR SACCHARUM	4 88	3 88	3 86	3 90	4 100	7 80	4 83	5 90	4 83
ACER SPICATUM	3 6							4 20	2 17
ACTAEA PACHYPODA	2 15				2 38	1 20	1 17	2 30	
ADIANTUM PEDATUM VAR PEDATUM	1 13	1 6		1 10	2 38			1 20	2 17
AESCULUS FLAVA	4 77	2 35	2 29	3 40	4 100	2 80	3 100	5 100	6 100
AGERATINA ALTISSIMA VAR ROANENSIS	3 83	2 71	2 71	1 70	2 63	3 100	3 100	4 90	4 100
AGRIMONIA GRYPOSEPALA	1 6	1 12	1 14	1 10				1 10	
AGROSTIS PERENNANS	1 12	1 6	1 14		1 25	2 40	1 17		
ALLIUM BURDICKII*	1 4					1 20		1 10	
ALLIUM TRICOCCUM	2 8							2 30	1 17
AMELANCHIER LAEVIS	2 58	2 88	2 86	3 90	1 63	2 60	2 50	2 20	4 33
AMPHICARPAEA BRACTEATA	2 35	2 47	2 43	2 50	2 63				2 83
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	2 27	2 18	2 43		2 63	2 40	2 33	2 20	
ANGELICA TRIQUINATA	2 4							2 10	1 17
ANTENNARIA PLANTAGINIFOLIA	2 4	2 12		2 20					
AQUILEGIA CANADENSIS	1 4								1 33
ARABIS CANADENSIS	2 10	2 6		2 10	2 38			1 10	
ARABIS LAEVIGATA VAR LAEVIGATA	1 25	1 29	1 29	1 30		2 40		1 30	2 50
ARALIA NUDICAULIS	5 2	5 6		5 10					
ARALIA RACEMOSA VAR RACEMOSA	2 31	1 35	2 29	1 40	2 50			2 20	2 67
ARISTOLOCHIA MACROPHYLLA	2 87	2 94	1 100	3 90	2 100	2 60	2 100	4 70	2 83
ARISTOLOCHIA SERPENTARIA	1 2	1 6		1 10					

Group:	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
ARISAEMA TRIPHYLLUM	2 94	2 88	2 86	1 90	2 100	2 80	2 100	2 100	2 100
ARNOGLOSSUM ATRIPLICIFOLIUM	1 15	2 29	1 57	3 10	1 13				1 33
ASARUM CANADENSE	2 4				1 13			3 10	
ASCLEPIAS EXALTATA	1 19	1 53	1 71	1 40		1 20			
ASCLEPIAS QUADRIFOLIA	1 2	1 6		1 10					
ASCLEPIAS VARIEGATA	1 10	1 12	1 29						1 50
ASPLENIUM MONTANUM	1 2						1 17		
ASPLENIUM PLATYNEURON	1 2				1 13				
ASTER ACUMINATUS VAR ACUMINATUS	2 19				2 13	3 40	2 67	2 20	2 17
ASTER CHLOROLEPIS	2 37	2 18		2 30		2 60	3 50	3 40	2 100
ASTER CORDIFOLIUS	1 15	2 24	1 29	2 20	1 13			1 30	
ASTER DIVARICATUS	2 56	2 76	2 100	2 60	2 100	2 20	2 33	2 50	
ASTER LATERIFLORUS VAR LATERIFLORUS	1 6	2 12	2 14	1 10		1 20			
ASTER MACROPHYLLUS	3 35	3 41	4 43	3 40	2 38	3 60	2 17	2 10	2 50
ASTER PATENS VAR PATENS	1 6	1 18		1 30					
ASTER RETROFLEXUS	1 12	1 18	1 43		2 25			1 10	
ASTER UNDULATUS	1 17	2 47	2 86	1 20			1 17		
ATHYRIUM ASPLENIOIDES	2 46	2 18		2 30	2 38	2 40	2 67	2 90	2 50
AUREOLARIA LAEVIGATA	1 2	1 6		1 10					
BETULA ALLEGHANIENSIS	4 42	1 12	1 29		4 50		6 100	4 70	2 50
BETULA LENTA	5 75	4 76	3 100	4 60	6 88	4 60	5 100	6 80	4 33
BOTRYCHIUM BITERNATUM	1 17	1 29	1 29	1 30	1 38	1 20			
BOTRYCHIUM VIRGINIANUM	1 58	1 53	2 57	1 50	2 75	1 20		1 80	1 100
BRACHYELYTRUM ERECTUM	2 21	1 29	1 14	2 40	2 38	2 20	2 17	2 10	
BROMUS PUBESCENS	2 19	2 18	2 14	2 20	2 25		2 17	2 20	2 33
CALYCANTHUS FLORIDUS VAR GLAUCUS	3 8	2 6	2 14		3 38				
CAMPANULASTRUM AMERICANUM	2 10	1 6		1 10					2 67
CAMPANULA DIVARICATA	1 10	1 29		1 50					
CARDAMINE CONCATENATA	2 4				1 13			2 10	
CARDAMINE DIPHYLLA	2 2				2 13				
CAREX SP.#1	1 2	1 6		1 10					
CAREX AESTIVALIS	1 31				1 25	1 60	2 67	2 60	1 17
CAREX APPALACHICA	1 21	1 6	1 14		1 25			1 50	1 50
CAREX AUSTROCAROLINIANA	5 2	5 6	5 14						
CAREX BLANDA	2 8	2 12	1 14	2 10	1 13			2 10	
CAREX COMMUNIS	1 19	1 41	1 14	2 60	1 13			1 20	
CAREX DIGITALIS	1 54	1 88	1 100	1 80	2 75	2 80		2 20	1 17
CAREX FLEXUOSA	1 13	1 18	2 29	1 10	1 13	2 20	2 17	1 10	
CAREX LUCORUM VAR AUSTROLUCORUM*	3 15	4 35	4 71	2 10	2 25				

Group:	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
CAREX LAXIFLORA VAR LAXIFLORA	2 27	2 35	2 29	2 40	1 63			2 20	1 17
CAREX MANHARTII*	1 13	2 6		2 10	2 25		1 17	1 30	
CAREX PENSYLVANICA	3 25				2 38	6 80	2 50	2 30	
CAREX PLANTAGINEA	2 2							2 10	
CAREX PLATYPHYLLA	1 2						1 17		
CAREX SCOPARIA VAR SCOPARIA	1 2								1 17
CAREX SWANII	1 8	1 24	1 29	1 20					
CAREX UMBELLATA	2 12	2 12	2 29		2 25			1 10	2 17
CAREX VIRESCENS	1 27	1 53	2 57	1 50	1 25	1 40	1 17		
CAREX WOODII*	5 2	5 6	5 14						
CARPINUS CAROLINIANA	1 2	1 6	1 14						
CARYA ALBA	3 35	4 53	4 86	5 30	3 50		2 33	1 20	3 17
CARYA CORDIFORMIS	2 10	3 12		3 20	2 25			2 10	
CARYA GLABRA	4 52	5 82	5 100	6 70	3 75			2 40	2 50
CARYA OVATA	3 4				4 13			2 10	
CASTANEA DENTATA	3 33	3 76	2 57	3 90	1 13				3 50
CASTANEA PUMILA VAR PUMILA	1 2				1 13				
CAULOPHYLLUM THALICTROIDES	2 63	2 41	1 43	2 40	2 88	2 80	1 50	2 80	2 67
CEANOTHUS AMERICANUS VAR AMERICANUS	2 2	2 6		2 10					
CHAMAELIRIUM LUTEUM	1 12	1 24	1 29	1 20	2 25				
CHELONE GLABRA	1 12				2 25		1 17	1 30	
CHIMAPHILA MACULATA VAR MACULATA	1 21	1 53	1 57	1 50	1 25				
CIMICIFUGA AMERICANA	1 2				1 13				
CIMICIFUGA RACEMOSA	3 56	2 47	2 29	2 60	2 38	2 40	1 50	3 70	4 100
CIRCAEA ALPINA VAR ALPINA	2 8				1 13			2 30	
CIRCAEA CANADENSIS	2 12	1 6	1 14		2 38				1 33
CIRSIUM DISCOLOR	2 2								2 17
CLEMATIS VIORNA	1 23	1 29	1 43	1 20	2 25			2 20	1 50
CLEMATIS VIRGINIANA	3 10	2 6	2 14						3 67
CLETHRA ACUMINATA	2 6						3 17	2 20	
CLINTONIA UMBELLULATA	2 27	2 47	1 57	2 40	2 25			2 30	2 17
COLLINSONIA CANADENSIS	2 60	2 76	2 100	2 60	2 63			2 70	3 100
CONOPHOLIS AMERICANA	2 56	2 94	2 100	2 90	1 50	2 60		1 20	2 67
COREOPSIS MAJOR VAR RIGIDA	2 6	2 18	2 14	2 20					
CORNUS ALTERNIFOLIA	3 12	2 6		2 10	1 13			2 10	3 50
CORNUS FLORIDA	4 44	4 82	4 86	5 80	4 88		1 17	2 10	
CORYLUS CORNUTA VAR CORNUTA	4 4	2 6		2 10	5 13				
CRATAEGUS MACROSPERMA	3 17	2 18	3 29	1 10	2 25			2 10	4 50
CUSCUTA SP. #1	1 8	1 6		1 10	1 13	1 20			1 17

Group:	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
CYPRIPEDIUM ACAULE	1 6	1 18	2 14	1 20					
CYPRIPEDIUM PARVIFLORUM VAR PUBESCENS	1 4								1 33
DANTHONIA COMPRESSA	1 19	1 41	1 71	1 20		1 40	1 17		
DENNSTAEDTIA PUNCTILOBULA	2 31	1 12	1 29		3 50	3 60	3 50	2 30	2 17
DEPARIA ACROSTICHOIDES	1 8							1 40	
DESMODIUM NUDIFLORUM	1 13	1 41	1 43	2 40					
DICHANTHELIUM ACUMINATUM VAR ACUMINATUM	1 2	1 6	1 14						
DICHANTHELIUM BOSCII	2 35	2 59	1 86	2 40	2 25	2 80			2 33
DICHANTHELIUM COMMUTATUM	1 13	1 29	2 29	1 30	1 25				
DICHANTHELIUM DICHOTOMUM VAR DICHOTOMUM	2 4	2 12	2 29						
DICHANTHELIUM LAXIFLORUM	1 2				1 13				
DICHANTHELIUM COMMUTATUM X LATIFOLIUM	1 2				1 13				
DICOT SP. #1	1 2	1 6		1 10					
DIOSCOREA QUATERNATA	2 81	2 94	2 100	2 90	2 100	1 80	1 17	2 80	2 83
DIOSPYROS VIRGINIANA	2 2	2 6		2 10					
DIPHYLLEIA CYMOSA	2 12				1 13			2 50	
DRYOPTERIS INTERMEDIA	1 8				2 13		1 17	1 20	
DRYOPTERIS MARGINALIS	2 15	2 29		2 50	2 13			3 10	2 17
ELYMUS HYSTRIX VAR HYSTRIX	2 2								2 17
ERIGERON PULCHELLUS VAR PULCHELLUS	2 25	2 47	2 86	3 20	1 63				
EUONYMUS AMERICANA	1 10	1 6		1 10	1 25			2 20	
EUONYMUS OBOVATA	2 8						2 33	1 20	
EUPATORIUM PURPUREUM	1 35	2 59	2 57	2 60	1 38	1 20	1 17	2 20	1 17
EUPHORBIA COROLLATA	2 2	2 6	2 14						
FAGUS GRANDIFOLIA	4 35	3 24	3 29	3 20	4 38	6 60	3 50	4 30	2 33
FESTUCA SUBVERTICILLATA	2 33	2 12		2 20	1 13	2 60	2 33	2 50	2 67
FRAXINUS AMERICANA	3 75	3 94	2 100	3 90	2 88	3 60	3 17	2 70	5 83
GALAX URCEOLATA	2 4	2 6		2 10		1 20			
GALEARIS SPECTABILIS	1 13	1 6	1 14		2 63				1 17
GALIUM CIRCAEZANS VAR CIRCAEZANS	2 62	2 82	2 86	2 80	2 75	2 40	1 33	1 50	2 50
GALIUM LANCEOLATUM*	1 2					1 20			
GALIUM LATIFOLIUM	2 8	2 24	2 14	1 30					
GALIUM TRIFLORUM	2 40				2 75	2 40	1 17	2 80	2 67
GENTIANA DECORA	1 15	1 29	1 43	1 20	2 25	1 20			
GERANIUM MACULATUM	1 13	1 18	1 29	1 10	2 25				2 33

Group:	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
GEUM CANADENSE	1 8				1 13				1 50
GOODYERA PUBESCENS	1 40	1 71	1 57	1 80	1 38	1 20	1 33	1 30	
HALESIA TETRAPTERA VAR MONTICOLA	5 75	4 82	5 100	4 70	5 88	6 100	6 67	4 70	6 33
HAMAMELIS VIRGINIANA	3 31	4 41	4 86	2 10	2 63	4 40		5 20	
HELIOPSIS HELIANTHOIDES VAR HELIANTHOIDES	2 2								2 17
HELIANTHUS MICROCEPHALUS	1 4	1 12	1 14	1 10					
HELIANTHUS RESINOSUS	1 2	1 6	1 14						
HELIANTHUS STRUMOSUS	2 15	2 47	1 57	2 40					
HERACLEUM LANATUM	2 2								2 17
HEUCHERA AMERICANA	1 8	1 18		1 30					1 17
HEUCHERA VILLOSA VAR VILLOSA	2 6	2 12		2 20				2 10	
HIERACIUM PANICULATUM	1 12	1 35	1 57	1 20					
HIERACIUM SCABRUM VAR SCABRUM	1 2	1 6	1 14						
HOUSTONIA PURPUREA VAR PURPUREA	1 50	1 94	2 86	1 100	1 63	2 60		1 10	1 17
HOUSTONIA SERPYLLIFOLIA	2 10	1 6	1 14		2 13	1 20		2 20	
HUPERZIA LUCIDULA	2 8	2 12	1 14	2 10	1 13			2 10	
HYDRANGEA ARBORESCENS	2 15	1 18	1 14	2 20				2 50	
HYDROPHYLLUM CANADENSE	2 12				1 13			2 50	
HYDROPHYLLUM VIRGINIANUM	2 6								2 50
HYPERICUM SP. #1	1 10	1 18	1 14	2 20		1 20			2 17
HYPERICUM MITCHELLIANUM*	1 2							1 10	
ILEX MONTANA	3 21	2 18	2 29	2 10	2 25	3 20	5 67	2 10	
IMPATIENS PALLIDA	1 33	1 12		1 20	1 13		1 17	2 80	1 83
JUGLANS NIGRA	2 6	3 12	3 29		2 13				
KALMIA LATIFOLIA	2 13	3 35	3 43	2 30	2 13				
LACTUCA BIENNIS	1 6				1 13				2 33
LAPORTEA CANADENSIS	2 46	1 18	1 14	1 20	2 50		1 67	3 100	2 50
LEUCOTHOE FONTANESIANA	5 8						5 67		
LIGUSTICUM CANADENSE	2 12	2 18	2 29	2 10	2 25	2 20			
LILIUM MICHAUXII	1 33	1 41	1 29	1 50	1 38			2 30	1 67
LINDERA BENZOIN	3 4				3 25				
LIPARIS LILIIFOLIA	1 2	1 6	1 14						
LIRIODENDRON TULIPIFERA	5 38	4 59	5 86	2 40	6 100		1 17	7 10	
LUZULA ACUMINATA	2 13	1 18	1 43		2 38	2 20			
LUZULA MULTIFLORA VAR CONGESTA*	1 19	1 47	1 57	1 40	1 13			1 10	
LYONIA LIGUSTRINA VAR LIGUSTRINA	1 2	1 6		1 10					
LYSIMACHIA QUADRIFOLIA	2 46	2 94	2 100	2 90	2 50				2 67
MAGNOLIA ACUMINATA	3 56	3 71	4 86	3 60	3 88	4 80	3 33	4 30	2 17
MAGNOLIA FRASERI	2 29	2 29	2 57	4 10	3 38	2 80	4 33	1 10	

Group:	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
MAIANTHEMUM RACEMOSUM	2 75	2 94	2 86	2 100	1 88	1 40	1 33	2 60	2 100
MALUS PUMILA	4 2								4 17
MEDEOLA VIRGINIANA	1 40	1 47	1 43	1 50	2 88	1 40		1 30	1 17
MELAMPYRUM LINEARE	2 8	2 24	2 43	1 10					
MELANTHIUM PARVIFLORUM	2 6						1 17	2 20	
MELANTHIUM VIRGINICUM	2 8	1 18	2 14	1 20					2 17
MITCHELLA REPENS	1 10	2 12	1 14	2 10	1 38				
MONARDA CLINOPODIA	2 33	2 35	2 29	2 40	2 13	2 20	1 17	2 20	3 100
MONARDA DIDYMA	2 6				2 13		2 17	2 10	
MONOTROPA UNIFLORA	1 17	1 35	1 29	1 40	1 13		2 33		
NYSSA SYLVATICA	2 4	2 12	1 14	3 10					
OSMORHIZA CLAYTONII	2 25	1 6		1 10	2 25		1 17	2 70	2 33
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	3 17	2 18	2 14	2 20	2 25	2 20		1 10	6 33
OSTRYA VIRGINIANA VAR VIRGINIANA	3 17	3 35	3 57	5 20		4 20		4 10	1 17
OXALIS STRICTA	2 4				2 13				1 17
OXYDENDRUM ARBOREUM	3 13	3 41	3 86	6 10					
PANAX QUINQUEFOLIUS*	1 17	1 12		1 20	1 25			1 30	2 33
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	2 21	2 29	2 29	3 30	1 63			2 10	
PEDICULARIS CANADENSIS	1 10	1 24	1 29	2 20					2 17
PHACELIA BIPINNATIFIDA	1 4	1 6	1 14					1 10	
PHEGOPTERIS HEXAGONOPTERA	1 12	1 6		1 10	2 50	1 20			
PHLOX CAROLINA SSP CAROLINA	2 2								2 17
PHRYMA LEPTOSTACHYA	2 2	2 6		2 10					
PHYTOLACCA AMERICANA	2 2	2 6		2 10					
PICEA RUBENS	7 2						7 17		
PINUS STROBUS	2 8	2 18	2 43		1 13				
POA ALSODES	2 12					2 20	2 17	1 10	2 50
POA AUTUMNALIS	1 8	1 6	1 14		1 13				2 33
POA CUSPIDATA	2 33	2 65	2 57	2 70	2 50			2 20	
PODOPHYLLUM PELTATUM	2 12				2 25			2 20	2 33
POLYGONATUM BIFLORUM VAR BIFLORUM	2 83	1 94	1 86	2 100	2 100	1 60	1 33	2 90	1 83
POLYGONUM CONVOLVULUS VAR CONVOLVULUS	2 10	1 6							2 67
POLYPODIUM APPALACHIANUM	1 2	1 6		1 10					
POLYPODIUM VIRGINIANUM	1 15	1 6	1 14	1 10		1 20	1 17	1 30	2 33
POLYSTICHUM ACROSTICHOIDES	2 90	2 94	2 86	2 100	2 100	2 60	2 83	2 100	2 83
PORTERANTHUS TRIFOLIATUS	1 4	1 12	1 29						

Group:	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
POTENTILLA CANADENSIS VAR CANADENSIS	2 46	2 82	3 100	1 70	2 63			2 10	2 67
PRENANTHES SP. #1	2 75	2 88	2 86	1 90	2 100	2 100	2 67	2 40	1 50
PROSARTES LANUGINOSUM	1 71	1 88	1 86	2 90	1 100	1 60		2 70	2 67
PRUNUS PENSYLVANICA	4 54	4 24	1 14	4 30	4 13	5 100	3 100	3 60	5 100
PRUNUS SEROTINA	2 35	2 71	2 86	2 60	2 50		2 17		1 17
PRUNELLA VULGARIS	2 2	2 6	2 14						
PTERIDIUM AQUILINUM	2 6	2 18		2 30					
PYCNANTHEMUM MONTANUM	2 52	2 94	2 86	2 100	2 63	2 40			2 67
PYCNANTHEMUM PYCNANTHEMOIDES VAR PYCNANTHEMOIDES	1 4	1 12	1 14	1 10					
PYRULARIA PUBERA	3 19	3 41	3 57	3 30	2 25			1 10	
QUERCUS ALBA	2 10	2 29	3 57	1 10					
QUERCUS COCCINEA VAR COCCINEA	4 2	4 6	4 14						
QUERCUS MONTANA	5 40	5 82	4 71	5 90	4 38	7 40			3 33
QUERCUS RUBRA	5 94	6 100	6 100	7 100	3 100	6 100	2 83	3 80	7 100
QUERCUS VELUTINA	1 6	2 12	2 14	1 10				1 10	
RANUNCULUS ABORTIVUS VAR ABORTIVUS	1 2								1 17
RANUNCULUS HISPIDUS	1 17	2 35	2 57	2 20	1 13				1 33
RANUNCULUS RECURVATUS	1 17	1 12	1 14	1 10	2 25			2 20	1 50
RHODODENDRON CALENDULACEUM	1 12	1 29	1 43	2 20		1 20			
RHODODENDRON CATAWBIENSE	3 4	2 6		2 10					3 17
RHODODENDRON MAXIMUM	3 37	3 29	2 29	4 30	4 50	1 20	4 50	4 40	1 33
RHODODENDRON MINUS	2 8					2 20		2 20	1 17
RHUS TYPHINA	1 2							1 10	
RIBES CYNOSBATI	2 8	2 6		2 10				2 30	
RIBES ROTUNDIFOLIUM	2 6							2 20	2 17
ROBINIA PSEUDOACACIA	4 85	3 94	4 100	3 90	5 63	4 80	5 83	4 80	5 100
ROSA MULTIFLORA	2 2				2 13				
ROSA WICHURAIANA	1 2	1 6	1 14						
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	2 27	2 41	1 29	2 50		1 60	2 33		1 33
RUBUS ARGUTUS	2 17	1 6	1 14		3 38		1 17	2 30	2 17
RUBUS CANADENSIS	2 29	1 12	1 14	1 10	2 25	2 40	2 33	2 50	3 33
RUDBECKIA HIRTA	1 2	1 6		1 10					
RUDBECKIA LACINIATA	2 2						2 17		
RUMEX CRISPUS	2 2								2 17
SAMBUCUS CANADENSIS VAR CANADENSIS	2 2				2 13				

Group:	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
SAMBUCUS RACEMOSA VAR PUBENS	2 10						2 17	2 20	2 33
SANGUINARIA CANADENSIS	1 37	2 59	1 43	2 70	2 50			1 20	2 50
SANICULA CANADENSIS VAR CANADENSIS	2 17	1 29	2 14	1 40	2 38				1 17
SANICULA ODORATA	1 21	2 12	2 29		2 13			2 60	1 33
SASSAFRAS ALBIDUM	2 19	2 53	2 71	3 40	2 13				
SCUTELLARIA ELLIPTICA VAR ELLIPTICA	2 8	2 12	1 14	2 10	2 25				
SCUTELLARIA INCANA VAR PUNCTATA	1 2	1 6	1 14						
SCUTELLARIA OVATA VAR BRACTEATA	5 2								5 17
SEDUM TERNATUM	2 29	2 29		2 50	2 13			2 40	2 83
SENECIO AUREUS	2 6								2 50
SILENE STELLATA	1 15	1 18	1 14	2 20		1 20		1 10	1 50
SILENE VIRGINICA VAR VIRGINICA	1 21	1 35	1 43	1 30	1 13	1 20			1 50
SISYRINCHIUM ANGUSTIFOLIUM	1 4	1 6	1 14		1 13				
SMILAX GLAUCA VAR GLAUCA	2 19	2 41	1 71	2 20	1 38				
SMILAX HERBACEA	1 65	1 88	1 86	1 90	1 63	1 80		2 40	2 100
SMILAX ROTUNDIFOLIA	2 63	2 94	2 100	2 90	2 88	2 80	2 50	1 30	
SOLIDAGO ARGUTA VAR CAROLINIANA*	2 25	2 59	2 71	1 50	2 25				2 17
SOLIDAGO CURTISII	2 96	2 100	2 100	2 100	2 88	2 100	2 83	2 100	2 100
SORBUS AMERICANA	1 6						1 17	1 10	1 17
STACHYS LATIDENS	2 29	2 24	2 14	2 30	2 25	1 60			2 100
STELLARIA PUBERA	1 19	1 35	1 57	1 20	2 50				
THALICTRUM CLAVATUM	2 44	1 41	1 29	2 50	2 50	2 40		2 70	2 50
THALICTRUM CORIACEUM	2 2	2 6		2 10					
THALICTRUM DIOICUM	2 2	2 6	2 14						
THALICTRUM PUBESCENS VAR PUBESCENS	2 6	2 6		2 10					2 33
THALICTRUM REVOLUTUM	1 2	1 6		1 10					
THASPIUM BARBINODE	2 13	1 12	1 29		2 13			2 10	2 50
THELYPTERIS NOVEBORACENSIS	3 40	4 35	4 86		3 100	3 80		2 20	2 17
TIARELLA CORDIFOLIA VAR CORDIFOLIA	2 35	2 24	1 14	2 30	2 63	2 20	1 17	2 60	2 17
TILIA AMERICANA VAR HETEROPHYLLA	4 65	3 47	1 29	3 60	3 100	6 40	4 67	7 90	6 50
TOXICODENDRON RADICANS	3 6	3 18	1 14	4 20					
TRADESCANTIA SUBASPERA	2 31	1 47	1 43	1 50	2 25				2 100
TRILLIUM ERECTUM	1 63	1 65	1 71	1 60	1 88	1 20	2 33	1 90	2 50
TRILLIUM UNDULATUM	1 4				1 25				

Group:	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
TSUGA CANADENSIS	4 58	3 47	2 71	5 30	5 50	3 80	5 83	4 60	2 50
UVULARIA GRANDIFLORA	2 2							2 10	
UVULARIA PERFOLIATA	2 38	2 65	1 43	2 80	2 38			2 20	2 67
UVULARIA PUBERULA VAR PUBERULA	1 25	1 53	1 57	1 50	1 25	1 20		1 10	
VACCINIUM CORYMBOSUM	1 8	1 18	2 14	1 20		1 20			
VACCINIUM PALLIDUM	1 6	1 18	1 29	1 10					
VACCINIUM SIMULATUM	2 15	2 24	2 14	2 30		1 40		1 10	2 17
VACCINIUM STAMINEUM	2 8	2 24	2 29	2 20					
VERONICA OFFICINALIS VAR OFFICINALIS	1 2				1 13				
VIBURNUM ACERIFOLIUM	2 31	2 65	1 29	2 90	1 50	1 20			
VIBURNUM LANTANOIDES	2 4						1 17	2 10	
VIBURNUM NUDUM VAR CASSINOIDES	1 2							1 10	
VICIA CAROLINIANA	2 8	2 24	1 14	2 30					
VIOLA AFFINIS	1 10	1 18		1 30	2 25				
VIOLA BLANDA	2 77	2 41	3 29	1 50	3 100	2 100	3 83	3 90	2 100
VIOLA CANADENSIS VAR CANADENSIS	3 8							3 40	
VIOLA CUCULLATA	2 4				2 13		1 17		
VIOLA HASTATA	2 48	2 47	2 86	2 20	2 88	2 100	1 17	2 30	2 17
VIOLA PALMATA VAR PALMATA	1 4	1 12	1 14	1 10					
VIOLA PUBESCENS VAR PUBESCENS	2 17	2 12	2 29		2 38			2 40	
VIOLA ROTUNDIFOLIA	2 56	2 12	1 14	2 10	2 63	2 80	2 100	2 90	1 50
VIOLA SORORIA	2 21	2 47	2 86	2 20			2 17	3 10	1 17
VITIS AESTIVALIS VAR AESTIVALIS	2 29	2 53	2 71	2 40	1 50	2 20		2 10	
VITIS AESTIVALIS VAR BICOLOR	2 6	2 12	1 14	2 10	2 13				
VITIS ROTUNDIFOLIA	1 2	1 6		1 10					
VITIS VULPINA	1 2						1 17		
XANTHORHIZA SIMPLICISSIMA	1 2							1 10	
ZIZIA TRIFOLIATA	2 48	2 94	2 100	2 90	1 50	1 60			1 33

Table 4.47. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Rich Cove and Slope Forests** vegetation class and associated community types and sub-types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

10. Rich Cove and Slope Forests

	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	29.55	88.59	3.07	121.21	2.29	5.57	6.38	5.97
ACER SACCHARUM VAR SACCHARUM	83.13	88.16	0.96	172.25	1.00	7.32	2.95	5.14
BETULA LENTA	2.96	70.59	3.22	76.78	2.97	4.34	8.53	6.44
HALESIA TETRAPTERA VAR MONTICOLA	192.07	108.34	0.67	301.08	1.39	14.17	3.37	8.77
LIRIODENDRON TULIPIFERA	4.42	23.27	11.85	39.54	3.79	2.00	9.69	5.85
QUERCUS RUBRA	13.04	83.09	17.54	113.67	6.85	5.44	18.62	12.03
ROBINIA PSEUDOACACIA	10.34	50.76	6.09	67.19	3.58	4.50	9.43	6.96
TILIA AMERICANA VAR HETEROPHYLLA	13.13	50.73	6.06	69.92	2.76	3.53	7.76	5.64
ALL	897.97	1189.08	71.40	2158.45	36.62	99.99	100.00	100.00

10.1 Quercus rubra-Carya glabra/Cornus florida Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	71.27	151.70	4.44	227.41	3.32	10.53	9.54	10.04
CARYA GLABRA	5.25	69.61	12.26	87.12	4.34	4.50	12.63	8.57
CORNUS FLORIDA	65.15	163.21	0.00	228.36	0.81	9.30	2.43	5.87
HALESIA TETRAPTERA VAR MONTICOLA	143.88	74.96	0.59	219.43	0.73	9.71	2.15	5.93
LIRIODENDRON TULIPIFERA	12.21	34.26	5.88	52.35	2.95	3.01	8.82	5.91
QUERCUS MONTANA	0.00	18.97	9.58	28.55	3.45	1.17	9.93	5.55
QUERCUS RUBRA	17.06	[illegible]	22.36	136.59	8.51	5.93	25.50	15.72
ALL	1224.39	1178.24	71.05	2473.67	33.95	100.00	100.00	100.00

10.1.1 Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	43.21	225.71	4.29	273.21	3.33	15.20	10.83	13.01
CARYA ALBA	0.00	65.71	2.86	68.57	1.78	2.78	5.51	4.15
CARYA GLABRA	7.14	53.21	2.86	63.21	1.56	3.23	5.15	4.19
CORNUS FLORIDA	31.43	150.00	0.00	181.43	0.67	8.61	2.23	5.42
HALESIA TETRAPTERA VAR MONTICOLA	163.57	101.43	1.43	266.43	1.36	13.56	4.09	8.83
HAMAMELIS VIRGINIANA	248.57	177.14	0.00	425.71	0.42	14.88	1.24	8.06
LIRIODENDRON TULIPIFERA	10.00	80.00	14.29	104.29	6.91	6.65	20.59	13.62
QUERCUS MONTANA	0.00	14.29	8.57	22.86	3.52	1.05	10.05	5.55
QUERCUS RUBRA	4.29	75.36	15.00	94.64	6.68	3.70	21.50	12.60
ALL	796.43	1262.14	58.21	2116.79	32.06	99.99	100.00	100.01

10.1.2 Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanicum sub-type

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	90.91	99.89	4.55	195.35	3.31	7.26	8.64	7.95
ACER SACCHARUM VAR SACCHARUM	177.11	67.06	0.00	244.17	0.24	9.20	0.75	4.97
CARYA GLABRA	3.92	81.08	18.85	103.85	6.29	5.39	17.87	11.63
CORNUS FLORIDA	88.76	172.45	0.00	261.21	0.91	9.78	2.57	6.17
QUERCUS MONTANA	0.00	22.25	10.28	32.53	3.40	1.26	9.85	5.56
QUERCUS RUBRA	26.00	112.43	27.52	165.95	9.79	7.50	28.29	17.89
SMILAX ROTUNDIFOLIA	147.75	0.00	1.67	149.42	1.42	5.05	3.23	4.14
ALL	1523.96	1119.50	80.04	2723.49	35.27	100.00	100.00	100.00

10.2 Liriodendron/Halesia Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	10.63	93.83	2.50	106.96	2.22	4.35	5.81	5.08
ACER SACCHARUM VAR SACCHARUM	231.25	87.81	1.56	320.63	1.20	11.40	3.05	7.23
AESCULUS FLAVA	80.73	59.34	1.25	141.32	0.91	5.39	2.68	4.04
BETULA LENTA	3.13	77.07	4.38	84.57	3.70	4.31	9.07	6.69
HALESIA TETRAPTERA VAR MONTICOLA	229.69	113.44	0.00	343.13	1.32	15.01	3.17	9.09
LIRIODENDRON TULIPIFERA	2.81	70.63	49.94	123.38	15.13	5.72	36.14	20.93
RHODODENDRON MAXIMUM	50.45	217.01	0.00	267.47	0.94	10.70	2.81	6.75
ROBINIA PSEUDOACACIA	1.56	43.13	6.56	51.25	3.85	2.18	9.09	5.64
TSUGA CANADENSIS	22.81	158.63	6.25	187.70	3.25	10.41	6.79	8.61
ALL	1068.54	1223.75	91.50	2383.80	40.89	100.00	99.99	100.00

10.3 Quercus rubra-Halesia/Acer pensylvanicum Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	16.00	138.74	5.83	160.57	4.84	6.84	12.41	9.63
ACER SACCHARUM VAR SACCHARUM	46.00	185.91	2.50	234.41	1.87	9.45	3.76	6.61
FAGUS GRANDIFOLIA	37.50	199.76	2.50	239.76	1.89	10.11	3.69	6.90
HALESIA TETRAPTERA VAR MONTICOLA	637.50	332.69	5.00	975.19	4.89	40.68	10.18	25.43
QUERCUS MONTANA	0.00	32.00	3.33	35.33	3.12	1.50	8.96	5.23
QUERCUS RUBRA	0.00	139.78	19.54	159.31	11.59	6.42	27.98	17.20
TILIA AMERICANA VAR HETEROPHYLLA	3.33	46.30	7.41	57.04	3.28	2.01	7.57	4.79
TSUGA CANADENSIS	6.00	5.83	7.50	19.33	5.02	0.91	7.99	4.45
ALL	974.67	1374.76	62.11	2411.54	44.09	100.00	100.00	100.00

10.4 Betula lenta-Robinia pseudo-acacia/Ageratina Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
BETULA ALLEGHANIENSIS	8.33	142.36	2.78	153.47	4.46	9.60	13.32	11.46
BETULA LENTA	0.00	219.44	6.25	225.69	8.89	13.58	26.07	19.83
HALESIA TETRAPTERA VAR MONTICOLA	105.56	86.11	0.00	191.67	1.14	13.57	2.99	8.28
ILEX MONTANA	43.75	89.58	0.00	133.33	0.26	8.76	0.90	4.83
PICEA RUBENS	16.67	120.83	0.00	137.50	1.11	5.98	3.25	4.62
RHODODENDRON MAXIMUM	37.50	408.33	0.00	445.83	1.09	14.12	3.28	8.70
ROBINIA PSEUDOACACIA	0.00	56.25	12.50	68.75	5.34	5.13	16.20	10.67
TILIA AMERICANA VAR HETEROPHYLLA	2.08	20.14	12.50	34.72	4.21	2.99	12.08	7.53
TSUGA CANADENSIS	0.00	45.83	7.64	53.47	3.10	2.83	8.31	5.57
ALL	336.11	1429.17	45.83	1811.11	34.05	100.00	100.00	100.01

10.5 Tilia-Betula lenta Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER SACCHARUM VAR SACCHARUM	22.42	139.00	2.50	163.92	2.58	9.16	8.91	9.04
AESCULUS FLAVA	89.58	132.08	2.25	223.92	1.53	14.53	4.59	9.56
ARISTOLOCHIA MACROPHYLLA	82.33	107.92	0.00	190.25	0.24	9.70	0.82	5.26
BETULA ALLEGHANIENSIS	2.50	46.83	1.25	50.58	1.64	3.14	5.48	4.31
BETULA LENTA	5.92	64.58	8.50	79.00	4.73	5.64	14.17	9.91
HALESIA TETRAPTERA VAR MONTICOLA	136.33	84.17	0.00	220.50	1.56	12.22	3.76	7.99
QUERCUS RUBRA	1.00	10.75	14.58	26.33	4.01	2.13	9.21	5.67
RHODODENDRON MAXIMUM	77.33	77.83	0.00	155.17	0.16	8.39	0.60	4.50
ROBINIA PSEUDOACACIA	0.00	25.42	9.17	34.58	3.50	2.28	8.06	5.17
TILIA AMERICANA VAR HETEROPHYLLA	32.50	134.92	15.67	183.08	7.35	10.79	21.90	16.35
TSUGA CANADENSIS	8.33	57.33	1.00	66.67	1.57	3.77	5.45	4.61
ALL	583.58	1008.08	77.75	1669.42	34.95	99.95	100.00	99.97

10.6 Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
AESCULUS FLAVA	50.56	88.47	1.67	140.69	1.61	8.71	4.25	6.48
FRAXINUS AMERICANA	90.97	113.33	1.67	205.97	0.97	8.32	2.63	5.48
HALESIA TETRAPTERA VAR MONTICOLA	86.67	71.67	0.00	158.33	0.43	7.45	1.10	4.27
PRUNUS PENSYLVANICA	11.25	53.33	8.33	72.92	3.70	6.21	9.96	8.08
QUERCUS RUBRA	59.31	282.92	38.47	380.69	15.18	19.53	40.20	29.86
ROBINIA PSEUDOACACIA	55.56	166.81	8.33	230.69	8.60	19.20	23.09	21.14
ALL	767.64	1080.42	68.33	1916.39	37.58	100.01	99.99	100.00

Table 49. Vertical structure of woody species in the **Rich Cove and Slope Forests** vegetation class and associated community types and sub-types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

10. Rich Cove and Slope Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	3	2	
ACER SACCHARUM VAR SACCHARUM	1	2	2	2	
AESCULUS FLAVA	1	2	1	1	
BETULA ALLEGHANIENSIS	1	1	1	1	
BETULA LENTA	1	1	3	3	
CARYA ALBA	1	1	1		
CARYA GLABRA	1	1	1	2	
CORNUS FLORIDA	1	1	1		
HALESIA TETRAPTERA VAR MONTICOLA	1	2	2	1	
LIRIODENDRON TULIPIFERA	1	1	1	2	
MAGNOLIA ACUMINATA	1	1	1	1	
PRUNUS PENSYLVANICA	1	1	1	1	
QUERCUS MONTANA	1	1	1	1	
QUERCUS RUBRA	1	1	4	4	
RHODODENDRON MAXIMUM	1	1			
ROBINIA PSEUDOACACIA	1	1	2	2	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	2	2	
TSUGA CANADENSIS	1	1	1	1	

10.1 Quercus rubra-Carya glabra/Cornus florida Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	2	4	4	
ACER SACCHARUM VAR SACCHARUM	1	2	1		
BETULA LENTA	1	1	2	2	
CARYA ALBA	1	1	2	2	
CARYA GLABRA	1	1	4	4	
CASTANEA DENTATA	1	1			
CORNUS FLORIDA	1	2	2		
FRAXINUS AMERICANA	1	1	1		
HALESIA TETRAPTERA VAR MONTICOLA	1	2	2		
HAMAMELIS VIRGINIANA	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	2	
MAGNOLIA ACUMINATA	1	1	1	1	
QUERCUS MONTANA	1	1	3	3	
QUERCUS RUBRA	1	1	5	5	
ROBINIA PSEUDOACACIA	1	1	2	1	

10.1.1 Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	4	4	
ACER SACCHARUM VAR SACCHARUM	1	1			
BETULA LENTA	1	1	2	1	
CARYA ALBA	1	1	3	2	
CARYA GLABRA	1	1	4	4	1
CORNUS FLORIDA	1	1	2		
HALESIA TETRAPTERA VAR MONTICOLA	1	3	3		
HAMAMELIS VIRGINIANA	1	3	1		
LIRIODENDRON TULIPIFERA	1	1	2	4	1
MAGNOLIA ACUMINATA	1	1	2	2	
OXYDENDRUM ARBOREUM	1	1	1		
PYRULARIA PUBERA	1	1			
QUERCUS MONTANA	1	1	2	2	
QUERCUS RUBRA	1	1	4	4	
ROBINIA PSEUDOACACIA	1	1	2	2	

10.1.2 Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanicum sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	1		
ACER RUBRUM VAR RUBRUM	1	2	4	4	
ACER SACCHARUM VAR SACCHARUM	1	2	1		
ARISTOLOCHIA MACROPHYLLA	1	1			
BETULA LENTA	1	1	2	2	
CARYA ALBA	1	1	2	1	
CARYA GLABRA	1	1	4	4	
CASTANEA DENTATA	1	2			
CORNUS FLORIDA	1	2	2		
FRAXINUS AMERICANA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	2	1		
QUERCUS MONTANA	1	1	3	3	
QUERCUS RUBRA	1	1	6	6	
RHODODENDRON MAXIMUM	1	1			
ROBINIA PSEUDOACACIA	1	1	1	1	
SASSAFRAS ALBIDUM	1	1			
TSUGA CANADENSIS	1	1	1		

10.2 Liriodendron/Halesia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	3	2	
ACER SACCHARUM VAR SACCHARUM	1	2	2	2	
AESCULUS FLAVA	1	2	2	1	
BETULA ALLEGHANIENSIS	1	1	1	2	
BETULA LENTA	1	1	4	3	
CARYA GLABRA	1	1	1	1	
CORNUS FLORIDA	1	1	1		
HALESIA TETRAPTERA VAR MONTICOLA	1	2	3	2	
LIRIODENDRON TULIPIFERA	1	1	4	6	1
MAGNOLIA ACUMINATA	1	1	1	1	
MAGNOLIA FRASERI	1	1	1	1	
QUERCUS MONTANA	1	1	1	1	
QUERCUS RUBRA	1	1	1	2	
RHODODENDRON MAXIMUM	1	2			
ROBINIA PSEUDOACACIA	1	1	2	3	
RUBUS ARGUTUS	1				
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	1	
TSUGA CANADENSIS	1	1	2	1	

10.3 Quercus rubra-Halesia/Acer saccharum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	4	4	
ACER SACCHARUM VAR SACCHARUM	1	4	5	3	1
BETULA LENTA	1	1	1	1	
FAGUS GRANDIFOLIA	1	2	3	3	1
FRAXINUS AMERICANA	1	1	1	1	
HALESIA TETRAPTERA VAR MONTICOLA	1	4	4	4	1
MAGNOLIA ACUMINATA	1	1	1	2	1
PRUNUS PENSYLVANICA	1	1	3	4	1
QUERCUS MONTANA	1	1	2	2	
QUERCUS RUBRA	1	1	5	6	1
ROBINIA PSEUDOACACIA	1	1	1	2	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	1	
TSUGA CANADENSIS	1	1	1	1	1

10.4 Betula lenta-Robinia pseudo-acacia/Ageratina Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	2	2	
ACER SACCHARUM VAR SACCHARUM	1	2	3	1	
AESCULUS FLAVA	1	2	1	1	
BETULA ALLEGHANIENSIS	1	1	6	6	
BETULA LENTA	1	1	5	5	
HALESIA TETRAPTERA VAR MONTICOLA	1	2	3	1	
ILEX MONTANA	1	2	1		
MAGNOLIA FRASERI	1	1	1	1	
PICEA RUBENS	1	1	1		
PRUNUS PENSYLVANICA	1	1	2	2	
QUERCUS RUBRA	1	1	1	1	
RHODODENDRON MAXIMUM	1	2	1		
ROBINIA PSEUDOACACIA	1	1	2	3	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	2	2	
TSUGA CANADENSIS	1	2	4	3	

10.5 Tilia-Betula lenta Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	1	1	
ACER SACCHARUM VAR SACCHARUM	1	2	3	3	
AESCULUS FLAVA	1	3	2	3	
ARISTOLOCHIA MACROPHYLLA	1	1	1	1	
BETULA ALLEGHANIENSIS	1	1	2	2	
BETULA LENTA	1	1	4	5	
FAGUS GRANDIFOLIA	1	1	1		
HALESIA TETRAPTERA VAR MONTICOLA	1	2	2	1	
MAGNOLIA ACUMINATA	1	1	1	1	
PRUNUS PENSYLVANICA	1	1	1	1	
QUERCUS RUBRA	1	1	2	2	
RHODODENDRON MAXIMUM	1	1			
ROBINIA PSEUDOACACIA	1	1	2	2	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	4	5	
TSUGA CANADENSIS	1	2	1	1	

10.6 Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	1		
ACER RUBRUM VAR RUBRUM	1	1	2	1	
ACER SACCHARUM VAR SACCHARUM	1	1	2	2	
AESCULUS FLAVA	1	3	4	4	
AMELANCHIER LAEVIS	1	1	1		
BETULA LENTA	1	1	1	1	
CASTANEA DENTATA	1	1			
CORNUS ALTERNIFOLIA	1	1			
CRATAEGUS MACROSPERMA	1	1			
FRAXINUS AMERICANA	1	2	2	1	
HALESIA TETRAPTERA VAR MONTICOLA	1	2	2	1	
PRUNUS PENSYLVANICA	1	1	4	3	
QUERCUS RUBRA	1	1	6	6	
ROBINIA PSEUDOACACIA	1	2	2	3	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	2	2	

Table 4.46. Average site information for the **Rich Cove and Slope Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 4. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**GMS**=garnet-mica schist, **MG**=mica gneiss, ?=unknown), Landform types (representing micro-scale topographic units) (**C**=coves, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**LS**=lower-slopes, **MS**=mid-slopes, **T**=toeslopes, **US**=upper-slopes).

10. Rich Cove and Slope Forests

	Group								
	10.	10.1	10.1.1	10.1.2	10.2	10.3	10.4	10.5	10.6
Site Characteristics:									
Elevation (m)	1247	1175	1061	1255	1082	1329	1296	1277	1506
Slope (o)	23	25	17	29	18	25	24	25	21
Aspect (o)		E-SW	S-SW	E-SW	NE-E,W	E,S-SW	N-NE	W	E-SW
Parent material	MG	GMS,MG	MG	?	MG	MG	MG	MG	MG
Soil depth (cm)	41.5	42.1	52.2	35.0	39.5	51.6	43.3	28.6	53.5
Surface Substrate (%):									
Moss/Lichen	8	7	2	11	8	3	5	20	2
Wood	6	5	4	5	5	6	8	6	9
Rock	15	14	4	20	14	5	16	28	2
Organic Matter	77	80	89	74	77	86	73	62	88
Water	1	0	0	0	2	0	0	4	0
Topographic Characteristics:									
Relative slope (%)	35	43	30	51	19	50	25	20	59
LFI	0.22	0.22	0.28	0.18	0.24	0.20	0.26	0.26	0.14
TSI	0.01	0.01	0.03	-0.01	0.01	-0.00	0.04	0.02	-0.01
Landform type	SS	SS	SS	SS	SS,C	SS	SS	SS	SS
Topographic position	LS	LS,MS	LS	MS	LS	LS,MS	LS,MS,T	LS	US

4.5.11 VEGETATION CLASS: 11. Alluvial Forests

Alluvial Forests have limited distributed in the Southern Appalachian Mountains, restricted to stream edges and river floodplains (Schafale and Weakley 1990). In Shining Rock this vegetation class is restricted to broad, flat areas along the margins of the major river systems.

COMMUNITY TYPE: [Betula alleghaniensis/Salix nigra Alluvial Forest] (11.1)

Synonymy

Montane Alluvial Forest (Schafale & Weakley 1990), Riverbank Shrub Thicket Community (Cooper & Hardin 1970).

Physiognomy

Betula alleghaniensis dominates the canopy (14 m height) of this alluvial forest (Tables 4.47, 4.48, 4.49). *Tsuga canadensis* and *Robinia pseudo-acacia* are present with limited abundance, with cover from the former overhanging from the adjacent, tall forest. Clumps of *Salix nigra* form an open shrub layer with a few *Rhododendron maximum* stems present. The ground surface is uneven, with moss and a limited range of vascular species restricted to the smoother, finer textured areas in the rocky matrix (Table 4.50).

Habitat and Distribution

This forest inhabits a small (150m^2) alluvial flat on the margin of the West Fork of the Pigeon River (elevation 1187 m), downstream from the Wash Hollow confluence (Figure 1.4, Table 4.50, Appendix 5). The soils are sandy and have the lowest B, cation exchange capacity, K, N, organic matter and S of any group identified in Shining Rock (Tables 4.4, 4.5).

Succession and Disturbance

This community type is subject to frequent flooding. The periodicity and intensity of flooding will determine the longevity and sustainability of this community type. High floods and high flood frequency could eliminate the herbaceous ground vegetation and limit tree seedling establishment. However, intermittent flooding may probably allow the present herbaceous component to flourish, and tree seedlings to establish and develop to a stage where they can survive future flooding. There are no *Betula alleghaniensis* saplings in the site sampled, which suggests that the present flooding regime is too frequent or intense to allow this species to establish (Table 4.48). Evidence suggests that the *Betula* canopy will not be maintained under the present flooding regime. The present *Betula* canopy will persist until individual trees senesce.

Discussion

Data summarized in this study adds further information to the seldom described **Alluvial Forests** vegetation class. Future research is needed to understand the role of flooding on the dynamics of this class.

Table 4.47. Average cover class and constancy of species present in the **Alluvial Forests** vegetation class. Values are given for the vegetation class which is represented by its abbreviation code. For full community type name see Table 4. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species.

Group:	11.
Number of plots:	1
	Cov/Con
Species	
AGERATINA ALTISSIMA VAR ROANENSIS	1 100
AGROSTIS PERENNANS	1 100
ASTER ACUMINATUS VAR ACUMINATUS	1 100
ASTER DIVARICATUS	2 100
ATHYRIUM ASPLENIOIDES	2 100
BETULA ALLEGHANIENSIS	7 100
BRACHYELYTRUM ERECTUM	1 100
CLETHRA ACUMINATA	2 100
COLLINSONIA CANADENSIS	1 100
DANTHONIA COMPRESSA	2 100
HOLCUS LANATUS	1 100
HOUSTONIA SERPYLLIFOLIA	2 100
HYPERICUM SP. #1	1 100
KALMIA LATIFOLIA	2 100
RHODODENDRON MAXIMUM	3 100
ROBINIA PSEUDOACACIA	2 100
RUBUS ARGUTUS	1 100
RUMEX ACETOSELLA	1 100
SALIX NIGRA	6 100
SAXIFRAGA MICHAUXII	1 100
SENECIO VULGARIS	1 100
SOLIDAGO CURTISII	1 100
SOLIDAGO PATULA VAR PATULA	1 100
TSUGA CANADENSIS	2 100
VACCINIUM ERYTHROCARPUM	2 100
VIOLA BLANDA	2 100

Table 4.48. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Alluvial Forests** vegetation class. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

11. Alluvial Forests

	AVSAPLDEN	AVTREDEN	AVBIGDEN	AVTOTDEN	AVTOTBA	REL DEN	REL B.A	TIV
BETULA ALLEGHANIENSIS	0.00	600.00	0.00	600.00	9.13	57.14	53.46	55.30
RHODODENDRON MAXIMUM	50.00	150.00	0.00	200.00	0.33	19.05	1.95	10.50
ROBINIA PSEUDOACACIA	0.00	50.00	0.00	50.00	4.15	4.76	24.29	14.53
SALIX NIGRA	0.00	100.00	0.00	100.00	0.44	9.52	2.59	6.06
TSUGA CANADENSIS	0.00	50.00	0.00	50.00	2.97	4.76	17.39	11.08
ALL	50.00	1000.00	0.00	1050.00	17.08	99.99	100.00	100.01

Table 4.49. Vertical structure of woody species in the **Alluvial Forests** vegetation class. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

11. Alluvial Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
BETULA ALLEGHANIENSIS	1	7	1		
KALMIA LATIFOLIA	1	2			
RHODODENDRON MAXIMUM	1	3			
ROBINIA PSEUDOACACIA	1				
SALIX NIGRA	1	6			
TSUGA CANADENSIS	1	4	1		

Table 4.50. Average site information for the **Alluvial Forests** vegetation class. The vegetation class is represented by its abbreviation code. For full community type name see Table 4.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Landform types (representing micro-scale topographic units) (**RM**=river margin) and Topographic position (representing macro-scale topographic units) (**P**=plain/level).

11. Alluvial Forests

	Group
	11.
Site Characteristics:	
Elevation (m)	1187
Slope (o)	4
Aspect (o)	N
Parent material	
Soil depth (cm)	1.6
Surface Substrate (%):	
Moss/Lichen	27
Wood	2
Rock	57
Organic Matter	2
Water	5
Topographic Characteristics:	
Relative Slope (%)	1
LFI	0.34
TSI	0.03
Landform type	RM
Topographic position	P

4.6 Discussion

4.6.1 Impact of past disturbances on vegetation composition and distribution

Logging and fire in the early twentieth century have greatly influenced the present-day distribution, composition and structure of community types in Shining Rock Wilderness. The effects of these past disturbances are more visible and perhaps more severe in the high-elevation areas. Historic records suggest that present-day **Spruce-Fir Forests** inhabit only a small portion of the area that they formerly dominated, probably as a result of intense logging activities (USFS *unpub. data*). Subsequent fires may also have restricted or reduced **Spruce-Fir Forest** distribution. This vegetation class appears to have only survived in areas that missed the fire in 1925, or on those adjacent to pastured land where fuel loadings would have been minimal. Most of the areas once inhabited by **Spruce-Fir Forests** are now dominated by successional *Betula alleghaniensis* types. The existence of several successionally young high-elevation vegetation classes (e.g. **Shrub Balds**) and community types (e.g. the **Betula alleghaniensis-Prunus pensylvanica/Rhododendron maximum-Vaccinium simulatum Forest**) and marked distributional changes of other high-elevation community types are an indication of the severity of past disturbances at high-elevations within the Shining Rock landscape. In contrast, disturbance appears to have had less impact in mid- and lower-elevation areas. Subtle compositional changes of individual species, such as increased presence of *Robinia pseudo-acacia* and *Liriodendron tulipifera* in the canopy, are more typical of mid- and low-elevation forests than the marked changes in community type structure and distribution associated with high-elevation vegetation.

Changes in the distribution of high-elevation community types described above reflect the intensity of burning in this area and also the inability of many tree species to withstand intense fire. High fuel loadings, caused by accumulations of spruce brush and the exposure of this area to high winds probably account for fire intensity. Moreover, the probable dominance of fire-intolerant species such as *Betula*, *Fagus*, and *Picea* highlights the susceptibility of high-elevation community types to damage by fire. Fire intensity was probably lower in the more sheltered topographic positions associated with mid- and low-elevation regions of the Shining Rock landscape. Moreover, dominance by fire-tolerant genera such as *Acer*, *Carya* and *Quercus* indicate that these forests had a greater ability to survive fire than high-elevation community types.

The comparatively recent impact of these disturbances suggests that community types in Shining Rock are in a state of transition, with species composition, density and dominance still changing at perhaps a higher rate than in a similar landscape containing old-growth forests or forests subject to less recent disturbance. Composition and structure data indicates that high-elevation community types are successionally younger than mid- and low-elevation types, and as a result will probably take longer to reach a successionally advanced stage. With time the distribution and dominance of successional vegetation classes such as **Shrub Balds** and community types dominated by *Betula alleghaniensis* will probably greatly decline in abundance with *Picea rubens* gaining dominance of the high-elevations. Size-class data suggests that successional changes in the mid- and low-elevations will be more subtle. Change will probably take the form of community type "fine-tuning", with a reduction in the existence of successional species within a stand, rather than total stand replacement possible at high-elevations.

Evidence from stumps, logs and persisting sprouts suggest that *Castanea dentata*, chestnut, was once a major species at Shining Rock. Its past and present distribution spans a wide range of vegetation classes and environmental conditions. Chestnut sprouts are present in all four mid- and lower-elevation vegetation classes (the **Acidic Cove and Slope Forests**, the **Montane Oak Forests**, the **Rich Cove and Slope Forests** and the **Xeric Evergreen Forests**) and also the **High-Elevation Mixed Hardwood Forests** class. This distribution corresponds to the patterns reported in other Southern Appalachian landscapes (e.g., see Whittaker 1956, Woods & Shanks 1959, Lorimer 1980, Chapter 5).

Summary cover and stem data suggest that chestnut reached highest abundance in the **Montane Oak Forests** vegetation class and at least one **Rich Cove and Slope Forests** community type. Chestnut was probably at least a subdominant canopy species in the **Quercus montana/Oxydendrum/Kalmia Forest**, the **Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest** and the ***Quercus rubra-Carya glabra/***

Cornus florida-Acer pensylvanica sub-type. These three forest groups inhabit mainly south-to-southwest, moderate-sloping faces and ridgelines between 945 and 1350 m (Tables 4.39, 4.42, 4.43, 4.46), corresponding to sites described elsewhere in the Southern Appalachians (Keever 1953, Whittaker 1956, Chapter 5). Chestnut was probably also a major canopy component of the possibly old-growth **Quercus rubra/Kalmia Forest** in the **High-Elevation Mixed Hardwood Forests** vegetation class. This type is situated on northeast- and west-facing ridgelines and associated upper-slopes between 1470 and 1640 m in elevation (Tables 4.23, 4.24, 4.26).

Based on information from previous studies (see Keever 1953, Woods & Shanks 1959, Johnson & Ware 1982) and this present study, I surmise that chestnut has most likely been replaced by *Quercus montana*, *Q. rubra*, *Acer rubrum*, *Betula lenta* and *Oxydendrum arboreum* in the mid- and low-elevation areas. In contrast, the present overwhelming dominance of *Q. rubra* in the canopy of high-elevation, old-growth stands, suggests that existing *Q. rubra* canopy trees probably expanded their canopies to infill many of the gaps left vacant by chestnut death. DeLapp (1978) hypotheses that canopy openings, caused by chestnut death may have enhanced species diversity and this may have augmented species diversity levels in forests once (co)dominated by chestnut. However, because most sites have been logged and subsequently burned, it is impossible to pin-point the specific type of disturbance and the degree to which stand composition and structure has been altered by chestnut death rather than logging or fire.

4.6.2. Vegetation composition: comparisons with other Southern Appalachian landscapes

Comparisons of species richness at seven spatial scales provide a means of quantifying structural and compositional differences between vegetation classes and community types. Richness is highest at the two smallest spatial scales in the high-elevation **Grasslands** and **Non-Alluvial Wetlands** (Table 4.6), reflecting the dominance of small-sized plants in these two non-forested vegetation classes. In general, forest vegetation classes occurring at high-elevations have high small-scale richness in comparison to mid- and low-elevation forest vegetation classes, although the **Montane Oak Forests** and the

Rich Cove and Slope Forests have higher richness than the **High-Elevation Mixed Hardwood Forests** at all scales but the smallest. The **Montane Oak Forests** and **Rich Cove and Slope Forests** vegetation classes have highest richness at the four largest spatial scales, reflecting the broad scattering of a diverse range of species. Differences in richness between these two classes correlate with differing soil conditions, with higher diversity present in the more fertile **Rich Cove and Slope Forests** (Table 4.4). Similarly, the **Grasslands** and **Non-Alluvial Wetlands** have comparatively fertile conditions, with high cation exchange capacity and, in the former class, high base saturation, Ca and pH levels.

Species richness is generally though to have a unimodal relationship with soil fertility (Al-Mufti *et al.* 1977). However, studies in the Southern Appalachian Mountains have consistently shown a positive correlation between species richness and soil fertility (McLeod 1988, Chapters 3 & 5). A similar patterns has been observed in forest on the piedmont of North Carolina (Christensen & Peet 1984, Palmer 1990).

The four vegetation classes which inhabit the mid- and lower-elevations of Shining Rock are common throughout most of the Southern Appalachians. The dominance of **Montane Oak Forests** and **Rich Cove and Slope Forests** in the mid- and lower-elevations of Shining Rock corresponds to the pattern observed in the Smoky Mountains (Whittaker 1956) and the Black Mountains (McLeod 1988). In contrast to most Southern Appalachian landscapes (e.g., Whittaker 1956, Golden 1981, McLeod 1988), the **Acidic Cove and Slope Forests** have relatively restricted distribution across Shining Rock. This pattern has been documented for the Balsam Mountains in general (Pittillo & Smathers 1979). There is no obvious explanation for this restricted distribution. Disturbance may have reduced **Acidic Cove and Slope Forests** distribution, or alternatively, lower-slopes and coves in Shining Rock may not be sheltered enough to support this vegetation class. The presence of xeric *Pinus*-dominated community types in the **Xeric Evergreen Forests** on dry, mid- and low-elevation ridgelines and upper-slopes corresponds to descriptions of similar communities in other high-mountain Southern Appalachian landscapes (e.g., Whittaker 1956, Golden 1981, McLeod 1988). However, in Shining Rock these communities are restricted to low-rainfall areas which previous descriptions have not noted.

The range of vegetation classes and communities at Shining Rock most closely follows those described by McLeod (1988) in the Black and Craggy Mountains. These two areas are geographically closer to one another than other high-mountain ranges and also have geologic similarities, with garnet-mica schist a common rock type in both localities. However, lenses of amphibolite and layers of metasandstone and hornblende-feldspar gneiss (McLeod 1988) suggest that some areas of the Black Mountains are probably more base-rich than the Shining Rock area. This is substantiated by the fact that corresponding community types in both landscapes have lower pH levels in the present study (Table 4.4; see Table 15 McLeod 1988).

Apart from the **Non-Alluvial Wetlands**, all vegetation classes identified in this study of Shining Rock are present within the Black Mountains. McLeod's (1988) study differs with the presence of forests dominated by *Abies fraseri*, *Tsuga caroliniana* and *Quercus alba*. Lack of suitable habitat probably accounts for the absence of the former two. The high-elevation areas of Shining Rock do not reach elevations suitable for the *Abies* dominance (Ramseur 1960). *Tsuga caroliniana* has very sparse distribution at Shining Rock, whereas this species dominates rocky bluffs, cliffs and valley flats in areas studied by McLeod (1988). The lack of prominent rock bluffs and cliffs in Shining Rock may explain the absence of *T. caroliniana* forests. At the Black Mountains, low-elevation terraces are dominated by *Q. alba*, which contrasts to the present study where such landforms are inhabited by *Liriodendron* and *Q. rubra*; reasons for this are discussed below. The abundance of *Quercus rubra* in many **Rich Cove and Slope Forests** contrasts to types in this vegetation class in the Black Mountains. This may reflect the broader range of topographic positions inhabited by this class at Shining Rock, as well as the generally drier, less fertile conditions.

The overwhelming dominance of *Betula alleghaniensis* forests across the high-elevations of Shining Rock contrasts to most other descriptions of Southern Appalachian high-elevation deciduous forests. Other studies have typically described a mixed dominance of *Acer saccharum*, *B. alleghaniensis*, *Fagus grandifolia* and *Aesculus flava* (Brown 1941, McLeod 1988, and Schafale & Weakley 1990). *Fagus* dominates areas of the Smoky

Mountains studied by Whittaker (1956), whereas *Betula alleghaniensis* and *Aesculus flava* are dominant in the central Smoky Mountains (Golden 1981). In Shining Rock, it is possible that severe disturbance may account for the dominance of successional *B. alleghaniensis*. However, this species does not dominate other high-elevation Southern Appalachian areas that probably were subjected to a similar disturbance regime during a the corresponding time period (see Saunders 1979, Pyle 1988). Dominance by *B. alleghaniensis* at Shining Rock perhaps reflects more intense disturbance, or alternatively, local climatic conditions. Golden (1981) attributed the codominance of *Betula* in the central Smoky Mountains to the sheltered, cool and moist conditions present in his study area. Similar environmental conditions exist at Shining Rock and perhaps at least partly explain the dominance of *Betula alleghaniensis*.

The presence of *Betula alleghaniensis* boulderfields at Shining Rock, noted by Schafale & Weakley (1990) have not been identified as a separate type in the present study. Pittillo & Smathers (1979) also described the existence of *Betula alleghaniensis* boulderfields at the head of some high-elevation coves in the Balsam Mountains. One stand (plot 458; elevation 1190 m) in the **Tilia-Betula lenta Forest** closely matches descriptions by Pittillo & Smathers (1979), while other rocky cove and stream margin sites in the **Tilia-Betula lenta Forest** have some affiliation with *B. alleghaniensis* and *Tilia americana* codominated boulderfields in north Georgia (Chafin & Jones 1989). These Shining Rock stands inhabit lower-elevations (1142-1453 m) than the *B. alleghaniensis* boulderfields (1300-1500 m) described by Pittillo & Smathers (1979) and may represent a lower-elevation type of boulderfield. The **Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest** in the present study has closest floristic resemblance to boulderfields described by Pittillo & Smathers (1979). However, although the soils of the Shining Rock community type are coarse-textured and sites have a marginally rocky surface substrate (10%; Table 4.26), this type inhabits convex faces and secondary ridges, rather than the concave landforms described by Pittillo & Smathers (1979) and Schafale & Weakley (1990).

Although other Southern Appalachian studies have documented the presence of *Quercus alba*-dominated communities (e.g., Whittaker 1956, Cooper & Hardin 1970, Baranski 1975, McLeod 1988, Schafale & Weakley 1990, Patterson 1994, Chapter 3) these are absent from Shining Rock. The White Oak forests described by McLeod (1988) are situated on nutrient-rich, well-drained valley flats and terraces. In Shining Rock, all potentially suitable habitats were severely disturbed in the past by logging and land clearance (USFS *unpub. data*) and are now mostly inhabited by the **Liriodendron/ Halesia Forest** and the ***Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type***.

Forests dominated by *Quercus alba* inhabit southwest slopes and ridgelines at moderate-elevations (Whittaker 1956, Baranski 1975, Patterson 1994, Chapter 3). In the Smoky Mountains *Q. alba* becomes a component of Red Oak-Chestnut forest below 1365 m, but is well distinguished as the dominant canopy species of forests above this elevation (Whittaker 1956). Baranski (1975) reported a similar distribution across the southern portion of the Southern Appalachian Mountains. At Shining Rock similar sites below 1365 m are inhabited by the **Montane Oak Forests** with *Q. alba* only a very minor component of this vegetation class. Similarly, above 1365 m the two *Q. rubra*-dominated types in the **High-Elevation Mixed Hardwood Forests** are the major types on habitats dominated by *Q. alba* in the Smoky Mountains. High-elevation *Q. rubra* forests in the Smoky Mountains typically inhabit more mesic, upper-slopes than the xeric ridgelines dominated by *Q. alba* (Whittaker 1956).

The absence of *Quercus alba* from high-elevation, southwest-facing ridgelines in Shining Rock and dominance by *Q. rubra* suggests that ridgelines of this landscape may be more mesic than those in the Smoky Mountains. Baranski (1975) suggests that *Q. rubra* dominates more mesic sites with deeper soils than *Q. alba*. In Shining Rock more mesic conditions may correspond to higher site moisture levels, caused by higher rainfall or greater soil depth or, in association with moisture, perhaps increased site fertility. However, a comparison of pH values between similar community types from these two landscapes (Cain 1931, Table 4.4) suggests that soils at Shining Rock are less fertile than those in the

Smoky Mountains. By contrast, the dominance of White Oak Ridge Forests in a high-rainfall, low-elevation landscape in the southern Blue Ridge Escarpment area (Patterson 1994) contradicts the rainfall hypothesis. Differentiation between Shining Rock and Patterson's area may reflect biogeographical differences between these landscapes, with the latter having close proximity to the mountains of South Carolina and Georgia where *Q. alba* is a dominant cove forest species (K. Patterson *pers. comm.*).

Quercus alba forests are absent from the central Smoky Mountains (Golden 1981), which Baranski (1975) attributes to lack of suitable southwest-facing habitats. However, suitable sites are present in Shining Rock. Similarly, McLeod (1988) did not report *Quercus alba*-dominated ridgelines, although he did document the presence of this species in *Quercus* forests up to 1525 m (5000 ft). All three study areas have high-rainfall conditions (see Golden 1981, McLeod 1988), which suggests that climate might account for the absence of *Q.* alba-dominated forests in these landscapes.

4.6.3. Vegetation-environment relationships

The environmental factors controlling vegetation patterns within the Shining Rock landscape are complex and vary with the scale of observation. At the landscape-scale, stands are distributed by elevation, distance to potential rainfall sources, topographic position and soil nutrients (Figures 4.2, 4.3). The vegetation classes separate into two subsets along these gradients. Environmental factors associated with vegetation patterns differ between the two subsets.

Within the high-elevation subset, the four small, outlier classes (**Grasslands**, **Non-Alluvial Wetlands**, **Rock Outcrops** and **Shrub Balds**) inhabit typically more exposed, upper-slope and higher-elevation sites than the majority of remaining types within the two remaining **High-Elevation Mixed Hardwood Forests** and **Spruce-Fir Forests** classes (Figs. 4,5). Community types within the latter two vegetation classes, are dispersed by topographic position, site moisture (TMI) and distance to rainfall source areas (Escarpment, Escarpment X central high ridge, central high ridge) (Figures 4.4, 4.5).

In contrast to high-elevation vegetation, classes within the mid- and low-elevation subset, are distributed by soil nutrients (in particular Ca, Cu, Fe, Mg, Mn and pH), topographic position and distance to rainfall source areas (Escarpment X central high ridge) (Figures 4.8-4.15). Within this subset the **Rich Cove and Slope Forests** generally inhabit the most fertile soils, with stands in the **Montane Oak Forests** also more fertile than the **Acidic Cove and Slope Forests** and the **Xeric Evergreen Forests** classes. Both the **Rich Cove and Slope Forests** and the **Acidic Cove and Slope Forests** inhabit lower-slope, concave sites and are situated closer to the rainfall source areas than the two remaining vegetation classes in this subset. The latter two classes separate from one another by topographic position, shape and distance to rainfall source areas. The **Xeric Evergreen Forests** class inhabits lower-rainfall areas, with stands positioned on drier (solar radiation, TMI), less fertile (lower cation exchange capacity, Mg), convex sites with higher slope positions than those in the **Montane Oak Forests** class.

Strong correlations between vegetation distribution and elevation, topographic position and soil nutrients at the full landscape-scale broadly follow the pattern suggested by Whittaker (1956) and others (e.g., Golden 1981, Callaway *et al.* 1987, Busing *et al.* 1993) in the Smoky Mountains and elsewhere in the Southern Appalachians (e.g., DeLapp 1978, McLeod 1988, see Chapter 5). In contrast to Linville Gorge Wilderness (Chapter 3), the vegetation patterns at Shining Rock are not closely associated with underlying geologic patterns. Although a multiple analysis of variance indicates that there are statistically significant differences in soil chemistry and texture between the three major geologic types (Tables 4.2, 4.3), geologic differences are not closely correlated with major compositional gradients. This may reflect the history of intense, widespread disturbance in the Shining Rock, and possibly the overriding influence of localized rainfall patterns and topographic gradients. Soil texture, a significant environmental variable for the distribution of vegetation at Linville Gorge (Chapter 3), has very limited significance at Shining Rock, important only for differentiating between community types within the **Rich Cove and Slope Forests** vegetation class (Figures 4.14, 4.15) and between *Betula alleghaniensis*-dominated types in the **High-Elevation Mixed Hardwood Forests** class (Figures 4.6, 4.7). Although soil texture varies with geologic type at both Linville Gorge and Shining Rock (Tables 3.2, 3.6, 4.2, 4.3), my results suggest that at Shining Rock textural differences between rock types may be more subtle, or perhaps overridden by other, stronger gradients, such as topographic shape and rainfall.

Apart from the study of Linville Gorge Wilderness (Chapter 3) and Whittaker's (1956) research in the Smoky Mountains, previous Southern Appalachian studies have described vegetation-environment relationships in landscapes widely disturbed by logging and fire in the early part of this century. This limits our ability to determine the extent to which disturbance has altered vegetation-environment relationships at Shining Rock. For high-elevations, based on historic records, I surmise that community type distribution and association with specific topographic characteristics, such as slope position, protection and shape, of at least the **Spruce-Fir Forests** and *Betula alleghaniensis* community types have been altered significantly by logging and fire. Changes in vegetation-environment relationships at the mid- and low-elevations are more difficult to ascertain. However, the presence of fire-tolerant species at mid- and low-elevations suggests that the patterns we described for this region of Shining Rock are probably more similar to those of the pre-disturbance landscape than those described for high-elevation vegetation classes.

The separation of Shining Rock stands into two distinct subsets follows the pattern observed by McLeod (1988). The separation between the two groups occurs at a similar elevation in both studies (1500 m in the Black Mountains (McLeod 1988); 1590 m at Shining Rock). In both studies high-elevation stands are primarily distributed along an elevational gradient. However, at Shining Rock, the high-elevation subset is also distributed by topographic position, site moisture and distance to rainfall source areas. McLeod (1988) observed that stands below 1500 m were primarily influenced by soil nutrient and topographic gradients, with elevation secondary. Similarly, at Shining Rock the mid- and low-elevation vegetation classes are distributed along gradients of soil nutrients, topographic position and distance to rainfall source areas, with elevation only a significant variable for separating community types within the **Rich Cove and Slope Forests** class. The pattern observed at Shining Rock follows the hypothesis put forward in Chapter 3. I proposed that vegetation inhabiting the more dissected mid- and lower-slope regions within the Southern Appalachians will be influenced by a broader range of topographic and soil extremes than higher-elevation sites. I suggested that such differences are more subtle at high-elevations, due to less dissected topography and the generally more exposed and extreme conditions at hand and that this enables elevational factors to have the primary influence on vegetation patterns.

More extreme soil conditions are visible in the high-elevations of Shining Rock. In general, high-elevation stands have less fertile soils, with higher Fe and organic matter and, with the exception of the **Grasslands** class, lower base saturation, Cu, pH and S values than mid- and low-elevation stands (Table 4.4). Less fertile conditions at high-elevations probably reflect down-slope nutrient movement and leaching associated with the moister high-elevation climate. It is also possible that high fire intensity at high-elevations may have decreased soil fertility by erosion.

The comparative abundance of xeric *Pinus*-dominated communities in the northern half of the Wilderness and near absence from the wetter southern portion of Shining Rock illustrates the influence of rainfall on plant community distribution in this landscape. Although the association between both regional and localized rainfall patterns and Southern Appalachian Mountain vegetation patterns has been noted by numerous authors (e.g., Shanks 1954, Whittaker 1956, Billings & Anderson 1966, Cooper & Hardin 1970, Golden 1981, White *et al.* 1993), this is the first Southern Appalachian vegetation study to attempt to quantify associations between specific vegetation groups and rainfall patterns. The sparsity of high-elevation weather stations continues to prevent scientists from accurately quantifying the rainfall patterns of most high-elevation, mountainous areas in this region. In recent years climatologists have made attempts at overcoming these problems by modeling rainfall patterns using digital elevational models (e.g., Doll 1992, Basist *et al.* 1994, Konrad 1996). In this study I used distance to known rainfall source areas as a surrogate for quantified rainfall. While this method cannot quantify rainfall levels, it has the potential to provide at least a crude estimate of localized rainfall patterns. My distance estimates proved to be strongly associated with the compositional patterns in all vegetation classes (Figures

4.2-4.15). I emphasize that these results indicate influence of potential rainfall patterns rather than quantified rainfall measurements.

The results of this study emphasize the complexity of vegetation patterns in the Southern Appalachian Mountains and suggest that topographic characteristics, their associated soil nutrient gradients and local climatic conditions are the most important factors controlling the distribution of vegetation in high-rainfall, high-mountain areas of the Southern Appalachian Mountains. This study reiterates the importance of quantitative environmental information and highlights the need to quantify climatic information to develop a greater understanding of vegetation patterns across this region.

The combination of high-rainfall, past logging and intense fire in Shining Rock have created an environment in which an unusual assemblage and abundance of vegetation communities have developed. The overall dominance of *Betula alleghaniensis* at high-elevations illustrates severity of past disturbances and the distinctiveness of this Wilderness in relation to other high-mountain landscapes in the Southern Appalachians. Moreover, the limited distribution of the **Xeric Evergreen Forests** and absence of other xeric community types highlights the proximity of Shining Rock to the high-rainfall Escarpment area. Indeed, although many studies have examined vegetation patterns in lower-elevation landscapes within the Escarpment region, this study is one of only a few to detail vegetation patterns in a high-elevation landscape adjacent to the Escarpment. Although the factors controlling the vegetation class distribution at the landscape-scale across Shining Rock correspond to those identified in other studies in the Southern Appalachians, detailed examination of closely associated vegetation classes have highlighted the importance of topographic characteristics and soil nutrients for differentiating subtle compositional differences between community types.

4.7 Overall trends and future research needs

The logging and fire that took place in the early part of this century have greatly influenced the distribution and composition of present-day community types in Shining

Rock and have caused them to be less predictable for site characteristics than forests of much of the Southern Appalachian region. The impact of these disturbances is most visible in the high-elevations of Shining Rock. Within this region of the landscape more severe disturbances, coupled with extreme weather conditions, have set back the starting point of succession and may have slowed the pace of successional development in comparison to community types present in the more sheltered, mid- and lower-elevations. Although several authors have produced hypothetical successional trajectories of high-elevation community types (e.g., Ramseur 1960, McLeod 1988), few have studied and quantified successional change. This restricts our overall understanding of these communities and limits our ability to project their future development. There is a need to monitor a series of permanent plots in Shining Rock to quantify successional changes of high-elevation community types. This would increase our ability to effectively manage high-elevation vegetation.

The overwhelming dominance of *Betula alleghaniensis* in the high-elevations of Shining Rock highlights the uniqueness of this landscape in comparison to other Southern Appalachian high-mountain areas. Research is needed to determine the impact of past disturbances and factors such as rainfall on the distribution of this species as well as understanding the dynamics and future role of this species.

While historic records suggest that **Spruce-Fir Forests** once dominated the high-elevations of Shining Rock, today this vegetation class is restricted to a very small portion of this Wilderness. The close proximity of this vegetation class to Shining Rock Gap and the associated heavy recreational activities threatens the integrity and future survival of **Spruce-Fir Forests**. This stresses the need to monitor the impact of human activities and determine the levels of degradation within this vegetation class to enable effective management and ensure the survival of the **Spruce-Fir Forests** in this landscape in an intact state.

This study has also made clear the compositional differences of **Spruce-Fir Forests** in Shining Rock in comparison to other **Spruce-Fir Forests** in the Southern Appalachians. More detailed study is needed to understand these differences and also the dynamics of this vegetation class in this landscape.

The limited level of *Quercus* regeneration relative to its canopy dominance has been widely observed throughout eastern North America (see Lorimer 1989, Abrams 1992, Newell & Peet 1995) and has again been documented in this study, particularly in the **Montane Oak Forests**. Summary information shows that *Quercus* species are regenerating in a limited number of community types in Shining Rock; particularly *Q. rubra* in the high-elevation *Quercus rubra* dominated community types, the ***Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanicum*** sub-type and the **Quercus rubra-Aesculus-Robinia pseudo-acacia Forest**, *Q. montana* in two of the three **Xeric Evergreen Forests** and *Q. coccinea* in the **Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest**. The presence of *Quercus* saplings may result from disturbances earlier this century. However, the disturbance regime described in Shining Rock is no doubt similar to many other landscapes across Eastern North America. This highlights the need to determine whether this pattern exists in other apparently non-regenerating *Quercus* landscapes and, with respect to the present study, the need to identify a disturbance periodicity necessary to maintain *Quercus* regeneration.

The presence of *Tsuga canadensis* in Shining Rock gives some insight into the possible consequences of a low disturbance regime. Although *Tsuga canadensis* dominated communities in the **Acidic Cove and Slope Forests** have limited distribution throughout the Wilderness, *Tsuga* is present as an understory species in many community types, particularly in the **Montane Oak Forests** vegetation class. Without periodic disturbance I predict that *Tsuga* presence will continue to increase and could eventually become a major component of these communities. It must be noted that the southward moving hemlock adelgid may possibly decrease *Tsuga* presence. Increases in *Tsuga* dominance could markedly change the character of present **Montane Oak Forests**. Evergreen *Tsuga* would reduce light conditions throughout the lower strata of these community types, and in conjunction with the acidic content and slow decomposition of its leaves, could drastically change the composition and species richness levels of **Montane Oak Forests** community types. This emphasizes the need to undertake research to understand the disturbance regime of specific community types and individual species within Shining Rock and possible consequences of increased *Tsuga* presence within **Montane Oak Forests**. Such information would be beneficial for management of forests throughout other areas of the Southern Appalachians.

This study highlights the presence of several community types that have limited distribution throughout the Southern Appalachian region and provides quantified information on their composition, structure and ecology. However, further research is needed to ensure the continuing survival of these types. Methods must be identified to ensure the maintenance and integrity of the **Non-Alluvial Wetlands**, one of the few cases where Southern Appalachian **Non-Alluvial Wetlands** are isolated from human disturbances. Further study is also needed to locate and document other **Non-Alluvial Wetlands** sites within Shining Rock in an effort to understand the species diversity and compositional variation within this vegetation class.

The results of this study emphasize the role of topographic position, soil nutrients and rainfall on the distribution of vegetation within the Shining Rock landscape. This study also suggests that high-elevation vegetation has strongest association with a different set of environmental characteristics than vegetation in the mid-to-low elevation regions of the Shining Rock. However, more detailed research is needed to understand the specific links between rainfall, topography, soil nutrients and vegetation attributes such as community type distribution and species richness.

This study is one of the few that has quantified the vegetation of a Southern Appalachian high-mountain landscape outside the Great Smoky Mountains. The results of this study highlight the uniqueness of Shining Rock Wilderness in relation to other high-mountain landscapes in this region.

CHAPTER 5. VEGETATION OF JOYCE KILMER/SLICKROCK WILDERNESS

5.1 Community classification

Thirty three community types were recognized in Joyce Kilmer using Ward's clustering method (Figure 5.1, Table 5.1). One hundred and eighty two of the 183 sites sampled (plot 650 was eliminated due to its unnatural status) and all 424 species were used in this classification. Ten of the twelve vegetation classes present in the Southern Appalachian Mountains are present within Joyce Kilmer (Figure 5.1, Table 5.1, see Table 2.3). Synonymy between the Joyce Kilmer/Slickrock Wilderness classification and the nationally recognized classification scheme developed by The Nature Conservancy is tabulated in Appendix 3. Community types and sub-types identified as "new alliance" or "new association" indicates cases where the results of this project have revealed communities that have not been previously recognized in The Nature Conservancy classification.

Vegetation groups in the classification generated using Ward's clustering technique were accepted at R-squared = 0.529 level (Figure 5.1). Divisions below this level subdivided closely associated groups, while those above lumped groups easily recognizable in the field. In this study of Joyce Kilmer, a total of 10 vegetation classes, 33 community types and 6 community sub-types were identified (Figure 5.1, Table 5.1)
(Figure 3, Table 5).

5.2 Mapping

A detailed map of Joyce Kilmer was produced showing the distribution and boundaries of the community types identified in this study (Appendix 5). The spatially restricted **Rock Outcrops** vegetation class were not mapped due to the small spatial extent of its distribution.

Figure 5.1 Dendrogram showing divisions and final vegetation groupings in Joyce Kilmer identified using the Bray Curtis dissimilarity measure in the Ward's clustering technique. 182 samples were used. Cut-off level for community type groupings is shown by dashed line. Ultimate groupings are represented by their abbreviation code. For full names see Table 5.1. For group sample size and membership see Appendix 3. Groups not connected to the main dendrogram were eliminated from the classification using the TRIM function.

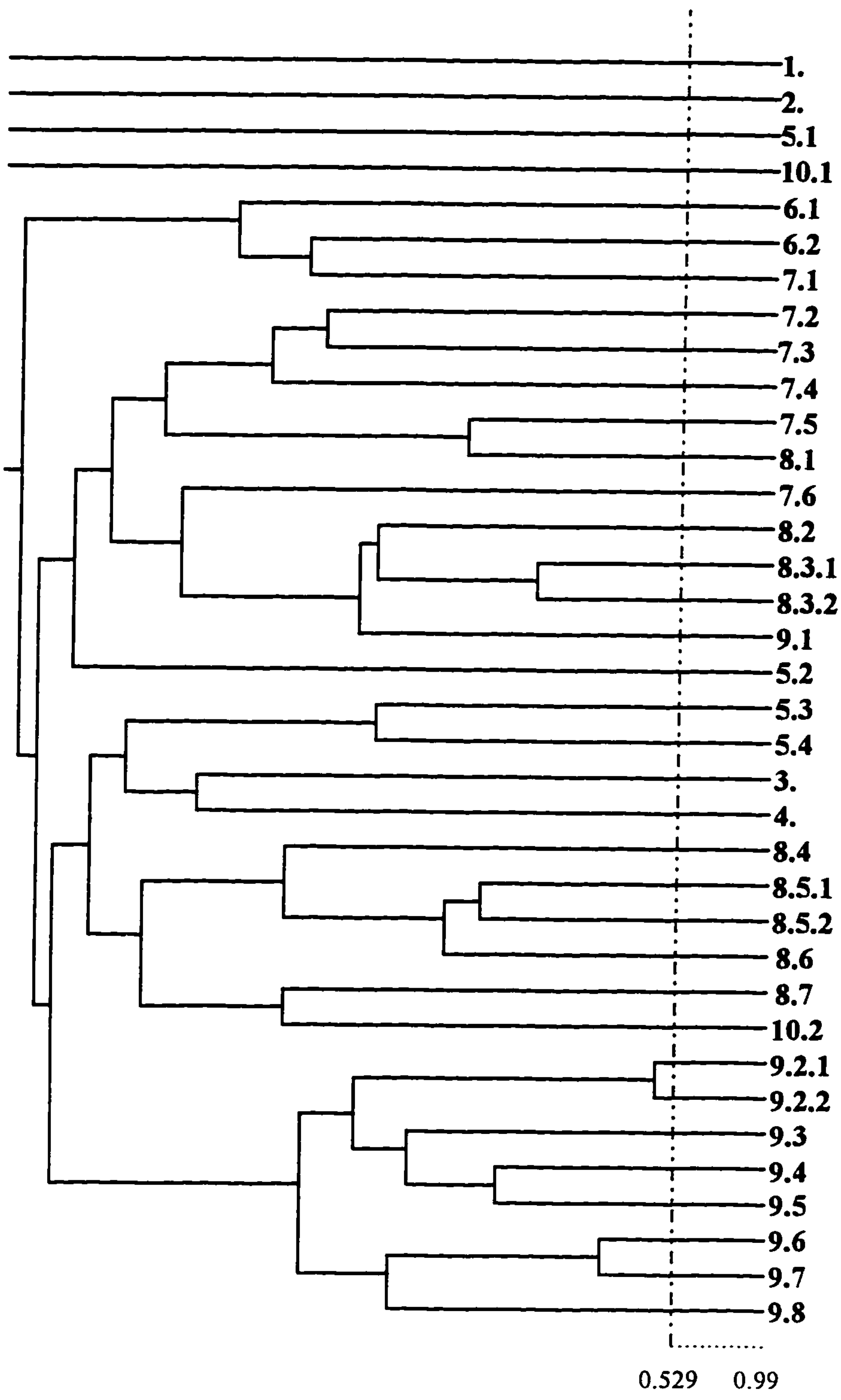


Table 5.1. Hierarchical community classification of Joyce Kilmer/Slickrock Wilderness. Each vegetation class is shown, listing all community types and community sub-types present. Names of the three levels of the hierarchy are as follows: Vegetation Class (e.g. code 8), Community type (e.g. code 8.5), Community sub-type (e.g. 8.5.1). A name enclosed by [] represents a tentative name owing to limited sample size. For the list of sample sites in each group see Appendix 3.

1. Rock Outcrops
   - 1.1 [Aronia melanocarpa/Danthonia compressa Outcrop]

2. Non-Alluvial Wetlands
   - **2.1 [Liriodendron-Acer rubrum/Carex ruthii Wetland]**

3. Grasslands
   - **3.1 [Crategus macrosperma/Fragaria virginiana/Phlox carolina Grassland]**

4. Shrub Balds
   - **4.1 [Rhododendron catawbiense-Kalmia Shrubland]**

5. High-Elevation Mixed Hardwood Forests
   - **5.1 Betula alleghaniensis-Fagus/Rhododendron maximum Forest**
   - **5.2 Quercus rubra/Thelypteris Forest**
   - **5.3 Fagus-Betula alleghaniensis/Dryopteris intermedia Forest**
   - **5.4 Fagus/Carex pensylvanica Forest**

6. Xeric Evergreen Forests
   - **6.1 Quercus montana-Pinus rigida/Vaccinium pallidum Forest**
   - **6.2 Quercus montana-Quercus coccinea/Galax Forest**

7. Montane Oak Forests
   - **7.1 Quercus montana-Quercus velutina/Oxydendrum Forest**
   - **7.2 Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest**
   - **7.3 Quercus montana-Quercus rubra/Cornus florida Forest**
   - **7.4 Carya alba-Quercus alba/Cornus florida/Polystichum Forest**
   - **7.5 Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest**
   - **7.6 Quercus rubra-Halesia/Thelypteris Forest**

Table 5.1 *cont.* Hierarchical community classification of Joyce Kilmer/Slickrock Wilderness vegetation.

8. <u>Acidic Cove</u> and <u>Slope Forests</u>

8.1 Acer rubrum/Rhododendron maximum Forest
8.2 Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest
8.3 Tsuga canadensis-Liriodendron/Thelypteris Forest
8.3.1 Tsuga canadensis-Liriodendron/Mitchella sub-type
8.3.2 Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type
8.4 Tsuga canadensis-Halesia/Dryopteris intermedia Forest
8.5 Tsuga canadensis-Magnolia fraseri Forest
8.5.1 Magnolia fraseri/Acer pensylvanicum sub-type
8.5.2 Tsuga canadensis-Fagus-Halesia sub-type
8.6 Tsuga canadensis/Rhododendron maximum Forest
8.7 Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest

9. <u>Rich Cove</u> and <u>Slope Forests</u>

9.1 Liriodendron/Cornus florida Forest
9.2 Acer saccharum-Halesia/Cimicifuga racemosa Forest
9.2.1 Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type
9.2.2 Halesia-Acer saccharum-Tilia/Viola blanda sub-type
9.3 Tsuga canadensis-Halesia/Laportea Forest
9.4 Acer saccharum-Fagus/Viola blanda Forest
9.5 Liriodendron-Tilia/Asarum canadense Forest
9.6 [Acer saccharum-Halesia/Cladrastis/Solidago curtisii Forest]
9.7 Aesculus-Acer saccharum/Solidago curtisii Forest
9.8 [Aesculus/Rudbeckia lacinata Forest]

10. <u>Alluvial Forests</u>

10.1 [Liriodendron-Platanus/Amphicarpaea Alluvial Forest]
10.2 Platanus-Betula alleghaniensis Alluvial Forest

5.3 Relationship of vegetation composition to major environmental gradients across the Joyce Kilmer landscape

The relationship between vegetation and environmental information was examined to identify what environmental factors might influence the distribution of vegetation across the Joyce Kilmer landscape. Ordination (DCA) was used to identify major compositional gradients within the Joyce Kilmer dataset. Associations between the first two compositional gradients and specific environmental variables were quantified using regression to identify site factors that correspond with vegetation patterns.

After the elimination of the outlying vegetation classes (**Rock Outcrops, Grasslands, Shrub Balds, Alluvial Forests** and the **Non-Alluvial Wetlands**) identified as outliers in preliminary ordinations, the remaining 172 stands, representing the five major vegetation classes (Figure 5.1, Table 5.1), were used in the first DCA analysis. The first two compositional gradients are displayed on a scatterplot diagram and are classified by their respective vegetation class (Figure 5.2). Stands positioned by their scores on the primary and secondary compositional gradients (Axis 1 and Axis 2) of the respective DCA ordination. Statistically significant relationships ($P \leq 0.01$) between the first two compositional gradients and environmental variables were identified in the regression analyses, and these are represented by a vector diagram (Figure 5.3). Each environmental variable is represented by a vector where the direction of maximum change indicates the relative correlation with the two axes. Vector length indicates the strength (representing R^2) of the association (ter Braak 1986, 1987).

5.3.1 Ordination of the 172 stand dataset

The five major vegetation classes are distributed across the Joyce Kilmer landscape primarily along elevation, soil nutrient, soil texture and topographic moisture gradients (Figures 5.2, 5.3). The **High-Elevation Mixed Hardwood Forests** vegetation class is situated at the upper-end of the elevation gradient, positioned on the upper-center and right of the scatterplot (Figure 5.2). This class also tends to have more organic, coarser-textured soils, with higher Fe levels (Figure 5.3). The **Xeric Evergreen Forests** are positioned at the opposing end of the elevation-soil texture gradient, inhabiting low-elevation sites with soils with a high clay component. These two vegetation classes are also positioned at the one end of the soil fertility-slope position gradient, which runs from the upper-left to lower-right of the diagram and typically inhabit less fertile, dryer (lower TMI), higher- slope positions (lower relative slope position) than the other three classes. The **Xeric Evergreen Forests** occur on dryer and warmer sites (higher solar radiation) than the **High-Elevation Mixed Hardwood Forests**. The remaining three vegetation classes separate along the soil fertility-slope position gradient, with the **Rich Cove and Slope Forests** inhabiting more fertile (higher Ca, Mg and Mn), moister (high TMI), lower-slope sites than the **Montane Oak Forests** and the **Acidic Cove and Slope Forests**.

The relationship between underlying parent material type and the major compositional gradients was also investigated. A multiple analysis of variance indicates that the sixteen major parent material types have statistically significantly different soil chemistry and texture (Tables 5.2, 5.3, 5.6). Stands were classified on the scatterplot by their bedrock type in an attempt to identify correlations between parent material and vegetation patterns. However, while stands in the **High-Elevation Mixed Hardwood Forests** are underlain by metagraywacke and arkosic metasandstone-metaconglomerate (parent material type 12; Figure 1.5), the majority of stands did not separate well by parent material type, reflecting both the geologic complexity and bedrock type distribution within Joyce Kilmer. This study area is somewhat systematically subdivided by geologic types with boundaries typically parallel to the main direction of the Wilderness (see Figure 1.5) with only one parent material type present in both major watersheds. Stands were also classified by the aggregate geologic classes but the patterns were no clearer. Possibly links between vegetation composition and broader-scale geologic differences were investigated by classifying stands by their respective metamorphic grade (see Figure 1.5). No clear patterns were observed, although a multiple analysis of variance indicates that the three metamorphic grades have statistically significantly different soil chemistry and texture (Tables 5.5, 5.6). Similar results were found in most subsequent ordination analyses and, as a consequence, no diagrams displaying stands classified by geologic type were included.

The relationship between position in the Joyce Kilmer landscape and the major compositional gradients was also investigated. Stands were classified on the scatterplot by their respective watershed in attempt to identify correlations between watershed and vegetation patterns. However, although soils from the four watersheds were statistically different (Tables 5.4, 5.6), stands did not separate well by watershed on the ordination diagram. Similar results were found in all subsequent ordinations.

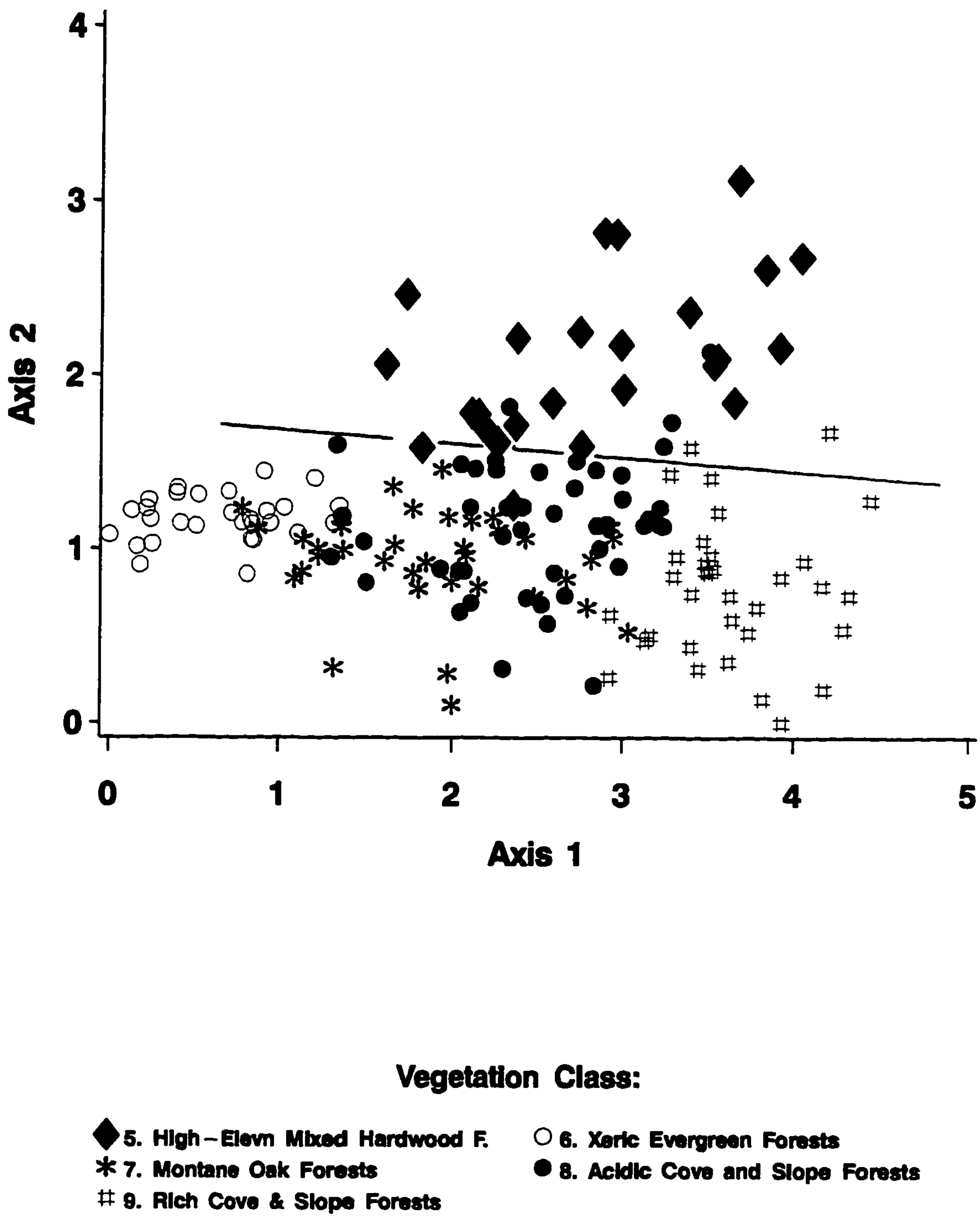
Although the ordination separated the **High-Elevation Mixed Hardwood Forests** from the four mid- and low-elevation vegetation classes (the **Acidic Cove and Slope Forests, Montane Oak Forests, Rich Cove and Slope Forests** and **Xeric Evergreen Forests** classes) along the elevational gradient (Figures 5.2, 5.3) stands in the latter four classes were not well grouped by their respective vegetation class. This restricts vegetation-environment interpretation. The inclusion of elevation in the two dimensional ordination diagram may well confound the solar radiation-site nutrient gradients. In an attempt to clarify compositional and environmental differences between individual vegetation classes the four mid- and low-elevation vegetation classes were fragmented from the **High-Elevation Mixed Hardwood Forests** class (shown by the black line; Figure 5.2) and were analyzed separately.

Subsequent ordinations of the mid- and low-elevation subset, consisting of the **Acidic Cove and Slope Forests, Montane Oak Forests, Rich Cove and Slope Forests** and **Xeric Evergreen Forests** classes are discussed at the beginning of the description for the **Xeric Evergreen Forests** (p. 573). Separate ordinations were also performed on stands in each of the five major vegetation class used in the initial 172 stand ordination in an attempt to identify the compositional and environmental differences between individual community types within a vegetation class. Each analysis is presented at the beginning of the description of the respective vegetation class.

5.4 Summary soil and species richness information

To aid in accessibility and for ease of interpretation and comparisons between different vegetation groups in Joyce Kilmer, I have summarized average soil chemistry and textural information for all 10 vegetation classes in two tables (Tables 5.7, 5.8). These tables are presented before the section containing the descriptions of each individual vegetation class. Multiple analyses of variance indicated that soil chemistry, texture and soil depth were statistically significantly different between vegetation classes and community types ($P \geq 0.001$). Mean species richness values (the average number of species per unit area) are also provided for all vegetation classes and associated community types for all of the seven spatial scales measured (Table 5.9). Summary soil characteristics are given for each geologic type and watershed (Tables 5.2, 5.3, 5.4).

Figure 5.2. DCA ordination diagram showing the distribution of the 172 stand dataset in the **Acidic Cove and Slope Forests, Montane Oak Forests, High-Elevation Mixed Hardwood Forests, Rich Cove and Slope Forests** and **Xeric Evergreen Forests** on the two major compositional gradients. The black line shows separation of stands for future reordinations.


Axis 2
Axis 1
0
1
2
3
4
5
Vegetation Class:
5. High-Elevn Mixed Hardwood F.
6. Xeric Evergreen Forests
7. Montane Oak Forests
8. Acidic Cove and Slope Forests
9. Rich Cove & Slope Forests

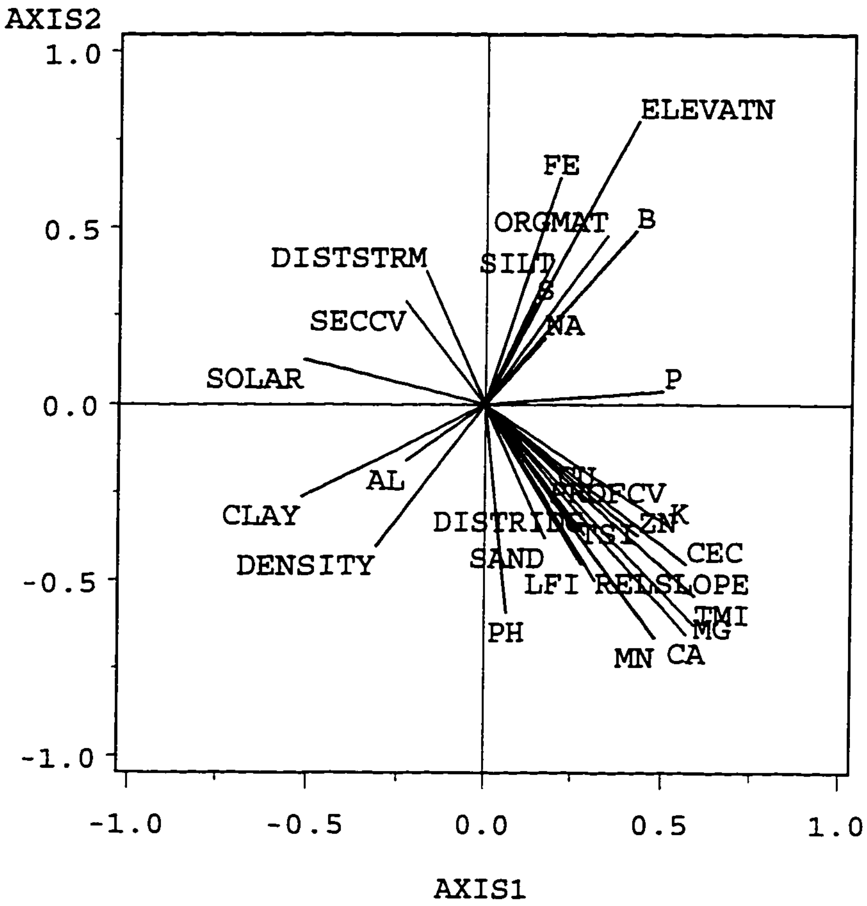


Figure 5.3. Vector diagram for DCA ordination of the 172 stand dataset showing association between species composition and major environmental gradients. DISTRIDG=distance to ridge, DISTSTRM=distance downslope to cove, RELSLOPE =relative slope position, with increasing values corresponding to higher position, PROFCV =profile curvature, SECCV=section curvature. Small LFI values represent unprotected upper-slopes progressing through to high values representing concave lower-slopes. Increasing TMI values correspond with increasing site moisture potential. Low TSI values represent convex upper-slopes while high values represent concave lower-slopes.

Table 5.2. Mean soil nutrient values for sample sites in each parent material class. Only the 169 stands with known parent material were used. Parent material abbreviations are as follows: Q: colluvium and alluvium, 1: cobble arkosic metasandstone, 2: pyritic slate, 3: metasandstone-metaconglomerate, 4: slate-metasandstone, 5: metaconglomerate-metasandstone, 6: arkosic metasandstone, 7: arkosic metasandstone-metaconglomerate-slate, 8: slate, 9: graphitic metagraywacke, 10: arkosic metasandstone-slate, 11: arkosic metasandstone-metaconglomerate-metasiltstone, 12: metagraywacke, 13: arkosic metasandstone-metaconglomerate, 14: phyllite-mica schist, 15: arkosic metasandstone-phyllite. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmt) (by loss on ignition) and soil bulk density (dens).

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
Q	1299.56	0.30	373.63	0.50	229.00	89.19	66.63	80.69	62.13	11.88	24.56	49.00	3.18	7.82	4.42	14.82	2.03	44.56
1	1447.33	0.25	204.00	0.23	154.17	42.17	40.83	103.33	54.67	10.00	31.33	51.17	1.28	4.40	4.30	6.79	2.29	41.71
2	1319.75	0.40	617.00	1.87	159.75	73.75	84.00	326.75	61.75	13.25	27.50	66.75	3.50	9.75	4.35	11.06	2.20	44.44
3	1143.08	0.30	133.50	0.64	205.50	42.08	37.08	55.83	52.92	11.08	20.58	47.00	2.27	3.53	4.33	7.29	2.18	41.83
4	1327.75	0.31	243.75	0.88	217.17	54.50	47.75	60.67	61.42	11.08	18.33	59.75	2.47	4.74	4.33	10.67	2.08	42.63
7	1264.00	0.28	110.00	0.74	202.00	72.00	45.00	65.00	65.00	14.00	23.00	41.00	2.53	3.72	4.28	20.10	1.74	40.50
8	1282.00	0.30	185.00	0.83	250.50	79.00	44.00	27.50	64.50	11.00	18.00	39.00	5.29	4.90	4.33	15.33	1.94	42.00
9	1580.25	0.28	211.50	0.41	195.75	67.50	47.25	27.00	63.50	11.75	21.50	55.75	2.76	5.51	4.25	15.97	1.88	40.56
10	1380.64	0.35	317.76	0.75	237.20	63.08	54.56	73.52	61.52	12.36	28.72	63.68	2.84	7.47	4.15	11.20	2.09	38.72
11	1081.08	0.46	343.83	0.76	303.25	75.42	79.42	52.08	64.08	15.08	42.83	67.83	4.61	10.97	3.69	28.65	1.89	33.31
12	1274.00	0.46	249.29	0.92	334.94	69.18	58.00	48.82	63.94	14.29	37.00	76.29	3.19	8.50	3.79	19.16	1.90	34.12
13	1469.18	0.35	302.95	0.77	222.44	80.18	56.49	62.51	63.72	10.56	21.97	52.72	3.05	6.34	4.40	16.12	1.84	43.55
14	1323.00	0.37	209.25	0.72	262.00	81.00	55.00	35.25	63.25	11.00	17.75	46.75	2.72	5.76	4.23	15.85	1.91	39.50
15	1357.20	0.35	402.60	0.69	191.33	82.87	73.00	51.60	61.60	10.47	17.67	43.00	2.92	7.77	4.54	14.58	2.01	46.20

Table 5.3. Mean soil texture values for sample sites in each parent material class. Only the 169 stands with known parent material were used. Parent material abbreviations are as follows: Q: colluvium and alluvium, 1: cobble arkosic metasandstone, 2: pyritic slate, 3: metasandstone-metaconglomerate, 4: slate-metasandstone, 5: metaconglomerate-metasandstone, 6: arkosic metasandstone, 7: arkosic metasandstone-metaconglomerate-slate, 8: slate, 9: graphitic metagraywacke, 10: arkosic metasandstone-slate, 11: arkosic metasandstone-metaconglomerate-metasiltstone, 12: metagraywacke, 13: arkosic metasandstone-metaconglomerate, 14: phyllite-mica schist, 15: arkosic metasandstone-phyllite. Values of sand, silt and clay are given as percentages. 'N' represents the number of stands in each geologic type.

	Sand	Silt	Clay	N
Q	30.63	53.77	15.61	16
1	40.27	39.77	19.96	6
2	25.93	55.97	18.11	4
3	40.03	43.72	16.25	12
4	20.12	62.21	17.67	12
7	14.80	79.36	5.84	1
8	24.60	56.56	18.84	2
9	26.80	57.68	15.52	4
10	28.93	52.39	18.68	25
11	23.70	65.78	10.52	12
12	26.26	60.58	13.16	17
13	23.51	61.60	14.89	39
14	21.20	60.81	17.99	4
15	24.42	59.27	16.31	15

Table 5.4. Mean soil nutrient and texture values for sample sites in watershed. All 182 stands were used. Watershed abbreviations are as follows: 1=Little Santeetlah, 2=Slickrock, 3=Horse Cove, 4=Deep Creek. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmat) (by loss on ignition) and soil bulk density (dens). Values of sand, silt and clay are given as percentages. 'N' represents the number of stands in each watershed.

VALLEY	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
1	1420.29	0.37	331.29	0.78	239.74	80.91	60.22	57.17	63.35	11.00	22.49	53.26	3.01	7.11	4.35	15.41	1.90	42.80
2	1275.25	0.33	275.91	0.73	228.51	62.71	56.61	78.65	60.46	12.54	28.46	59.72	3.04	6.86	4.16	14.33	2.07	39.73
3	1378.00	0.41	90.00	0.47	174.00	49.00	36.00	46.00	58.00	8.00	13.00	40.00	1.60	2.49	4.53	8.23	2.24	45.50
4	1206.50	0.51	183.50	0.65	335.50	63.00	48.50	21.00	64.00	13.50	39.50	58.00	2.02	7.73	3.58	20.93	1.73	30.75

VALLEY	Sand	Silt	Clay	N
1	24.09	60.87	15.05	78
2	29.44	54.09	16.47	88
3	31.00	48.80	20.20	10
4	22.30	65.50	12.20	6

Table 5.5. Mean soil nutrient and texture values for sample sites in each metamorphic grade. Only the 169 stands with known geology were used. Metamorphic grade abbreviations are as follows: 1=Chlorite, 2=Biotite, 3=Garnet. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmat) (by loss on ignition) and soil bulk density (dens). Values of sand, silt and clay are given as percentages. 'N' represents the number of stands in each metamorphic grade.

METGR-ADE	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
1	1272.03	0.31	246.47	0.82	199.76	54.00	48.76	98.09	57.97	11.53	23.24	53.50	2.59	5.04	4.31	9.99	2.13	42.04
2	1320.09	0.39	286.04	0.72	276.93	70.78	57.85	61.64	62.75	12.74	30.96	64.58	3.20	7.79	4.06	16.86	1.96	37.99
3	1416.19	0.33	351.35	0.74	192.94	81.80	64.15	58.56	62.80	10.63	19.61	46.70	2.97	6.91	4.47	14.95	1.93	45.04

METGR-ADE	Sand	Silt	Clay	N
1	30.88	52.35	16.77	34
2	26.29	58.15	15.56	81
3	25.39	59.0.	15.52	54

Table 5.6. Results from a multivariate analysis of variance to determine the significance of soil characteristics (nutrients and texture) per parent material type, watershed and metamorphic grade. These analyses were performed using the General Linear Models Procedure for unbalanced designs.

a) *Parent material type*. Only the 169 stands with known parent material and classified in the sixteen major parent material types (see Table 2 for listing, Figure 1 for distribution) were included.

Statistic	F value	Pr > F
Wilks' Lamba	2.365	0.0001
Pillai's Trace	2.089	0.0001
Hotelling-Lauley Trace	2.633	0.0001
Roy's Greatest Root	12.625	0.0001

b) *Watershed*. All 182 stands were included.

Statistic	F value	Pr > F
Wilks' Lamba	2.014	0.0001
Pillai's Trace	1.905	0.0001
Hotelling-Lauley Trace	2.129	0.0001
Roy's Greatest Root	4.575	0.0001

c) *Metamorphic rock grade*. All 169 stands with known geology were included (see Figure 1 for distribution).

Statistic	F value	Pr > F
Wilks' Lamba	3.624	0.0001
Pillai's Trace	3.636	0.0001
Hotelling-Lauley Trace	3.612	0.0001
Roy's Greatest Root	4.200	0.0001

Table 5.7. Average soil nutrient values by vegetation class and associated community types and sub-types. Groups are referenced by their abbreviation code. For full names see Table 5.1. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmat) (by loss on ignition) and soil bulk density (dens).

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
1.	724.00	0.47	319.00	2.49	310.00	75.00	70.00	10.00	65.00	24.00	78.00	92.00	11.70	14.39	3.30	22.30	2.15	28.00
2.	1264.00	0.28	110.00	0.74	202.00	72.00	45.00	65.00	65.00	14.00	23.00	41.00	2.53	3.72	4.28	20.10	1.74	40.50
3.	1236.50	0.56	207.00	1.65	379.50	64.00	50.50	46.00	61.00	14.00	62.00	106.00	2.60	7.11	3.75	9.40	1.89	33.00
4.	322.50	0.38	104.50	0.24	70.00	92.00	177.00	4.00	65.00	30.50	51.50	43.50	8.00	21.12	2.70	88.50	1.97	23.50
5.	1437.15	0.43	189.23	0.64	324.88	76.08	46.23	36.69	65.15	11.88	30.38	69.12	2.42	6.39	3.95	19.03	1.81	36.24
5.1	1236.25	0.50	181.25	0.33	416.75	74.50	45.25	10.00	65.00	12.25	26.25	46.00	1.94	7.64	3.78	22.49	1.87	34.00
5.2	1612.62	0.35	211.46	0.73	230.23	86.08	45.00	38.54	65.46	11.15	19.69	59.38	2.85	5.51	4.25	18.20	1.80	40.56
5.3	1291.57	0.52	163.43	0.67	428.57	61.86	48.86	54.86	64.71	12.29	49.57	102.29	1.93	7.09	3.62	17.80	1.84	31.21
5.4	1208.00	0.51	151.00	0.59	393.50	64.00	47.00	14.50	65.00	14.50	41.00	62.50	2.28	7.15	3.53	21.76	1.67	30.25
6.	1386.34	0.28	134.34	0.59	232.97	48.41	34.97	28.34	58.55	11.00	16.03	52.38	2.04	3.84	4.21	9.25	2.15	39.51
6.1	1394.30	0.30	140.70	0.68	226.20	45.30	32.20	50.20	58.40	11.20	15.90	53.90	1.85	4.02	4.13	9.72	2.15	38.50
6.2	1382.16	0.27	131.00	0.53	236.53	50.05	36.42	16.84	58.63	10.89	16.11	51.58	2.14	3.75	4.24	9.00	2.15	40.04
7.	1435.25	0.30	212.03	0.82	174.17	63.31	52.19	83.97	61.14	10.97	22.56	49.89	2.43	5.10	4.41	11.76	2.11	43.52
7.1	1560.60	0.25	165.40	0.61	160.20	66.20	38.60	25.40	59.60	9.40	13.60	43.00	2.19	3.54	4.66	10.16	2.08	48.15
7.2	1406.00	0.33	170.25	1.30	179.75	58.00	40.25	79.25	63.25	11.00	17.00	47.25	3.95	3.92	4.48	12.59	2.04	44.94
7.3	1503.57	0.25	242.14	0.78	184.00	71.14	58.57	67.43	61.29	11.14	18.14	44.14	2.44	5.31	4.51	10.08	2.12	45.36
7.4	1347.80	0.29	209.40	0.86	148.00	50.40	53.40	207.60	59.20	12.00	43.60	66.60	2.03	5.22	4.24	9.07	2.23	40.55
7.5	1279.67	0.39	128.83	0.70	207.50	60.33	55.50	39.33	59.67	11.33	16.83	41.67	2.00	4.13	4.43	11.66	2.18	43.63
7.6	1477.78	0.31	290.00	0.81	164.11	67.11	57.22	92.56	63.00	10.89	25.56	55.56	2.41	6.90	4.25	15.17	2.02	40.45

Table 5.7. *cont.* Average soil nutrient values by vegetation class and associated community types and sub-types. Groups are referenced by their abbreviation code. For full names see Table 5.1. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g./100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (p.p.m)), percent base saturation (Basesat), extractable micronutrients (B, Fe, Mn, Cu, Zn, Al, (p.p.m)), soluble S, percentage organic matter (Orgmat) (by loss on ignition) and soil bulk density (dens).

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
8.	1361.85	0.33	275.40	0.63	233.40	66.87	55.47	66.81	62.19	11.62	22.64	56.32	2.65	6.31	4.24	14.55	2.01	41.04
8.1	1421.29	0.27	164.86	0.63	208.14	55.86	39.14	24.86	59.71	11.43	14.43	53.71	2.11	4.15	4.33	10.58	1.97	41.64
8.2	1422.20	0.33	221.40	0.70	180.40	77.80	53.60	119.20	62.00	12.80	24.00	52.00	2.57	6.51	4.14	14.94	1.99	38.65
8.3	1392.00	0.28	493.58	0.85	144.42	88.67	74.08	104.42	61.75	10.25	19.75	38.75	2.84	6.98	4.80	11.21	2.09	51.65
8.3.1	1400.80	0.24	289.60	0.94	166.00	91.80	54.40	57.80	61.80	9.00	15.20	37.80	2.23	5.84	4.57	10.91	2.04	46.40
8.3.2	1385.71	0.31	639.29	0.78	129.00	86.43	88.14	137.71	61.71	11.14	23.00	39.43	3.28	7.80	4.97	11.42	2.12	55.39
8.4	1445.00	0.43	183.13	0.62	315.38	50.50	45.63	55.38	63.63	11.00	25.75	75.75	2.09	6.14	3.87	13.51	2.02	34.09
8.5	1279.67	0.36	181.83	0.59	282.50	57.33	49.00	19.17	64.33	12.50	27.67	70.17	2.94	6.71	3.84	22.54	1.92	34.50
8.5.1	1259.00	0.40	178.67	0.59	340.33	38.00	44.33	26.33	64.67	13.00	31.67	84.67	2.33	7.21	3.60	16.70	1.90	31.08
8.5.2	1300.33	0.32	185.00	0.58	224.67	76.67	53.67	12.00	64.00	12.00	23.67	55.67	3.55	6.21	4.08	28.38	1.94	37.92
8.6	1460.25	0.30	161.50	0.31	322.00	44.75	46.00	33.00	62.75	12.50	16.50	62.25	2.07	5.19	4.00	15.17	1.91	36.31
8.7	1032.80	0.36	311.60	0.37	274.40	74.40	66.60	85.40	61.60	13.20	33.60	54.00	4.03	8.19	4.13	19.27	2.10	39.90
9.	1291.82	0.39	689.82	0.90	215.21	104.48	93.42	118.24	63.76	12.18	31.79	53.58	4.73	12.05	4.52	15.00	1.95	46.25
9.1	1253.33	0.22	401.33	0.52	168.67	86.33	78.67	128.33	59.67	11.33	27.67	45.00	3.00	6.99	4.78	9.67	2.06	50.67
9.2	1483.70	0.34	482.00	0.66	184.90	104.50	78.90	63.20	64.20	11.20	17.90	40.40	2.87	8.60	4.64	15.04	2.00	48.53
9.2.1	1402.33	0.22	661.00	0.42	126.67	103.67	96.00	56.00	62.00	10.67	16.33	28.67	2.26	8.23	5.19	11.58	2.16	61.67
9.2.2	1518.57	0.38	405.29	0.77	209.86	104.86	71.57	66.29	65.14	11.43	18.57	45.43	3.13	8.75	4.40	16.53	1.93	42.89
9.3	1245.33	0.49	380.33	1.24	167.00	87.00	74.00	70.33	64.67	10.00	20.67	43.00	3.23	6.00	4.88	15.37	0.89	53.75
9.4	1313.20	0.45	715.60	0.74	276.00	107.60	90.20	90.40	65.40	11.80	30.80	60.40	5.37	14.44	4.13	19.92	1.87	38.55
9.5	1116.75	0.43	1002.25	0.65	228.00	131.50	125.75	138.50	65.00	14.25	35.25	50.00	7.74	16.27	4.61	19.94	1.80	48.54
9.6	1185.50	0.54	983.50	1.52	217.00	90.00	109.50	181.00	64.00	12.50	70.00	102.50	5.03	20.03	4.16	13.69	2.08	38.88
9.7	1198.00	0.39	860.20	1.31	220.80	107.20	93.80	188.20	63.20	12.60	48.60	66.60	6.03	14.18	4.48	12.23	1.93	45.20
9.8	1056.00	0.53	618.50	1.81	297.50	73.00	79.50	177.50	62.50	15.50	32.00	53.50	6.68	11.21	4.46	12.07	2.01	44.13
10.	740.00	0.31	496.50	0.74	199.50	60.50	86.50	115.50	44.50	10.50	21.50	30.75	3.33	6.62	4.83	5.55	2.14	52.63
10.1	1217.00	0.36	1396.00	0.90	158.00	129.00	198.00	174.00	63.00	10.00	22.00	42.00	5.05	14.24	5.38	11.30	2.09	66.50
10.2	581.00	0.30	196.67	0.68	213.33	37.67	49.33	96.00	38.33	10.67	21.33	27.00	2.75	4.08	4.65	3.64	2.16	48.00

Table 5.8. Mean soil texture values for each vegetation class and associated community types and sub-types. All groups are represented by their abbreviation code. For full names see Table 5.1. Values of sand, silt and clay are given as percentages.

	Sand	Silt	Clay
1.	29.20	64.60	6.20
2.	14.80	79.36	5.84
3.	24.00	61.80	14.20
4.	28.10	65.70	6.20
5.	20.10	65.27	14.63
5.1	24.20	66.31	9.49
5.2	20.28	63.48	16.24
5.3	16.69	68.78	14.54
5.4	22.65	62.61	14.74
6.	22.78	53.81	23.41
6.1	21.17	57.30	21.53
6.2	23.63	51.97	24.40
7.	27.39	56.65	15.96
7.1	23.26	55.52	21.22
7.2	28.40	57.99	13.61
7.3	28.49	54.55	16.97
7.4	36.80	47.94	15.26
7.5	26.07	56.79	17.14
7.6	24.04	63.06	12.89
8.	28.33	56.66	15.01
8.1	24.26	56.97	18.77
8.2	26.84	54.30	18.86
8.3	31.35	52.07	16.58
8.3.1	29.00	54.22	16.78
8.3.2	33.03	50.54	16.43
8.4	27.65	57.38	14.98
8.5	18.90	71.23	9.87
8.5.1	17.73	74.31	7.96
8.5.2	20.07	68.16	11.77
8.6	33.35	55.20	11.45
8.7	36.64	52.10	11.26
9.	27.88	58.61	13.51
9.1	33.07	46.85	20.08
9.2	25.37	58.87	15.76
9.2.1	25.80	58.00	16.20
9.2.2	25.19	59.24	15.57
9.3	53.47	38.09	8.44
9.4	21.58	67.36	11.06
9.5	26.80	63.25	9.95
9.6	26.60	61.20	12.20
9.7	37.32	49.97	12.71
9.8	28.50	62.30	9.20
10.	65.45	24.53	10.02
10.1	27.80	56.00	16.20
10.2	78.00	14.04	7.96

Table 5.9. Species richness at 7 spatial scales. Separate partitions within this table show values for each vegetation class and associated community type and sub-types. Each group is represented by its abbreviation code. For full names see Table 5.1.

Group:	1000 m	400 m	100 m	10 m	1 m	0.1 m	0.01 m
1.	.	.	12.00	8.50	2.00	1.00	0.00
2.	63.00	58.00	27.50	10.25	2.88	0.88	0.63
3.	.	.	18.50	9.63	6.63	4.25	1.63
4.	.	.	6.50	5.30	1.88	0.58	0.35
5.	57.65	46.20	29.53	14.53	6.37	2.05	0.58
5.1	38.00	18.33	11.94	5.04	2.22	0.69	0.19
5.2	68.36	58.54	38.40	18.29	7.65	2.37	0.61
5.3	44.71	38.00	25.04	14.49	7.13	2.56	0.81
5.4	50.00	36.50	22.75	9.19	3.75	0.88	0.38
6.	38.90	33.69	21.57	9.75	3.92	1.35	0.39
6.1	42.75	37.10	24.83	11.63	4.59	1.34	0.39
6.2	36.54	31.89	19.86	8.76	3.56	1.36	0.39
7.	73.11	63.40	40.38	17.51	6.34	1.51	0.35
7.1	67.00	55.20	35.45	13.93	5.03	1.23	0.15
7.2	62.00	52.75	30.31	12.25	4.13	1.16	0.22
7.3	87.40	78.57	49.61	20.74	6.95	1.34	0.23
7.4	70.80	61.80	37.65	17.60	5.95	0.93	0.18
7.5	55.50	52.33	32.83	13.73	5.44	1.61	0.25
7.6	80.25	69.88	46.97	21.79	8.40	2.23	0.76
8.	50.12	40.72	24.97	10.86	4.12	1.12	0.32
8.1	38.60	32.50	18.63	7.88	2.84	0.67	0.19
8.2	47.20	40.40	25.35	10.43	3.93	1.15	0.28
8.3	79.11	63.58	38.02	15.34	5.80	1.61	0.58
8.3.1	68.00	55.00	33.95	14.95	6.13	2.00	0.80
8.3.2	82.29	69.71	40.93	15.61	5.57	1.32	0.41
8.4	44.83	38.13	25.56	13.58	5.91	1.69	0.44
8.5	40.33	37.00	24.21	12.17	4.06	0.94	0.13
8.5.1	46.00	38.67	26.50	13.79	4.67	0.88	0.00
8.5.2	29.00	35.33	21.92	10.54	3.46	1.00	0.25
8.6	27.00	18.75	10.31	3.63	1.16	0.35	0.10
8.7	33.25	28.80	16.40	5.73	2.13	0.58	0.23
9.	66.63	57.64	39.03	20.09	9.54	3.30	1.05
9.1	72.00	61.33	41.50	20.71	9.67	3.50	1.17
9.2	72.00	64.20	44.93	23.73	11.00	3.46	1.08
9.2.1	78.00	72.00	49.67	25.63	11.30	3.67	1.42
9.2.2	69.71	60.86	42.89	22.91	10.88	3.38	0.93
9.3	66.67	56.33	36.67	17.67	8.13	3.33	1.34
9.4	76.00	59.00	39.30	19.23	8.98	2.78	0.75
9.5	65.00	56.50	35.79	16.98	7.77	2.54	0.83
9.6	66.00	53.50	39.13	21.19	10.69	4.25	1.44
9.7	49.50	41.60	29.85	17.90	9.20	3.55	1.20
9.8	57.50	50.00	31.75	16.19	8.26	3.26	0.88
10.	.	70.50	40.81	14.60	4.19	1.18	0.26
10.1	.	84.00	51.50	22.50	10.50	3.50	0.88
10.2	.	57.00	37.25	11.96	2.08	0.40	0.06

5.5 Description of vegetation classes and community types

5.5.1 VEGETATION CLASS: 1. Rock Outcrops

Rock Outcrops have limited distribution, scattered throughout the Southern Appalachian Mountains on exposed summits and bluffs (Schafale & Weakley 1990, Wiser *et al.* 1996). In Joyce Kilmer this class is restricted to the exposed Hangover summit, which is the high-point of the ridge between the Slickrock valley and Deep Creek (Figure 1.5).

COMMUNITY TYPE: [Aronia melanocarpa/Danthonia compressa Outcrop] (1.1)

Synonymy

High Elevation Rocky Summit p.p. (Schafale & Weakley 1990), Low Elevation Rocky Summit p.p. (Schafale & Weakley 1990), *Aronia arbutifolia/Kalmia latifolia* outcrop community p.p. (Wiser *et al.* 1997).

Listed species

Carex manhartii.

Physiognomy

Exposed rock with scattered patches of lichen (84%, 20% surface substrate respectively; Table 5.11) dominate the ground surface. Prostrate (0.1 to 0.3 m mean height) vascular species are sparsely distributed across this substrate, concentrated in small clumps where soil can accumulate. *Danthonia compressa* and *Aronia melanocarpa* are most abundant vascular species (Table 5.10). The latter shrub and *Vaccinium corymbosum* are distributed as scattered, prostrate shrub mats.

Habitat and Distribution

This vegetation class is restricted to the small, convex summit (150 m^2) of the Hangover (elevation 1563 m, 5° slope; Tables 1.5, 5.11). Similar vegetation inhabits the precipitous northeastern-facing outcrop 20 meters north of the site described here, however, there it is restricted to isolated flat crevices in the rock face.

In this vegetation class, soil has limited distribution, restricted to a shallow layer in small, sheltered concavities and crevices. The **Rock Outcrops** class has coarse-textured and infertile soils which are low in Al, base saturation, Mn and pH levels and high Zn and P values in comparison to most other vegetation classes identified in this study (Tables 5.7, 5.8).

Distinguishing Features

This class has the most limited spatial distribution of any vegetation class in Joyce Kilmer.

Succession and Disturbance

The **Rock Outcrops** class is subjected to a harsh climate and must withstand the extremes of sun, wind and rain. Continual trampling from hikers has destroyed much of the lichen and vascular plant cover on the flatter surfaces. Weather, in conjunction with limited abundance and depth of soil, will continue to limit the invasion of woody species and secure the persistence of small, herbaceous species. Trampling, however, may threaten the longevity of this class.

Discussion

This site does not fall neatly into previous descriptions of the Southern Appalachian **Rock Outcrops** class (e.g., Schafale & Weakley 1990, Wiser *et al.* 1996, Chapter 3). The site has closest, but loose affiliation with the *Aronia arbutifolia/Kalmia latifolia* outcrop community described by Wiser *et al.* (1996). Isolation from other **Rock Outcrops** sites may account for the lack of compositional similarity with other stands in this vegetation class.

Table 5.10. Average cover class and constancy of species present in the **Rock Outcrops** vegetation class. The vegetation class is represented by its abbreviation code. For full name see Table 5.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species.

Group:	1.
Number of plots:	1
	Cov/Con
Species	
ANGELICA TRIQUINATA	1 100
ARONIA MELANOCARPA	3 100
BETULA LENTA	1 100
CAREX AESTIVALIS	2 100
CAREX MANHARTII*	1 100
DANTHONIA SPICATA	3 100
GALAX URCEOLATA	2 100
JUNCUS TENUIS VAR TENUIS	2 100
KALMIA LATIFOLIA	2 100
RHODODENDRON CATAWBIENSE	2 100
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1 100
VACCINIUM CORYMBOSUM	2 100

Table 5.11. Average site information for the **Rock Outcrops** vegetation class. The vegetation class is represented by its abbreviation code. For full community type name see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material type (**11**=arkosic metasandstone-metaconglomerate-metasiltstone); Landform type (representing micro-scale topographic units) (**R**=ridge) and Topographic position (representing macro-scale topographic units) (**C**=crest).

1. Rock Outcrops

	Group
	1.
Site Characteristics:	
Elevation (m)	1563
Slope (o)	5
Aspect (o)	
Parent material	11
Soil depth (cm)	3.2
Surface Substrate (%):	
Moss/Lichen	20
Wood	1
Rock	84
Organic Matter	2
Water	0
Topographic Characteristics:	
Relative slope (%)	6
LFI	-0.01
TSI	-0.18
Landform type	R
Topgraphic position	C

5.5.2 VEGETATION CLASS: 2. Non-Alluvial Wetlands

Non-Alluvial Wetlands have very limited distribution throughout the Southern Appalachian Mountains (Schafale and Weakley 1990). Members of this vegetation class vary in physiognomy and structure from open bog-like community types to temporary ponds and temporary forested seepage areas (for examples see Chapters 3 & 4). This vegetation class has extremely limited distribution in Joyce Kilmer with only one locality known on the western border of the Wilderness in the mid-section of the Slickrock valley (Appendix 3).

COMMUNITY TYPE: [Liriodendron-Acer rubrum/Carex ruthii Wetland] (2.1)

Synonymy

Swamp Forest-Bog Complex (Schafale & Weakley 1990).

Listed species

Carex ruthii, *Juncus gymnocarpus*.

Physiognomy

Large-diameter *Quercus rubra* and *Liriodendron tulipifera* and smaller-diameter *Acer rubrum* dominate the canopy (31 m height). *Liriodendron* is typically situated in the moister, concave seepage area with *Q. rubra* dominant on the drier slopes rising up either side. *Acer rubrum* is more evenly distributed throughout (Tables 5.12, 5.13, 5.14). *Nyssa sylvatica* dominates the subcanopy. *Lindera benzoin* and more sparsely distributed *Tsuga canadensis* shrubs provide a scattered shrub stratum across the site. *Thelypteris* dominates the ground on the drier sideslopes. In contrast, *Carex ruthii*, *C. gynandra* and *Juncus gymnocarpus* are the major seepage species with scattered, isolated clumps of *Osmunda cinnamomea* var. *cinnamomea* also present.

Habitat and Distribution

This community type inhabits a southeast-facing, mid-elevation (991 m; Table 5.15), seepage area at the base of an upper-slope draw. The site is located on the western side of the central Slickrock valley, north of Big Stack Gap (see Appendix 8).

The soils are silty with highest silt content of any type in the study and have similar fertility to average **Acidic Cove and Slope Forests** class values (Tables 5.7, 5.8). The site is underlain by metasandstone-metaconglomerate-slate (parent material type 7; see Figure 1.5).

Distinguishing Features

This is the only community type with permanent standing water and wetland species present. Low small-scale richness in this type reflects the combination of water and an understory plant matrix dominated by large monospecific vegetation patches (Table 5.9). This type has higher large-scale richness than the **Acidic Cove and Slope Forests** vegetation class.

Succession and Disturbance

Slopes adjacent to this site were probably logged in the past. The absence of *Quercus rubra* saplings suggests that the dominance of this species will decline in the future (Table 5.13). Abundant *Liriodendron*, *Acer rubrum* and *Tsuga* saplings indicate that the former two species will continue to dominate the canopy with *Tsuga* perhaps replacing *Q. rubra*.

Discussion

This stand adds to the information on a little-known, spatially restricted vegetation class. Although herbaceous-dominated **Non-Alluvial Wetlands** have been described by Schafale & Weakley (1990), Weakley & Schafale (1994) (see Chapter 4) there is virtually no published quantitative information for forest-dominated types in this class. The Joyce Kilmer type has loose resemblance to two wetlands sampled in the Nantahala Mountains

(North Carolina Vegetation Survey *unpub. data*). These two stands are dominated by *Fagus* and *Betula alleghaniensis*, reflecting their higher-elevation position (approximately 1200 m elevation) than the Joyce Kilmer type. Herbaceous species have greater dominance in the understory of the Nantahala sites with *Chelone glabra* the most dominant.

Table 5.12. Average cover class and constancy of species present in the **Non-Alluvial Wetlands** vegetation class. The vegetation class is represented by its abbreviation code. For full name see Table 5.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species.

Group:	2.
Number of plots:	1
	Cov/Con
Species	
ACER PENSYLVANICUM	1 100
ACER RUBRUM VAR RUBRUM	7 100
AGERATINA ALTISSIMA VAR ROANENSIS	2 100
AMELANCHIER ARBOREA	1 100
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	1 100
ASTER DIVARICATUS	1 100
ATHYRIUM ASPLENIOIDES	2 100
CALYCANTHUS FLORIDUS VAR GLAUCUS	2 100
CAREX DIGITALIS	1 100
CAREX FLEXUOSA	2 100
CAREX GYNANDRA	2 100
CAREX PENSYLVANICA	1 100
CAREX RUTHII*	4 100
CAREX SP.#1	2 100
CHELONE GLABRA	2 100
CHIMAPHILA MACULATA VAR MACULATA	1 100
CLETHRA ACUMINATA	1 100
CONOPHOLIS AMERICANA	1 100
CORNUS FLORIDA	2 100
DANTHONIA COMPRESSA	2 100
DICHANTHELIUM BOSCII	1 100
DIOSCOREA QUATERNATA	1 100
EUPATORIUM PURPUREUM VAR PURPUREUM	1 100
GAYLUSSACIA URSINA	2 100
GENTIANA DECORA	1 100
HALESIA TETRAPTERA VAR MONTICOLA	1 100
HIERACIUM PANICULATUM	1 100
HOUSTONIA PURPUREA VAR PURPUREA	1 100
HYPOXIS HIRSUTA	1 100
JUNCUS GYMNOCARPUS*	5 100
LINDERA BENZOIN	3 100
LIRIODENDRON TULIPIFERA	7 100
MEDEOLA VIRGINIANA	1 100
MELAMPYRUM LINEARE	1 100
MELANTHIUM PARVIFLORUM	1 100
NYSSA SYLVATICA	6 100
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	2 100
OXALIS STRICTA	2 100
OXYDENDRUM ARBOREUM	2 100
OXYPOLIS RIGIDIOR	2 100
PLATANTHERA CLAVELLATA	2 100
POLYGONUM PERSICARIA	2 100
POLYSTICHUM ACROSTICHOIDES	2 100

Group:	2.
	Cov/Con
POTENTILLA CANADENSIS VAR CANADENSIS	1 100
PRENANTHES SP. #1	1 100
PRUNUS SEROTINA	4 100
QUERCUS ALBA	2 100
QUERCUS MONTANA	1 100
QUERCUS RUBRA	6 100
RHODODENDRON CALENDULACEUM	1 100
RHODODENDRON MAXIMUM	1 100
ROBINIA PSEUDOACACIA	4 100
RUBUS CANADENSIS	2 100
SASSAFRAS ALBIDUM	2 100
SMILAX GLAUCA VAR GLAUCA	1 100
SMILAX ROTUNDIFOLIA	2 100
SOLIDAGO CURTISII	1 100
STENANTHIUM GRAMINEUM VAR MICRANTHUM	2 100
THELYPTERIS NOVEBORACENSIS	8 100
TIARELLA CORDIFOLIA VAR CORDIFOLIA	2 100
TSUGA CANADENSIS	4 100
VIOLA HASTATA	2 100
VITIS VULPINA	1 100

Table 5.13. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Non-Alluvial Wetlands** vegetation class. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

2. Non-Alluvial Wetlands

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	20.00	180.00	10.00	210.00	4.24	26.58	12.76	19.67
LINDERA BENZOIN	80.00	0.00	0.00	80.00	0.01	10.13	0.02	5.07
LIRIODENDRON TULIPIFERA	20.00	50.00	10.00	80.00	3.19	10.13	9.62	9.87
NYSSA SYLVATICA	0.00	60.00	10.00	70.00	2.61	8.86	7.86	8.36
QUERCUS RUBRA	0.00	10.00	50.00	60.00	21.78	7.59	65.65	36.62
TSUGA CANADENSIS	30.00	30.00	0.00	60.00	0.30	7.59	0.91	4.25
ALL	300.00	410.00	80.00	790.00	33.18	100.02	99.99	100.00

Table 5.14. Vertical structure of woody species in the **Non-Alluvial Wetlands** vegetation class. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥ 1 in a stratum are shown.

2. Non-Alluvial Wetlands

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	3	6	
CALYCANTHUS FLORIDUS VAR GLAUCUS	1	1	1		
CORNUS FLORIDA	1	1	1		
LINDERA BENZOIN	1	3			
LIRIODENDRON TULIPIFERA	1	1	1	7	
NYSSA SYLVATICA	1	3	5	1	
PRUNUS SEROTINA	1	1	1		
QUERCUS RUBRA	1	1	3	4	
ROBINIA PSEUDOACACIA	1	1	2	1	
SMILAX ROTUNDIFOLIA	1	1	1		
TSUGA CANADENSIS	1	2	1	1	

Table 5.15. Average site information for the **Non-Alluvial Wetlands** vegetation class. The vegetation class is represented by its abbreviation code. For full community type name see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material type (7=arkosic metasandstone-metaconglomerate-slate), Landform type (representing micro-scale topographic units) (C=cove) and Topographic position (representing macro-scale topographic units) (US=upper slopes).

2. Non-Alluvial Wetlands

	Group
	2.
Site Characteristics:	
Elevation (m)	991
Slope (o)	13
Aspect (o)	SE
Parent material	7
Soil depth (cm)	37.7
Surface Substrate (%):	
Moss/Lichen	1
Wood	5
Rock	5
Organic Matter	79
Water	8
Topographic Characteristics:	
Relative slope (%)	8
LFI	0.10
TSI	-0.07
Landform type	C
Topgraphic position	US

5.5.3 VEGETATION CLASS: 3. <u>Grasslands</u>

The **Grasslands** vegetation class contains a typically diverse range of herbaceous species with only limited shrub and small-tree presence. This class is uncommon in the Southern Appalachians, with distribution typically restricted to the gentle slopes, ridge-tops and knobs of the high-mountains in this region (Schafale & Weakley 1990). In Joyce Kilmer this vegetation class is confined to a small portion of the broad, high-elevation ridge between the two major watersheds (Appendices 3, 6).

COMMUNITY TYPE: [Crategus macrosperma/Fragaria virginiana-Phlox carolina Grassland] (3.1)

Synonymy

Grassy Bald p.p. (Schafale & Weakley 1990), Grassy Bald (Whittaker 1956), Fire Meadow p.p. (McLeod 1988), [*Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland*] p.p. (Chapter 4).

Listed species

Stachys clingmanii.

Physiognomy

The two sites sampled characterize the two major structural components of this community type. The more extensive open, 0.5 m tall areas are dominated by *Fragaria virginiana* var. *virginiana* and *Phlox carolina* ssp. *carolina* (both cover 7), in association with *Aster lateriflorus* var. *lateriflorus* (cover 6), *Danthonia compressa* and *Stachys clingmanii* (both cover 5; Tables 5.16, 5.17, 5.18). Prostrate patches of *Crategus macrosperma* (cover 3) have more isolated distribution. There are isolated 2.5 m tall shrub clumps dominated by *C. macrosperma* (cover 9) scattered across the open herbaceous matrix. *Rubus canadensis* and *S. clingmanii* are the two major ground species with

Solidago curtisii (cover 4), *Phlox carolina* ssp. *carolina* and *Fragaria virginiana* var. *virginiana* (both cover 3) also abundant.

Habitat and Distribution

This community type is restricted to Bob Bald at the western end of Stratton Bald on the central high-elevation ridge (1597 m elevation; Figure 1.5; Table 5.19). The area is a shallow-sloped (3° slope), broadly convex ridgeline.

The soils are infertile with low base saturation and pH levels (Tables 5.7, 5.8). The **[Crategus macrosperma/Fragaria virginiana-Phlox carolina Grassland]** also has the highest B, Cu, P and S levels of any type in this study. Both sites are underlain by metagraywacke (parent material type 12; Figure 1.5).

Distinguishing Features

This type has highest species richness at the two smallest spatial scales in comparison to other types in this study (Table 5.9). The small physical size of species present and their high small-scale packing accounts for this high small-scale diversity.

Succession and Disturbance

The low, herbaceous variant of this community type is kept open by occasional mowing (*pers. obs.*). Without this disturbance the open form would rapidly be invaded by shrub species, developing into the shrub variant. Under the present disturbance regime the shrub form clumps are generally too small for successful tree seedlings establishment. However, without periodic disturbance the shrub form would become dominant and will be invaded by tree species such as *Amelanchier*, *Betula alleghaniensis* and *Fagus* that are dominant in the adjacent **High-Elevation Mixed Hardwood Forests**. Based on the topographic position and orientation of this site we expect that the **[Crategus macrosperma/Fragaria virginiana-Phlox carolina Grassland]** would eventually succeed into the **Fagus/Carex pensylvanica Forest**.

The **Grasslands** vegetation class was more common in the early part of the century and probably owes its extent at that time to grazing (Lindsay & Bratton 1979). Today in many areas, such as Bob Bald, this class is maintained by mowing. However, what impact that shifting from grazing to mowing may have had on the composition of **Grasslands** remains unknown.

Discussion

The **[Crategus macrosperma/Fragaria virginiana-Phlox carolina Grassland]** does not resemble the typical descriptions of Southern Appalachian **Grasslands** (e.g., see Wells 1937, Brown 1941, Mark 1959, Lindsay & Bratton 1979, McLeod 1988, Chapter 4), which are typically dominated by grass and sedge species. The dominance of herbaceous species and abundance of *Phlox carolina* gives this type closest, but weak resemblance to the **[Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]** in Shining Rock Wilderness (Chapter 4) and loose affiliations with McLeod's 'fire meadow'. All three types have endured recurrent disturbance, although the latter two have been disturbed by fire rather than mowing. Similar vegetation has been noted along the road margins of the Blue Ridge Parkway (G. Kauffman *pers. comm.*) which is mown frequently.

Table 5.16. Average cover class and constancy of species present in the **Grasslands** vegetation class. The vegetation class is represented by its abbreviation code. For full name see Table 5.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. Homoteneity is the mean constancy of the prevalent species.

Group:	3.	
Number of plots:	2	
Homotenity:	0.861	
	Cov/Con	
Species		
AGERATINA ALTISSIMA VAR ROANENSIS	1	50
AGROSTIS PERENNANS	2	100
ANGELICA TRIQUINATA	2	50
ASTER CHLOROLEPIS	1	50
ASTER LATERIFLORUS VAR LATERIFLORUS	4	100
ASTER UNDULATUS	1	50
ATHYRIUM ASPLENIOIDES	1	50
BOTRYCHIUM BITERNATUM	1	50
BOTRYCHIUM VIRGINIANUM	1	50
CAREX FLEXUOSA	2	100
CAREX SCOPARIA VAR SCOPARIA	3	100
CRATAEGUS MACROSPERMA	6	100
DANTHONIA COMPRESSA	4	100
FRAGARIA VIRGINIANA VAR VIRGINIANA	5	100
HOLCUS LANATUS	2	100
HOUSTONIA CAERULEA	2	50
JUNCUS TENUIS VAR TENUIS	2	50
PHLEUM PRATENSE	2	100
PHLOX CAROLINA SSP CAROLINA	5	100
POACEAE SP. #1	2	100
RUBUS CANADENSIS	4	100
SOLIDAGO CURTISII	4	50
STACHYS CLINGMANII*	5	100
VIOLA BLANDA	2	50

Table 5.17. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Grasslands** vegetation class. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

3. Grasslands

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
CRATAEGUS MACROSPERMA	7600.00	0.00	0.00	7600.00	0.98	100.00	100.00	100.00
ALL	7600.00	0.00	0.00	7600.00	0.98	100.00	100.00	100.00

Table 5.18. Vertical structure of woody species in the **Grasslands** vegetation class. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

3. Grasslands

	<0.5m	6-0.5m	15-6m	35-15m	>35m
CRATAEGUS MACROSPERMA	3	5			

Table 5.19. Average site information for the **Grasslands** vegetation class. The vegetation class is represented by its abbreviation code. For full community type name see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material type (**12**=metagraywacke), Landform type (representing micro-scale topographic units) (**R**=ridge) and Topographic position (representing macro-scale topographic units) (**C**=crest).

3. Grasslands

	Group
	3.
Site Characteristics:	
Elevation (m)	1597
Slope (o)	3
Aspect (o)	
Parent material	12
Soil depth (cm)	50.4
Surface Substrate (%):	
Moss/Lichen	0
Wood	0
Rock	1
Organic Matter	99
Water	0
Topographic Characteristics:	
Relative slope (%)	8
LFI	0.01
TSI	-0.08
Landform type	R
Topgraphic position	C

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5.5.4 VEGETATION CLASS: 4. Shrub Balds

The **Shrub Balds** vegetation class is scattered at high-elevations throughout the Southern Appalachian Mountains, inhabiting exposed peaks, sharp ridges and steep slopes. The class has a characteristically dense shrub stratum, typically dominated by ericaceous species, but with a few stunted tree species present in some locations (Whittaker 1956, McLeod 1988, Schafale & Weakley 1990, Chapter 4). In Joyce Kilmer this vegetation class has extremely limited distribution restricted to exposed portions of the high-elevation ridge dividing the two major watersheds and a secondary ridgeline in upper-reaches of the Slickrock valley (Appendices 3, 6). In this Wilderness the **Shrub Balds** vegetation class is mostly found in association with the **High-Elevation Mixed Hardwood Forests** vegetation class.

COMMUNITY TYPE: [Rhododendron catawbiense-Kalmia Shrubland] (4.1)

Synonymy

Heath Bald (Schafale & Weakley 1990), Rhododendron Bald Community (Brown 1941), high-elevation variant of Heath Balds (Whittaker 1956), Heath bald community (Ramseur 1960), Heath Balds (McLeod 1988), Heath Balds (White *et al.* 1993), [*Rhododendron catawbiense-Pieris* Shrubland] (Chapter 4).

Physiognomy

Rhododendron catawbiense dominates the almost impenetrable 2 to 3.5 m tall shrub canopy of this community type in association with *Kalmia latifolia*, *R. maximum* and *Vaccinium corymbosum* (Tables 5.20, 5.21, 5.22). A thick litter layer predominates the ground with sparsely scattered *Galax urceolata* present.

Habitat and Distribution

This community type inhabits steep (28° and 38°, northeast- and northwest-facing), exposed, high-elevation ridgelines and upper-slopes (1418 and 1562 m elevation; Table

5.23). The two sites sampled are located on a ridge in the upper Slickrock watershed below Naked Ground and at the summit of the Hangover on the central high-elevation ridge (see Figure 1.5, Appendix 6).

The soils are highly organic and infertile, with lowest Al, base saturation, Fe, Mn pH and P and highest cation exchange capacity, Mg, Na, organic matter and Zn of any type recognized in this study (Tables 5.7, 5.8). Doubtless the peculiar soil chemistry reflects the extremely organic character of the soils and the associated cation exchange characterization. One site is underlain by metagraywacke (parent material type 12) and the other arkosic metasandstone-metaconglomerate-metasiltstone (parent material type 11; Table 5.23)

Distinguishing Features

The **[Rhododendron catawbiense-Kalmia Shrubland]** has by far the highest stem density (171,500 stems/ha) of any community type in this study. Low species richness at all spatial scales measured is indicative of the density of *Rhododendron catawbiense* stems, as well as the dense, thick litter layer and highly acidic soils which inhibit the establishment of other species.

Succession and Disturbance

Blackened stems provided evidence of fire in the Hangover site. Lack of tree saplings suggests *Rhododendron catawbiense* will continue to dominate this community type. Although the **[Rhododendron catawbiense-Kalmia Shrubland]** is successional, the present stunted stature and composition may well be maintained in the highly exposed Hangover site, as Whittaker (1956) and White *et al.* (1993) have suggested for similar communities elsewhere. The lack of tree saplings suggests that levels of exposure are extreme enough to retard tree establishment and limit growth (Table 24). Moreover, the uniformly dense shrub canopy may also inhibit tree seedling establishment. In the more sheltered conditions at the upper Slickrock site the composition and structure of this community may show greater change, with initial succession perhaps very slow. The leaves of *Rhododendron* species are nutrient poor, highly fibrous and as a consequence, decay slowly, producing a thick litter layer and acidic soils (Whittaker 1963, Clinton & Vose 1996). Such conditions, combined with the deep, year-round shade associated with the ericaceous shrub layer, restrict initial tree establishment to small openings in the dense shrub stratum.

Although there is no quantitative information to substantiate this, I project that with time the shrub canopy will break up at the upper Slickrock site, increasing light levels within the shrub stratum that will provide conditions more conducive for successful seedling establishment (Plocher & Carvell 1987). The proximity of this class to other high-elevation community types suggests that successional species such as *Amelanchier*, *Betula alleghaniensis* and possibly *Fagus* may invade. These species will probably eventually form a canopy over the shrub stratum, with the stand evolving to resemble the **Betula alleghaniensis-Fagus/Rhododendron maximum Forest**, which presently occurs down-slope of the **[Rhododendron catawbiense-Kalmia Shrubland]**.

Discussion

This study adds more quantitative information to the seldom quantified, but often described **Shrub Balds** vegetation class (but see Brown 1941, Whittaker 1962, Whittaker 1963, McLeod 1988, Risk 1993, Chapter 4). The **[Rhododendron catawbiense-Kalmia Shrubland]** corresponds closely to most descriptions of **Shrub Balds** community types throughout the Southern Appalachian Mountains (e.g., Cain 1931, Brown 1941, Whittaker 1956, Ramseur 1960, McLeod 1988, White *et al.* 1993, Chapter 4). The Joyce Kilmer type has similar composition and structure to the **[Rhododendron catawbiense-Pieris Shrubland]** at Shining Rock Wilderness, with *Rhododendron catawbiense* dominant in both. The subdominant species vary with *Pieris floribunda* as the subdominant species at Shining Rock and *Kalmia latifolia* at Joyce Kilmer. Such differences reflect the biogeographic distribution of *Pieris*, which is not found in the western-most portion of the Southern Appalachians and the lower-elevational position of the **[Rhododendron catawbiense-Kalmia Shrubland]**. Both Whittaker (1956) and McLeod (1988) document higher *Kalmia* abundance at lower elevations (<1525 m; McLeod 1988). In the Smokies this species is replaced by *Rhododendron minus* and *Vaccinium corymbosum* in high-elevation **Shrub Balds** community types (Whittaker 1956).

Both the **[Rhododendron catawbiense-Pieris Shrubland]** at Shining Rock Wilderness and the Joyce Kilmer **[Rhododendron catawbiense-Kalmia Shrubland]** have highest stem density of any type in the respective studies. However the Shining Rock type has much lower density (49,900 stems/ha; Table 4.16). The soils of the **[Rhododendron catawbiense-Pieris Shrubland]** are less organic (33.55%) and more fertile (pH 3.75, percent base saturation 33.50, Ca 104.5 ppm, Mn 23.0 ppm; Table 4.4) than the **[Rhododendron catawbiense-Kalmia Shrubland]** in Joyce Kilmer. The extreme infertility of the **[Rhododendron catawbiense-Kalmia Shrubland]** perhaps relates to a combination of down-slope leaching of nutrients from these steep sites and slow soil decomposition rates, that is indicated by the exceptionally high organic content of these soils. It is also possibly that moister site conditions, due to higher rainfall levels in Joyce Kilmer, might be responsible.

Table 5.20. Average cover class and constancy of species present in the **Shrub Balds** vegetation class. The vegetation class is represented by its abbreviation code. For full name see Table 5.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. Homoteneity is the mean constancy of the prevalent species.

Group:	4.	
Number of plots:	2	
Homoteniety:	0.917	
	Cov/Con	
Species		
ARONIA MELANOCARPA	6	50
GALAX URCEOLATA	2	100
KALMIA LATIFOLIA	6	100
RHODODENDRON CATAWBIENSE	9	100
RHODODENDRON MAXIMUM	5	100
VACCINIUM CORYMBOSUM	5	100
VACCINIUM ERYTHROCARPUM	2	50
VIBURNUM NUDUM VAR CASSINOIDES	3	50

Table 5.21. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Shrub Balds** vegetation class. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

4. Shrub Balds

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
KALMIA LATIFOLIA	3750.00	2650.00	0.00	6400.00	5.04	3.80	13.43	8.61
RHODODENDRON CATAWBIENSE	132250.0	7300.00	0.00	139550.0	27.89	83.92	77.15	80.53
RHODODENDRON MAXIMUM	14250.00	550.00	0.00	14800.00	2.43	6.66	5.23	5.94
VACCINIUM CORYMBOSUM	9750.00	0.00	0.00	9750.00	1.57	5.23	3.95	4.59
ALL	161000.0	10500.00	0.00	171500.0	37.07	100.01	100.00	100.00

Table 5.22. Vertical structure of woody species in the **Shrub Balds** vegetation class. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

4. Shrub Balds

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ARONIA MELANOCARPA	2	3			
KALMIA LATIFOLIA	2	6			
RHODODENDRON CATAWBIENSE	5	9			
RHODODENDRON MAXIMUM	3	5			
VACCINIUM CORYMBOSUM	3	5			

Table 5.23. Average site information for the **Shrub Balds** vegetation class. The vegetation class is represented by its abbreviation code. For full community type name see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**11**=arkosic metasandstone-metaconglomerate-metasiltstone, **12**=metagraywacke), Landform types (representing micro-scale topographic units) (**R**=ridges,**SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**C**=crest,**US**=upper slopes).

4. Shrub Balds

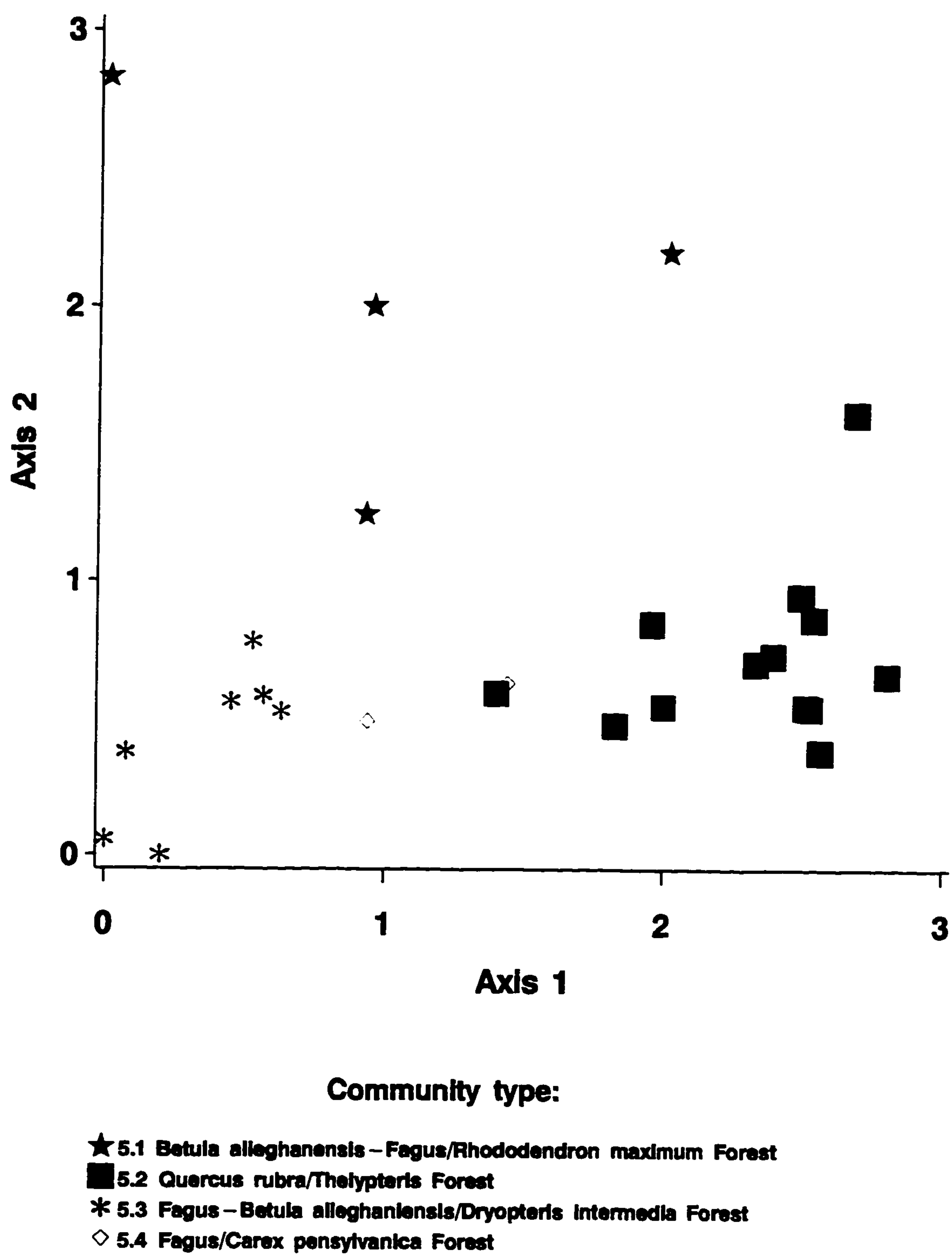
	Group
	4.
Site Characteristics:	
Elevation (m)	1490
Slope (o)	28
Aspect (o)	NE,NW
Parent Material	11,12
Soil depth (cm)	62.2
Surface Substrate (%):	
Moss/Lichen	4
Wood	4
Rock	2
Organic Matter	91
Water	0
Topographic Characteristics:	
Relative slope (%)	9
LFI	0.05
TSI	-0.13
Landform type	SS,R
Topgraphic position	US,C

5.5.5 VEGETATION CLASS: 5. **High-Elevation Mixed Hardwood Forests**

This vegetation class is widely distributed throughout the high-elevation areas in the Southern Appalachian Mountains, where it is often found in association with the **Grasslands**, **Shrub Balds** and **Spruce-Fir Forests** vegetation classes. The **High-Elevation Mixed Hardwood Forests** class inhabits relatively exposed sites susceptible to fire, wind and ice storms (Schafale & Weakley 1990). In Joyce Kilmer this vegetation class dominates the central, high-elevation ridge between the two major watersheds and associated upper-slope areas (Figures 5.2, 5.3). Stands in this class are underlain by metagraywacke (parent material type 12) and arkosic metasandstone-metaconglomerate (parent material type 13; Figure 1.5, Table 5.27).

An ordination of stands in the **High-Elevation Mixed Hardwood Forests Class** was used to clarify site differences between the four community types. Types separate by temperature (solar radiation), soil fertility and microtopographic shape. The **Quercus rubra/Thelypteris Forest** inhabits the warmest (high solar radiation), most fertile sites (higher pH, lower Fe; Figures 5.4, 5.5). The **Betula alleghaniensis-Fagus/ Rhododendron maximum Forest** inhabits concave sites (high section curvature values; curvature perpendicular to slope) in comparison to convex sites dominated by the two *Fagus* types. The two *Fagus*-dominated types inhabit similar environmental conditions, but are separated by site aspect, with the **Fagus/Carex pensylvanica Forest** occurring on marginally warmer, south-facing sites (see Table 5.27).

Figure 5.4. DCA ordination diagram showing the distribution of the **High-Elevation** **Mixed Hardwood** **Forests** class on the two major compositional gradients.


3
2
1
0
Axis 2
0
1
2
3
Axis 1
Community type:
5.1 Betula alleghanensis – Fagus/Rhododendron maximum Forest
5.2 Quercus rubra/Thelypteris Forest
5.3 Fagus – Betula alleghaniensis/Dryopteris intermedia Forest
5.4 Fagus/Carex pensylvanica Forest

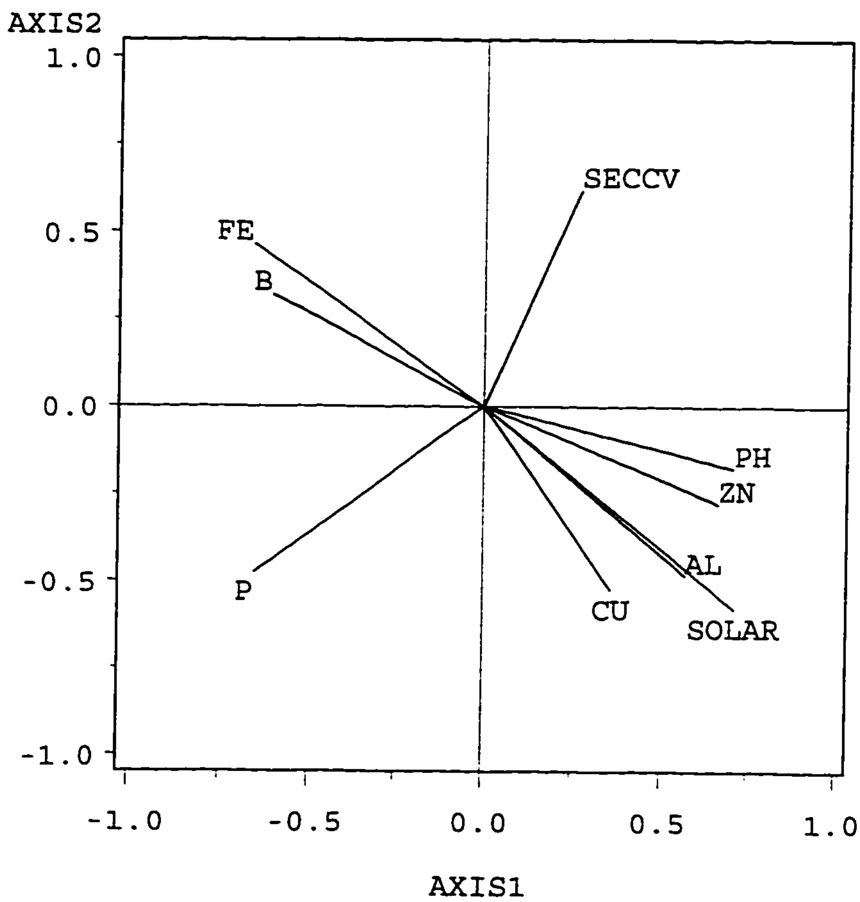


Figure 5.5. Vector diagram for DCA ordination of the **High-Elevation Mixed Hardwood Forests** class showing association between species composition and major environmental gradients. SECCV=section curvature.

COMMUNITY TYPE: Betula alleghaniensis-Fagus/Rhododendron maximum Forest (5.1)

Synonymy

Acidic Cove Forest p.p. (Schafale & Weakley 1990), Birch gaps p.p. (Crandell 1958).

Constant species

Acer rubrum var. *rubrum*, *Amelanchier arborea*, *Betula alleghaniensis*, *Fagus grandifolia*, *Hamamelis virginiana*, *Ilex montana*, *Rhododendron maximum*, *Rubus canadensis*, *Smilax rotundifolia*, *Trillium undulatum*.

Listed species

Carex manhartii, *Vaccinium hirsutum*.

Physiognomy

Scattered large-diameter *Betula alleghaniensis* (45 to 68 cm; largest 101 cm, plot 664) dominate the canopy of the three forest stands (22 m height) in this canopy type, with smaller-diameter *Fagus* subdominant (Tables 5.24, 5.25, 5.26). Both species also dominate the understory. *Rhododendron maximum* is the major species of the particularly dense 3 to 5 m tall shrub layer with *Ilex montana*, *Hamamelis* and *Acer rubrum* are also present in this stratum. The forest floor is covered with a dense litter layer and scattered patches of *Dryopteris intermedia* and *Rubus canadensis*. *Smilax rotundifolia* and *Trillium undulatum* are present in this stratum throughout all four sites with low abundance.

The fourth, high-elevation stand (the "shrub" stand; plot 681) is stunted (2.5 m canopy height) and dominated by an almost impenetrable stand of small-diameter *Rhododendron maximum* (cover 8), *Fagus*, *Kalmia* (both cover 7), *Amelanchier* (cover 6) and *Vaccinium corymbosum* (cover 5).

Although this type generally has a dense *Rhododendron maximum* shrub stratum, the density of the shrub stand may have augmented the values presented here.

Habitat and Distribution

The three forest stands inhabit steep (29° average slope), cool, west-through north to northeast-facing, high-elevation (1285 to 1480 m range, 1356 m average) sideslopes. Two stands are located in Little Santeetlah and the third on the north-facing slope below the Hangover in Slickrock (Figure 1.5, Table 5.27). The shrub stand is situated on the central high-elevation ridgeline (10° slope, 1516 m elevation) between the two major watersheds.

The **Betula alleghaniensis-Fagus/Rhododendron maximum Forest** has moderately coarse-textured, organic and infertile soils (Tables 5.7, 5.8). This type has more fertile soils (represented by higher percent base saturation, Ca, cation exchange capacity, pH) than the two *Fagus*-dominated types.

Distinguishing Features

The **Betula alleghaniensis-Fagus/Rhododendron maximum Forest** has lowest species richness levels of any **High-Elevation Mixed Hardwood Forests** type, which may relate to the dense evergreen shrub layer and highly acidic soils associated with this type (Table 5.9). This type has the highest stem density of any forest community type in the study.

Succession and Disturbance

There is no evidence of chestnut loss or logging in these sites. The patchy distribution of this community type suggests that its presence may be the result of fire; charred stems and charcoal in 75% of the sites support such a hypothesis. Moreover, trees in this type are typically between 70 and 100 years in age. Cores from canopy trees indicate that *Betula alleghaniensis* trees are marginally older than the *Fagus* stems. *Betula alleghaniensis* establishes in high-light conditions (White *et al.* 1985) which provides additional support for disturbance and opening of these sites in the past.

The high *Betula alleghaniensis* and *Fagus* sampling numbers indicate that the present composition of this community type will be maintained in the future (Table 5.25).

The exposed position of the shrub stand suggests that this plot may remain stunted, or that tree canopy development will be extremely slow.

COMMUNITY TYPE: Quercus rubra/Thelypteris Forest (5.2)

Synonymy

High-Elevation Red Oak Forests (Schafale & Weakley 1990), Red Oak-Chestnut Forest (Whittaker 1956), Northern red oak type (Golden 1974), Mixed fern phase of High-Elevation Red Oak Forest (DeLapp 1978), tall herb phase of High-Elevation Red Oak Forest (DeLapp 1978), Red Oak Forests (McLeod 1988), Northern Hardwood Forests (White *et al.* 1993), *Quercus rubra/Kalmia* Forest p.p. (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Amelanchier arborea*, *Athyrium asplenioides*, *Castanea dentata*, *Dioscorea quaternata*, *Fagus grandifolia*, *Fraxinus americana*, *Gentiana decora*, *Halesia tetraptera* var. *monticola*, *Hieracium paniculatum*, *Houstonia purpurea* var. *purpurea*, *Ilex montana*, *Lysimachia quadrifolia*, *Magnolia acuminata*, *Maianthemum racemosum*, *Medeola virginiana*, *Melampyrum lineare*, *Polygonatum biflorum* var. *biflorum*, *Prenanthes* species, *Quercus rubra*, *Rhododendron calendulaceum*, *Robinia pseudo-acacia*, *Smilax herbacea*, *Smilax rotundifolia*, *Solidago arguta* ssp. *caroliniana*, *Solidago curtisii*, *Stellaria pubera*, *Thelypteris novaeboracensis*, *Tsuga canadensis*, *Viola hastata*, *Viola sororia*.

Listed species

Brachyelytrum septentrionale, *Vaccinium hirsutum*.

Physiognomy

The canopy of community type is typically dominated by large-diameter *Quercus rubra* (stems 40 to 86 cm; largest 105 cm, plot 607), in association with smaller-diameter

Acer rubrum and *Halesia tetraptera* (Tables 5.24, 5.25, 5.26). The latter two species are scattered throughout the understory. *Castanea dentata* and *Rhododendron calendulaceum* dominate the deciduous shrub stratum in conjunction with *Acer pensylvanicum*, *Amelanchier arborea* and *Ilex montana*. The fern *Thelypteris novaeboracensis* is the major ground species with *Melampyrum lineare* also highly abundant. *Dennstaedtia punctilobula* is present in some sites. *Athyrium asplenioides*, *Dioscorea quaternata*, *Gentiana decora*, *Hieracium paniculatum*, *Houstonia purpurea* var. *purpurea*, *Lysimachia quadrifolia*, *Maianthemum racemosum*, *Medeola virginiana*, *Polygonatum biflorum*, *Prenanthes* species, *Smilax herbacea*, *Smilax rotundifolia*, *Solidago arguta* ssp. *caroliniana*, *Solidago curtisii*, *Stellaria pubera*, *Viola hastata* and *V. sororia* are present with consistent, but low abundance.

There is a higher-elevation/moister variant within this type where *Quercus montana* is replaced in the canopy by *Betula alleghaniensis*. In this variant *Castanea dentata* has limited cover and *Rhododendron calendulaceum* is absent from the understory. This variant has higher *Acer saccharum*, *Ageratina altissima* var. *roanensis*, *Rubus canadensis* and *Stachys clingmanii* cover. *Viola blanda* is also present. Higher cover by these ground species indicates that conditions are moister than typical sites inhabited by this community type.

Habitat and Distribution

The **Quercus rubra/Thelypteris Forest** has wide distribution in Little Santeetlah across southeast- to southwest-facing, moderately high-elevation (1188 - 1409 m range, 1320 m mean) upper-slopes and ridges (23° average slope, 6 to 37° range; Table 5.27).

The soils are deep, medium-textured and more fertile than the other **High-Elevation Mixed Hardwood Forests** community types, with higher base saturation, Ca and pH levels, but lower cation exchange capacity, Fe and P (Tables 5.7, 5.7, 5.27). This type has the highest Al levels of any type in the study. Sites are mostly underlain by arkosic metasandstone-metaconglomerate (parent material type 13), but with 31% underlain by metagraywacke (parent material type 12; Figure 1.5, Table 5.27).

Distinguishing Features

The **Quercus rubra/Thelypteris Forest** has highest species richness levels of any **High-Elevation Mixed Hardwood Forests** type at the largest five scales, reflecting the scattered distribution of a broad set of species (Table 5.9).

Succession and Disturbance

The **Quercus rubra/Thelypteris Forest** is an old-growth community type, with medium-sized *Q. rubra* canopy trees (50 to 70 cm diameter) aged between 120 and 170 years. One 56 cm *Q. montana* was 210 years in age (plot 669). Abundant small-diameter *Acer rubrum* and the presence of young-aged *Q. rubra* trees (30 to 40 cm, aged between 65 and 80 years) suggests that these forests were disturbed approximately about the time of peak chestnut blight. Eleven of the thirteen plots have abundant chestnut logs, and sprouts persist today in 92% of the plots in this type. This evidence suggests that chestnut was at least a minor canopy component in most sites. There is evidence of fire in 5 of the 13 sites.

The high numbers of *Acer rubrum* and *Halesia* saplings and low *Quercus rubra* sapling densities suggest that the *Quercus* dominance of the canopy will decline with increasing dominance by *Acer rubrum* and *Halesia* (Table 5.25).

COMMUNITY TYPE: Fagus-Betula alleghaniensis/Dryopteris intermedia Forest (5.3)

Synonymy

Northern Hardwood Forest (Schafale & Weakley 1990), northeast-facing Beech-Maple Community (Brown 1941), north slope variant of Gray Beech Forest (Whittaker 1956), Beech-Birch gaps (Crandell 1958), Beech type (Golden 1974), Beech Gap community (Pittillo & Smathers 1979), Buckeye-Yellow birch forest p.p. (Callaway *et al.* 1987), Beech, Birch Forests (McLeod 1988), Northern Hardwood Forests (White *et al.* 1993), *Betula alleghaniensis/Ageratina-Aster acuminatus* Forest p.p. (Chapter 4).

Constant species

Aesculus flava, Ageratina altissima var. *roanensis, Aster chlorolepis, Athyrium asplenioides, Betula alleghaniensis, Carex pensylvanica, Dryopteris intermedia, Fagus grandifolia, Polygonatum biflorum* var. *biflorum, Smilax herbacea, Solidago curtisii, Stellaria pubera, Viola blanda.*

Listed species

Allium burdickii, Brachyelytrum septentrionale, Carex manhartii, Stachys clingmanii.

Physiognomy

Fagus and large-diameter *Betula alleghaniensis* (mostly between 47 and 86 cm in size) dominate the canopy (23 m height) of this community type with variable levels of *Halesia* and *Aesculus flava* (Tables 5.24, 5.25, 5.26). *Acer saccharum* dominates the subcanopy in some sites. *Fagus* forms a 2 to 4 m tall shrub layer with *Viburnum lantanoides* and *Acer pensylvanicum* more variable in abundance. The former species has greater dominance in higher-elevation sites. *Dryopteris intermedia* dominates the forest floor with *Carex pensylvanica, Ageratina altissima* var. *roanensis, Aster chlorolepis, Athyrium asplenioides* and *Viola blanda* also abundant. Consistent low-cover species include; *Polygonatum biflorum, Smilax herbacea, Stellaria pubera* and *Solidago curtisii.*

There are two variants in this type. *Betula alleghaniensis* dominates the canopy with *Fagus* and *Halesia* subdominant in the lower-slope, or lower-elevation variant. *Aster chlorolepis, Carex pensylvanica,* and *Viola blanda* have higher abundance in this variant. *Dryopteris* is the dominant ground floor species throughout both variants. *Fagus* dominates the canopy of the higher-elevation, or upper-slope variant with *B. alleghaniensis* subdominant. *Halesia* is absent from this variant, whereas *A. altissima* var. *roanensis* and *C. intumescens* have higher abundance on the forest floor. *Stachys clingmanii* (cover 7) is the major ground species in one moist concave site (plot 676).

Habitat and Distribution

The **Fagus-Betula alleghaniensis/Dryopteris intermedia Forest** inhabits steep (26° average, 16 to 36° range), northwest- to east-facing, high-elevation (1430 m average) upper-slopes (Table 5.27). The two variants differ in site position and/or elevation. The lower-elevation (1294 to 1455 m) *Betula alleghaniensis-Fagus-Halesia* variant occurs in both major watersheds where it inhabits lower-slope positions at higher-elevations or upper-slope sites at lower-elevations. In contrast, the high-elevation (1442 to 1540 m) *Fagus-Betula alleghaniensis* variant dominates upper-slopes at high-elevations. This variant inhabits similar elevations to the **Fagus/Carex pensylvanica Forest** but occurs on the moister, northwest-facing upper-slopes of Slickrock whereas the **Fagus/Carex pensylvanica Forest** is situated on the dryer, southwest-facing slopes of Little Santeetlah.

This community type has infertile soil with low percent base saturation, Ca and pH levels and highest levels of B, Fe, Mg, P and S levels of any **High-Elevation Mixed Hardwood Forests** type. This type has highest Fe levels of any type in the study (Tables 5.7, 5.8). Forty three percent of sites in this type are underlain by metagraywacke (parent material type 12) with the same percentage also situated on metasandstone-metaconglomerate (parent material type 13; Table 5.27).

Distinguishing Features

This type has highest species richness of all **High-Elevation Mixed Hardwood Forests** types in the two smallest scales, which is indicative of the range of small-sized plants present in this type (Table 5.9). At these two scales richness is higher than levels in **Montane Oak Forests** types but is still substantially lower than values recorded in the **Rich Cove and Slope Forests** class.

Succession and Disturbance

Charred stems and charcoal provide evidence for fire in three of the seven stands. One site (plot 548) had a 5 cm thick layer of charcoal in the soil profile. There is evidence of logging in the lowest-elevation site in Slickrock (plot 640). One lower-elevation Little

Santeetlah stand (plot 548, 1352 m elevation) had two 70 cm diameter chestnut logs suggesting that lower-elevation areas inhabited by this type may have had minor chestnut presence in the canopy.

The absence of *Betula alleghaniensis* saplings and presence of *Fagus* saplings suggests that *Fagus* will replace *Betula* in the canopy to a large extent (Table 5.25). *Betula alleghaniensis* requires high-light conditions for establishment (White *et al.* 1985) suggesting that the dominance of this species may result from past disturbance events, such as fire or wind.

COMMUNITY TYPE: Fagus/Carex pensylvanica Forest (5.4)

Synonymy

Beech Gap subtype of Northern Hardwood Forest, ridge variant of Typic subtype of Northern Hardwood Forest (Schafale & Weakley 1990), Beech Gap (Russell 1953), south slope variant of Gray Beech Forest (Whittaker 1956), Beech Gap (Crandell 1958), Beech Forest (Ramseur 1960), Beech type (Golden 1974), Beech gap forest (Pittillo & Smathers 1979), Beech forest (Callaway *et al.* 1987), exposed variant of Beech, Birch Forest (McLeod 1988), Northern Hardwood Forest (White *et al.* 1993), *Fagus/Carex pensylvanica* Forest (Chapter 4).

Physiognomy

Fagus grandifolia is the most prominent species in the canopy of this community type (20 m canopy height) with scattered *Quercus rubra* and *Betula alleghaniensis* also present (Tables 5.24, 5.25, 5.26). Small-sized *Fagus* dominate the strata below, forming a dense 1.5 to 2 m tall shrub layer in association with *Hamamelis*. There is a dense carpet of *Carex pensylvanica* on the forest floor with *Agrostis perennans*, *Aster chlorolepis*, *Carex flexuosa*, *C. intumescens*, *Dioscorea quaternata*, *Dryopteris intermedia*, *Epigaea repens*, *Galax urceolata*, *Luzula multiflora* var. *congesta*, *Medeola virginiana*, *Rubus canadensis*, *Stellaria pubera*, *Smilax rotundifolia*, *Solidago curtisii*, *Prenanthes* species, *Vaccinium pallidum* and *Viola blanda* having low cover in both sites.

Habitat and Distribution

The **Fagus/Carex pensylvanica Forest** inhabits steep (30 and 34°), exposed, southeast- to south-facing, high-elevation (1467 and 1503 m) ridgelines and associated upper-slopes on the ridgeline between the two major watersheds (Table 5.27). The somewhat stunted nature of this type reflects the degree of exposure of these sites.

This community type has infertile soils, with the lowest base saturation, and pH levels of any forest community type in this study (Table 5.7).

Succession and Disturbance

There is no evidence of logging in either stand; however, both have evidence of past disturbance by fire. The canopy trees of one of the sites are young (aged 75 to 80 years; plot 680). It is possible that the fires that followed logging in Slickrock swept over the summit-ridge of this watershed and down onto the upper-slopes of the Little Santeetlah valley.

The dominance of *Fagus* in the small-tree and shrub stratum point to the continuing prominence of this species in the canopy of this community type (Table 5.25).

Discussion

The **High-Elevation Mixed Hardwood Forests** vegetation class is restricted to the high-elevation areas of Joyce Kilmer. In Little Santeetlah the **Quercus rubra/ Thelypteris Forest** inhabits more fertile, southeast- to southwest-facing upper-slopes and ridgelines at mid- to high-elevations. This type grades into the **Fagus/Carex pensylvanica Forest** on ridgelines above. The **Fagus-Betula alleghaniensis/Dryopteris intermedia Forest** is present on mesic and sheltered upper-slopes at high-elevations. In Slickrock the high-elevation variant of this type inhabits the same elevation and slope position as the **Fagus/Carex pensylvanica Forest** in Little Santeetlah. The presence of the more mesic

Fagus-Betula alleghaniensis/Dryopteris intermedia Forest on the upper-slopes of Slickrock is indicative of the less-exposed and cooler conditions in the upper-portion of this north-facing valley.

The two *Fagus*-dominated community types separate by site aspect and temperature. The dominance of *Dryopteris intermedia*, *Ageratina altissima* var. *roanensis*, *Athyrium asplenioides* and lower abundance of *Carex pensylvanica* in the **Fagus-Betula alleghaniensis/Dryopteris intermedia Forest** reflects the mesic conditions of this type, whereas the dominance of the sedge *Carex pensylvanica* in the **Fagus/Carex pensylvanica Forest** is an indication of warmer, exposed conditions inhabited by this type. The latter type also has lower basal area, but higher stem density indicating the dominance of small-sized trees on these exposed sites. Broad differences in small-scale diversity between these types (Table 5.9) reflect the overwhelming dominance of *Carex pensylvanica* and limited pool of species that inhabit the dry conditions associated with the **Fagus/Carex pensylvanica Forest**.

Site moisture and compositional differences observed between the **Fagus-Betula alleghaniensis/Dryopteris intermedia Forest** and the **Fagus/Carex pensylvanica Forest** correspond to patterns described elsewhere (e.g., Brown 1941, Russell 1953, Whittaker 1956, Crandell 1958, Schafale & Weakley 1990, White *et al.* 1993). At Roan Mountain Brown (1941) noted that *Dryopteris* was restricted to the more mesic north- slopes, with higher abundance of *Carex pensylvanica* on south-slope variants. Codominance of *Acer saccharum*, *Betula alleghaniensis* and *Aesculus flava* in the canopy of moister, north-slope types has been documented widely (e.g., Brown 1941, Whittaker 1956, Crandell 1958, Ramseur 1960). These forests tend to have a high diversity of herbaceous species on the forest floor (White *et al.* 1993), corresponding to patterns described for the **Fagus-Betula alleghaniensis/Dryopteris intermedia Forest** in this study. The sedge-dominated **Fagus/Carex pensylvanica Forest** is similar to the dry, exposed variants of the *Fagus* forest associated with high-ridges described in other regions of the Southern Appalachians (e.g., Whittaker 1956, Crandell 1958, Ramseur 1960, McLeod 1988, Schafale & Weakley 1990, Chapter 4).

The **Betula alleghaniensis-Fagus/Rhododendron maximum Forest** dominates high-elevation, west-to northeast-facing slopes in Slickrock and Little Santeetlah and appears to represent the high-elevation version of the *Tsuga canadensis-Rhododendron maximum*-dominated community types. The **Betula alleghaniensis-Fagus/ Rhododendron maximum Forest** has not been described in previous studies. The closest descriptions are those of Crandell (1958). She noted the presence of a dense *Rhododendron minus* shrub layer under *Betula alleghaniensis* and *Sorbus americana* canopy on cool, steep slopes adjacent to spruce stands with a *Rhododendron minus* shrub component. Whittaker (1956) documented increasing heath density in Eastern Hemlock Forests with increasing elevations and noted decreasing presence of herbaceous species. A similar pattern is visible at Joyce Kilmer, with high stem density and limited species diversity in the **Betula alleghaniensis-Fagus/Rhododendron maximum Forest**.

The **Betula alleghaniensis-Fagus/Rhododendron maximum Forest** has more fertile soils than the other two *Fagus* types which is somewhat surprising considering that ericaceous species tend to be associated with highly infertile soils (Graves & Monk 1985). However, although all three types inhabit similar elevations, the **Betula alleghaniensis-Fagus/Rhododendron maximum Forest** is situated on lower-slope sites where soils might accumulate nutrient-runoff from slopes above.

Abundant *Rhododendron calendulaceum* in the **Quercus rubra/Thelypteris Forest** gives this type close resemblance to the lower-elevation variant of Whittaker's (1956) high-elevation red oak forests. The Joyce Kilmer type is also very similar to two of DeLapp's (1978) phases. The main variant of the **Quercus rubra/Thelypteris Forest** corresponds with DeLapp's mixed fern phase. DeLapp (1978) noted importance of chestnut in this phase, which corresponds with my findings. He also noticed the absence of *Betula alleghaniensis* from this phase in the Nantahala mountains which is also true at Joyce Kilmer. The higher-elevation/moister variant of the **Quercus rubra/Thelypteris Forest** with *Betula alleghaniensis* present corresponds with DeLapp's (1978) tall herb phase that is found in steep, rocky sites at the head of coves . He notes that *Betula* is a feature of this phase. The **Quercus rubra/Thelypteris Forest** also has some similarity with the **Quercus**

rubra/Kalmia Forest at Shining Rock, although the Joyce Kilmer type has higher fern cover and species typical of more mesic conditions than the Shining Rock type. This suggests that conditions may be fertile in the Joyce Kilmer type. Indeed, the **Quercus rubra/Thelypteris Forest** has soils with higher pH and percent base saturation levels (**Quercus rubra/Kalmia Forest** pH of 4.04, percent base saturation 36.72; Chapter 4), which perhaps accounts for the higher species richness at all spatial scales (Tables 4.6, 5.4) in the Joyce Kilmer type.

Table 5.24. Average cover class and constancy of species present in the **High-Elevation Mixed Hardwood Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 5.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	5.	5.1	5.2	5.3	5.4
Number of plots:	26	4	13	7	2
Homoteneity:	0.553	0.558	0.712	0.693	0.811
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species					
ACER PENSYLVANICUM	3 81	3 50	3 100	4 71	2 50
ACER RUBRUM VAR RUBRUM	5 88	4 75	6 100	3 71	4 100
ACER SACCHARUM VAR SACCHARUM	3 54	1 25	3 54	4 71	1 50
ACER SPICATUM	3 15	4 50		2 29	
ACTAEA PACHYPODA	2 8			2 29	
AESCULUS FLAVA	2 50		1 38	3 100	4 50
AGERATINA ALTISSIMA VAR ROANENSIS	2 62		2 69	3 86	1 50
AGROSTIS PERENNANS	1 42		1 62	2 14	2 100
ALLIUM BURDICKII*	2 4			2 14	
AMELANCHIER ARBOREA	3 69	3 75	3 100	4 14	4 50
AMIANTHIUM MUSCAETOXICUM	1 12		1 23		
AMPHICARPAEA BRACTEATA	2 23		2 46		
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	1 42		2 46	1 57	1 50
ANGELICA TRIQUINATA	2 8			2 14	1 50
ANGELICA VENOSA	1 8		1 15		
ARALIA NUDICAULIS	2 4		2 8		
ARISTOLOCHIA MACROPHYLLA	2 8		2 15		
ARISAEMA TRIPHYLLUM VAR TRIPHYLLUM	1 31		1 23	1 71	
ARNOGLOSSUM ATRIPLICIFOLIUM	2 23		2 46		
ARNOGLOSSUM MUHLENBERGII	1 4		1 8		
ARONIA MELANOCARPA	3 4	3 25			
ARUNCUS DIOICUS VAR DIOICUS	1 4		1 8		
ASCLEPIAS EXALTATA	1 12		1 23		
ASTER CHLOROLEPIS	2 73	1 25	2 69	3 100	2 100
ASTER DIVARICATUS	2 8		2 15		
ASTER LATERIFLORUS VAR LATERIFLORUS	1 12		1 23		
ASTER RETROFLEXUS	1 23		1 46		
ASTER UNDULATUS	1 35		1 69		
ATHYRIUM ASPLENIOIDES	2 73	2 25	2 77	3 100	3 50
AUREOLARIA LAEVIGATA	2 23		2 46		
BETULA ALLEGHANIENSIS	5 73	6 100	4 54	5 100	3 50
BETULA LENTA	2 23	1 25	2 38		
BRACHYELYTRUM ERECTUM	1 12		1 23		
BRACHYELYTRUM SEPTENTRIONALE*	2 23		2 8	2 71	
CAMPANULA DIVARICATA	2 23		2 46		
CARDAMINE DIPHYLLA	1 8			1 29	
CAREX AESTIVALIS	1 38	1 25	1 46	2 43	
CAREX APPALACHICA	1 12		1 8	2 29	
CAREX BLANDA	1 4		1 8		
CAREX DIGITALIS	1 8	1 25			1 50

Group:	5.	5.1	5.2	5.3	5.4
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
CAREX FLEXUOSA	2 27		2 15	1 43	2 100
CAREX INTUMESCENS	2 19			3 43	2 100
CAREX LEPTONERVIA	1 8			1 29	
CAREX LAXIFLORA VAR LAXIFLORA	2 8		2 15		
CAREX MANHARTII*	2 12	2 25		2 29	
CAREX PENSYLVANICA	4 50		2 31	4 100	7 100
CAREX SCABRATA	1 4			1 14	
CAREX SWANII	1 4		1 8		
CARYA CORDIFORMIS	3 8		3 15		
CARYA GLABRA	2 19		2 38		
CARYA OVATA	4 4		4 8		
CASTANEA DENTATA	4 50	2 25	4 92		
CAULOPHYLLUM THALICTROIDES	2 12			2 43	
CHAMAELIRIUM LUTEUM	1 12		1 23		
CHIMAPHILA MACULATA VAR MACULATA	1 12		1 23		
CIMICIFUGA RACEMOSA	3 8			3 29	
CLETHRA ACUMINATA	3 4		3 8		
CLINTONIA BOREALIS	2 4			2 14	
CLINTONIA UMBELLULATA	2 42		2 69	1 14	1 50
COLLINSONIA CANADENSIS	2 35		2 69		
CONOPHOLIS AMERICANA	1 27		1 46		1 50
COREOPSIS MAJOR VAR RIGIDA	1 19		1 38		
CORNUS ALTERNIFOLIA	2 15	2 25	1 8	2 29	
CORNUS FLORIDA	2 4		2 8		
CRATAEGUS FLABELLATA	1 4		1 8		
CUSCUTA SP. #1	2 4			2 14	
CYPRIPEDIUM ACAULE	1 4		1 8		
CYSTOPTERIS PROTRUSA	1 12	1 25	1 8	1 14	
DANTHONIA COMPRESSA	1 27		1 54		
DENNSTAEDTIA PUNCTILOBULA	3 38		3 69		2 50
DESMODIUM NUDIFLORUM	1 12		1 23		
DICHANTHELIUM BOSCII	1 35		2 62		1 50
DICHANTHELIUM COMMUTATUM	1 4		1 8		
DICHANTHELIUM LATIFOLIUM	2 4		2 8		
DIOSCOREA QUATERNATA	2 73		2 92	1 71	2 100
DIPHYLLEIA CYMOSA	2 8		2 8	2 14	
DRYOPTERIS INTERMEDIA	4 42	4 50		5 100	2 100
DRYOPTERIS MARGINALIS	1 15	1 25	1 8	2 29	
EPIFAGUS VIRGINIANA	2 19			2 43	2 100
EPIGAEA REPENS	2 8		2 15		
ERIGERON PULCHELLUS VAR PULCHELLUS	1 4		1 8		
EUPATORIUM PURPUREUM VAR PURPUREUM	2 38		2 54	2 43	
EUPATORIUM STEELEI	2 12		2 23		
EUPHORBIA COROLLATA	1 4		1 8		
FAGUS GRANDIFOLIA	5 96	6 100	2 92	8 100	9 100
FESTUCA SUBVERTICILLATA	1 12		1 15	1 14	
FRAXINUS AMERICANA	2 38		2 77		
GALAX URCEOLATA	2 23	2 25	3 23		1 100
GALEARIS SPECTABILIS	1 4		1 8		
GALIUM CIRCAEZANS VAR CIRCAEZANS	1 4		1 8		
GALIUM LATIFOLIUM	2 12		2 23		
GAYLUSSACIA URSINA	2 4		2 8		
GENTIANA DECORA	1 50		1 92		1 50
GOODYERA PUBESCENS	1 23	1 25	1 31		1 50
HALESIA TETRAPTERA VAR MONTICOLA	5 69	3 25	6 100	5 57	
HAMAMELIS VIRGINIANA	4 42	4 75	5 23	2 43	6 100

Group:	5.	5.1	5.2	5.3	5.4
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
HELIANTHUS MICROCEPHALUS	2 8		2 15		
HELIANTHUS STRUMOSUS	1 8		1 15		
HEUCHERA VILLOSA VAR VILLOSA	2 8		2 8	2 14	
HIERACIUM PANICULATUM	1 42		1 85		
HOUSTONIA CAERULEA	2 31		2 46	2 14	2 50
HOUSTONIA PURPUREA VAR PURPUREA	2 46		2 85		1 50
HOUSTONIA SERPYLLIFOLIA	2 19		2 31		2 50
HUPERZIA LUCIDULA	2 19	1 25	1 8	2 43	
HYDRANGEA ARBORESCENS	2 27		2 38	2 29	
HYPERICUM SP. #1	1 4				1 50
HYPOXIS HIRSUTA	1 4		1 8		
ILEX MONTANA	3 88	4 100	3 100	2 57	2 100
IMPATIENS PALLIDA	1 4			1 14	
IRIS CRISTATA	2 4			2 14	
ISOTRIA VERTICILLATA	1 12		1 23		
KALMIA LATIFOLIA	3 27	7 25	3 38		1 50
LAPORTEA CANADENSIS	2 15			2 57	
LILIUM MICHAUXII	1 4		1 8		
LILIUM SUPERBUM	1 4		1 8		
LIRIODENDRON TULIPIFERA	3 27		3 54		
LISTERA SMALLII	1 4	1 25			
LUZULA ACUMINATA	2 12			2 43	
LUZULA MULTIFLORA VAR CONGESTA	1 31		1 38	1 14	2 100
LYCOPODIUM DENDROIDEUM	2 4	2 25			
LYSIMACHIA QUADRIFOLIA	2 54	2 25	2 92		1 50
MAGNOLIA ACUMINATA	2 50	1 25	3 77	2 14	1 50
MAGNOLIA FRASERI	2 46	1 25	1 54	2 29	2 100
MAIANTHEMUM CANADENSE	2 23	1 25	2 8	2 57	
MAIANTHEMUM RACEMOSUM	2 69		2 100	2 57	1 50
MEDEOLA VIRGINIANA	2 73	1 50	2 100	2 29	2 100
MELAMPYRUM LINEARE	3 38		3 77		
MELANTHIUM PARVIFLORUM	2 27	1 25	1 8	2 71	
MITCHELLA REPENS	2 23	2 25	1 8	2 43	1 50
MONARDA CLINOPODIA	1 12		1 23		
MONARDA DIDYMA	1 4		1 8		
MONOTROPA UNIFLORA	1 12		1 15	1 14	
MUHLENBERGIA TENUIFLORA VAR VARIABILIS	1 4		1 8		
NYSSA SYLVATICA	2 8		2 15		
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	1 15		1 31		
OXALIS MONTANA	2 15			2 57	
OXALIS STRICTA	2 4			2 14	
OXYDENDRUM ARBOREUM	1 8		1 15		
PANICUM SPECIES	3 4				3 50
PEDICULARIS CANADENSIS	1 35		1 69		
PINUS STROBUS	2 4		2 8		
POA COMPRESSA	1 35		2 46	1 43	
POA CUSPIDATA	1 23		1 23	1 29	1 50
PODOPHYLLUM PELTATUM	2 8			2 29	
POLYGONATUM BIFLORUM VAR BIFLORUM	1 62		1 77	2 86	
POLYGONATUM PUBESCENS	2 4			2 14	
POLYPODIUM APPALACHIANUM	2 8			2 29	
POLYSTICHUM ACROSTICHOIDES	2 23		1 15	2 57	
POTENTILLA CANADENSIS VAR CANADENSIS	2 31		2 62		
PRENANTHES SP. #1	2 73		2 92	1 71	2 100
PROSARTES LANUGINOSA	1 12		1 15	2 14	
PRUNUS PENSYLVANICA	2 42	1 25	2 54	2 29	1 50
PRUNUS SEROTINA	2 38	2 50	2 46	2 14	2 50

Group:	5.	5.1	5.2	5.3	5.4
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
PYRULARIA PUBERA	2 15		2 31		
QUERCUS ALBA	4 12		4 23		
QUERCUS MONTANA	4 31		4 62		
QUERCUS RUBRA	6 77	4 50	8 100	1 43	4 100
QUERCUS VELUTINA	2 8		2 15		
RANUNCULUS HISPIDUS	1 8		1 8	1 14	
RHODODENDRON ARBORESCENS	3 4		3 8		
RHODODENDRON CALENDULACEUM	4 50	2 25	4 77		2 100
RHODODENDRON CATAWBIENSE	5 4	5 25			
RHODODENDRON MAXIMUM	4 69	8 100	2 62	3 57	2 100
RIBES CYNOSBATI	2 4			2 14	
ROBINIA PSEUDOACACIA	2 38		2 77		
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	2 15		2 31		
RUBUS ARGUTUS	2 19		2 38		
RUBUS CANADENSIS	3 65	3 75	3 54	3 71	2 100
RUDBECKIA LACINIATA	2 8			2 29	
SAMBUCUS CANADENSIS VAR CANADENSIS	2 4	2 25			
SAMBUCUS RACEMOSA VAR PUBENS	2 8		2 8	2 14	
SASSAFRAS ALBIDUM	2 19		2 38		
SILENE STELLATA	1 23		1 46		
SILENE VIRGINICA VAR VIRGINICA	1 12		2 15	1 14	
SMILAX GLAUCA VAR GLAUCA	1 15		1 31		
SMILAX HERBACEA	2 73		2 92	2 86	1 50
SMILAX ROTUNDIFOLIA	2 73	2 75	2 100	1 14	2 100
SOLIDAGO SP. #2	1 4		1 8		
SOLIDAGO ARGUTA SSP CAROLINIANA	1 42		2 77		1 50
SOLIDAGO CURTISII	2 88	1 25	2 100	2 100	2 100
SOLIDAGO ERECTA	2 8		2 15		
SORBUS AMERICANA	1 4			1 14	
STACHYS CLINGMANII*	3 31		2 54	7 14	
STELLARIA PUBERA	2 65		2 77	2 100	
STENANTHIUM GRAMINEUM VAR MICRANTHUM	2 8	2 25	1 8		
STREPTOPUS ROSEUS VAR ROSEUS	1 19			1 71	
THALICTRUM CLAVATUM	1 4			1 14	
THALICTRUM CORIACEUM	1 12		1 23		
THALICTRUM DIOICUM	1 12		1 23		
THELYPTERIS NOVEBORACENSIS	4 58		5 100		2 100
TIARELLA CORDIFOLIA VAR CORDIFOLIA	2 19			2 71	
TILIA AMERICANA VAR HETEROPHYLLA	1 12		1 15	2 14	
TIPULARIA DISCOLOR	1 4			1 14	
TRAUTVETTERIA CAROLINIENSIS VAR CAROLINIENSIS	2 15			2 57	
TRILLIUM ERECTUM	1 23	1 25		1 71	
TRILLIUM UNDULATUM	1 35	1 75	1 31	1 29	
TSUGA CANADENSIS	3 81	4 50	3 100	3 57	1 100
UVULARIA PERFOLIATA	1 19		1 38		
UVULARIA PUBERULA	1 4		1 8		
VACCINIUM CORYMBOSUM	4 19	5 25	4 31		
VACCINIUM ERYTHROCARPUM	2 35		3 38	2 29	2 100
VACCINIUM HIRSUTUM*	2 8	1 25	2 8		
VACCINIUM PALLIDUM	2 31	1 25	2 38		2 100
VACCINIUM SIMULATUM	3 42	4 25	3 62	2 14	1 50
VACCINIUM STAMINEUM	2 35	2 25	2 62		
VIBURNUM ACERIFOLIUM	3 8		3 15		
VIBURNUM LANTANOIDES	3 35	2 25	2 15	4 71	3 50
VIBURNUM NUDUM VAR CASSINOIDES	2 27	3 50	2 31	1 14	

Group:	5.	5.1	5.2	5.3	5.4
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
VIOLA BLANDA	2 54		1 38	3 100	2 100
VIOLA HASTATA	1 65		2 92	1 57	1 50
VIOLA PUBESCENS VAR PUBESCENS	1 4		1 8		
VIOLA ROTUNDIFOLIA	2 23	1 25	1 8	2 43	1 50
VIOLA SORORIA	1 42		1 77	2 14	
VITIS AESTIVALIS VAR AESTIVALIS	1 12		1 23		
VITIS VULPINA	1 4		1 8		

Table 5.25. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **High-Elevation Mixed Hardwood Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

5. High-Elevation Mixed Hardwood Forests

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	54.23	123.75	4.49	182.47	3.17	3.79	9.23	6.51
BETULA ALLEGHANIENSIS	36.15	45.45	11.31	92.92	4.91	1.48	14.05	7.77
FAGUS GRANDIFOLIA	1518.81	550.99	2.40	2072.21	4.95	25.55	16.12	20.83
HALESIA TETRAPTERA VAR MONTICOLA	170.51	130.26	4.62	305.38	2.59	7.66	6.19	6.93
QUERCUS RUBRA	31.41	41.96	33.14	106.51	13.23	1.73	33.79	17.76
RHODODENDRON MAXIMUM	2378.21	897.95	0.00	3276.15	1.92	11.97	4.66	8.31
SMILAX ROTUNDIFOLIA	678.88	0.77	0.00	679.65	0.02	9.12	0.06	4.59
ALL	7788.01	2560.90	63.91	10412.82	36.11	100.00	100.00	100.00

5.1 Betula alleghaniensis-Fagus/Rhododendron maximum Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
BETULA ALLEGHANIENSIS	157.50	79.17	32.92	269.58	15.57	0.81	40.42	20.61
FAGUS GRANDIFOLIA	832.50	532.92	0.00	1365.42	3.14	2.68	8.58	5.63
ILEX MONTANA	1465.00	816.67	0.00	2281.67	2.38	6.44	7.11	6.77
KALMIA LATIFOLIA	5050.00	1150.00	0.00	6200.00	2.14	6.94	5.89	6.41
RHODODENDRON MAXIMUM	15216.67	5720.83	0.00	20937.50	12.07	70.71	29.06	49.88
ALL	27040.83	8960.00	35.42	36036.25	38.20	100.00	100.00	100.00

5.2 Quercus rubra/Thelypteris Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	87.69	236.47	5.90	330.06	5.12	7.30	14.54	10.92
HALESIA TETRAPTERA VAR MONTICOLA	294.10	230.51	0.00	524.62	2.36	13.23	6.25	9.74
QUERCUS RUBRA	16.67	62.37	64.74	143.78	24.52	3.15	61.88	32.52
RHODODENDRON CALENDULACEUM	681.54	106.86	0.00	788.40	0.25	12.63	0.90	6.77
SMILAX ROTUNDIFOLIA	974.10	1.54	0.00	975.64	0.03	16.69	0.11	8.40
ALL	3680.77	1100.26	80.38	4861.41	38.27	100.00	100.00	100.00

5.3 Fagus-Betula alleghaniensis/Dryopteris intermedia Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
AESCULUS FLAVA	25.71	25.71	8.57	60.00	2.04	1.69	7.88	4.78
BETULA ALLEGHANIENSIS	0.00	22.86	21.43	44.29	7.66	0.98	23.53	12.25
FAGUS GRANDIFOLIA	3862.86	1287.14	7.14	5157.14	12.72	73.63	40.92	57.27
HALESIA TETRAPTERA VAR MONTICOLA	87.14	54.29	17.14	158.57	5.25	3.88	11.38	7.63
ALL	4790.00	1611.43	62.86	6464.29	33.15	100.00	100.00	100.00

5.4 Fagus/Carex pensylvanica Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
BETULA ALLEGHANIENSIS	0.00	37.50	6.25	43.75	3.14	0.54	12.70	6.62
FAGUS GRANDIFOLIA	4436.25	1548.75	6.25	5991.25	13.43	65.57	48.98	57.28
HAMAMELIS VIRGINIANA	973.75	513.75	0.00	1487.50	1.53	16.22	5.67	10.94
QUERCUS RUBRA	0.00	135.00	5.00	140.00	8.43	1.41	26.49	13.95
SMILAX ROTUNDIFOLIA	693.75	0.00	0.00	693.75	0.01	8.03	0.05	4.04
ALL	6472.50	2580.00	17.50	9070.00	28.26	99.99	100.00	99.98

Table 5.26. Vertical structure of woody species in the **High-Elevation Mixed Hardwood Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

5. High-Elevation Mixed Hardwood Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1		
ACER RUBRUM VAR RUBRUM	1	1	3	3	
BETULA ALLEGHANIENSIS	1	1	1	2	
CASTANEA DENTATA	1	2			
FAGUS GRANDIFOLIA	1	3	2	3	
HALESIA TETRAPTERA VAR					
MONTICOLA	1	1	2	2	
HAMAMELIS VIRGINIANA	1	1			
ILEX MONTANA	1	1			
QUERCUS MONTANA	1	1	1	1	
QUERCUS RUBRA	1	1	2	4	
RHODODENDRON CALENDULACEUM	1	1			
RHODODENDRON MAXIMUM	1	2			
RUBUS CANADENSIS	1	1			
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	1			
VACCINIUM SIMULATUM	1	1			

5.1 Betula alleghaniensis-Fagus/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1		
ACER RUBRUM VAR RUBRUM	1	1	1	1	
AMELANCHIER ARBOREA	1	1			
BETULA ALLEGHANIENSIS	1	2	3	5	
FAGUS GRANDIFOLIA	1	2	1	3	
HAMAMELIS VIRGINIANA	1	2	1		
ILEX MONTANA	1	3	1		
KALMIA LATIFOLIA	1	2			
QUERCUS RUBRA	1	1			
RHODODENDRON MAXIMUM	3	9			
RUBUS CANADENSIS	1	1			
TSUGA CANADENSIS	1	2	1		
VACCINIUM CORYMBOSUM	1	1			
VACCINIUM SIMULATUM	1	1			

5.2 Quercus rubra/Thelypteris Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	1		
ACER RUBRUM VAR RUBRUM	1	2	5	4	
ACER SACCHARUM VAR SACCHARUM	1	1	1	1	
BETULA ALLEGHANIENSIS	1	1	1	1	
CASTANEA DENTATA	1	3			
HALESIA TETRAPTERA VAR MONTICOLA	1	2	4	3	
HAMAMELIS VIRGINIANA	1	1			
ILEX MONTANA	1	1			
MAGNOLIA ACUMINATA	1	1			
QUERCUS MONTANA	1	1	1	1	
QUERCUS RUBRA	1	1	4	7	
RHODODENDRON CALENDULACEUM	1	2			
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	1			
VACCINIUM SIMULATUM	1	1			
VACCINIUM STAMINEUM	1	1			

5.3 Fagus-Betula alleghaniensis/Dryopteris intermedia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	2		
ACER RUBRUM VAR RUBRUM	1	1	1	1	
ACER SACCHARUM VAR SACCHARUM	1	1	1	1	
AESCULUS FLAVA	1	1	1	1	
BETULA ALLEGHANIENSIS	1	1	1	4	
FAGUS GRANDIFOLIA	1	6	7	7	
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1	2	
RUBUS CANADENSIS	1	1			
TSUGA CANADENSIS	1	1	1		
VIBURNUM LANTANOIDES	1	2			

5.4 Fagus/Carex pensylvanica Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	1	3	
AMELANCHIER ARBOREA	1	1	1	2	
FAGUS GRANDIFOLIA	1	8	6	8	
HAMAMELIS VIRGINIANA	1	5	3		
ILEX MONTANA	1	1			
QUERCUS RUBRA	1	1	1	4	
SMILAX ROTUNDIFOLIA	1	1			
VIBURNUM LANTANOIDES	1	1			

Table 5.27. Average site information for the **High-Elevation Mixed Hardwood Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**11**=arkosic metasandstone-metaconglomerate-metasiltstone, **12**=metagraywacke, **13**=arkosic metasandstone-metaconglomerate), Landform types (representing micro-scale topographic units) (**R**=ridge, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**MS**=mid slopes, **US**=upper slopes).

5. High-Elevation Mixed Hardwood Forests

	Group				
	5.	5.1	5.2	5.3	5.4
Site Characteristics:					
Elevation (m)	1374	1396	1320	1430	1485
Slope (o)	24	24	23	26	32
Aspect (o)	SE-SW	W-NE	SE-SW	NW-E	SE-SW
Parent material	12,13	13	13	12,13	11,12
Soil depth (cm)	63.5	43.3	71.1	60.9	58.5
Surface Substrate (%):					
Moss/Lichen	2	2	2	2	3
Wood	4	4	4	5	3
Rock	3	3	3	1	6
Organic Matter	92	92	91	92	89
Water	0	0	0	0	2
Topographic Characteristics:					
Relative slope (%)	35	47	33	38	14
LFI	0.17	0.18	0.17	0.17	0.18
TSI	-0.03	-0.10	-0.03	0.01	-0.04
Landform type	SS	SS	SS	SS	R,SS
Topgraphic position	US	MS,US	US	US	US

5.5.6 VEGETATION CLASS: 6. **Xeric Evergreen Forests**

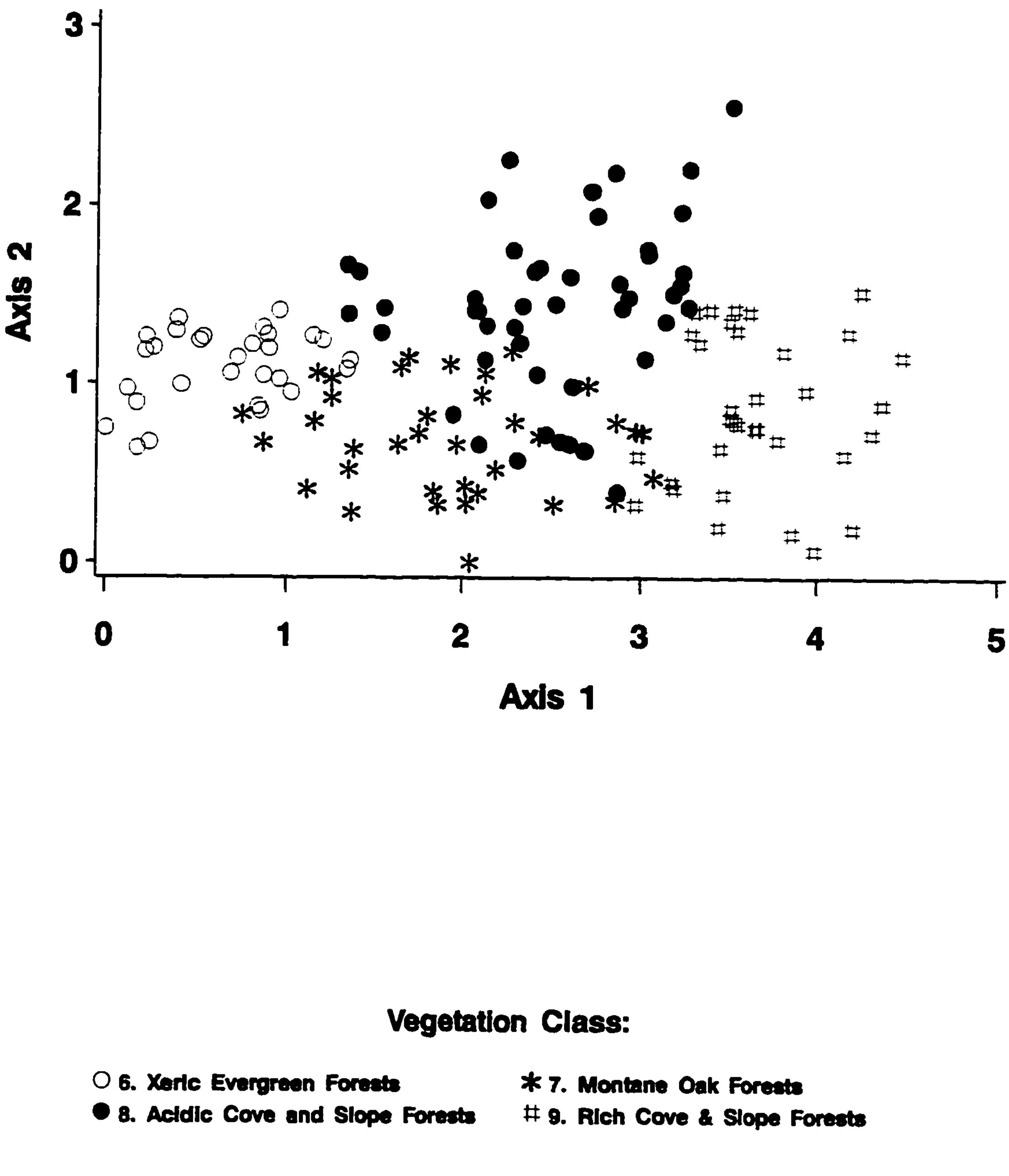
The **Xeric Evergreen Forests** class inhabits dry, infertile sites with thin soils and is restricted to lower-elevation areas of the Southern Appalachian Mountains (Schafale & Weakley 1990). This vegetation class is not evenly distributed throughout Joyce Kilmer but is mostly restricted to the lower-section of the Slickrock valley (Figure 1.5; Appendices 3, 6). In Joyce Kilmer this class is characterized by the dominance of xerophytic *Pinus* (*P. rigida*) and *Quercus* species (*Quercus coccinea, Q. montana*) and a dense ericaceous shrub stratum, typically dominated by *Gaylussacia ursina*.

The **Xeric Evergreen Forests** are distributed across the mid- and lower-elevation areas of Joyce Kilmer, in association with the **Montane Oak Forests**, the **Rich Cove and Slope Forests** and the **Acidic Cove and Slope Forests** (Figures 5.2, 5.3). A separate ordination of these vegetation classes was performed to identify habitat differences between these four classes. The four classes separate primarily along gradients of soil nutrients, topographic position, topographic moisture and soil texture (Figures 5.6, 5.8) with less significant associations with elevation and slope position. The **Rich Cove and Slope Forests** inhabits more fertile soils, with higher Ca, Mg, Mn and cation exchange capacity. Stands in this class typically have more sheltered (high LFI), lower-slope positions than the other three classes. The **Acidic Cove and Slope Forests** and the **Xeric Evergreen Forests** are positioned at the opposite end of the soil fertility gradient, and are separated from one another along the site moisture (solar radiation, TMI) gradient, with the latter class situated on dry (high solar radiation, low TMI) sites. The **Acidic Cove and Slope Forests** also separate from the other three vegetation classes by having infertile (high Fe), organic soils. The **Montane Oak Forests** have an intermediate position along the soil fertility gradient and have typically dryer site conditions than either the **Acidic Cove and Slope Forests** or the **Rich Cove and Slope Forests**.

Stands within the **Xeric Evergreen Forests** were well separated by community type in this ordination in contrast to types in other vegetation classes (Figures 5.7, 5.8). The

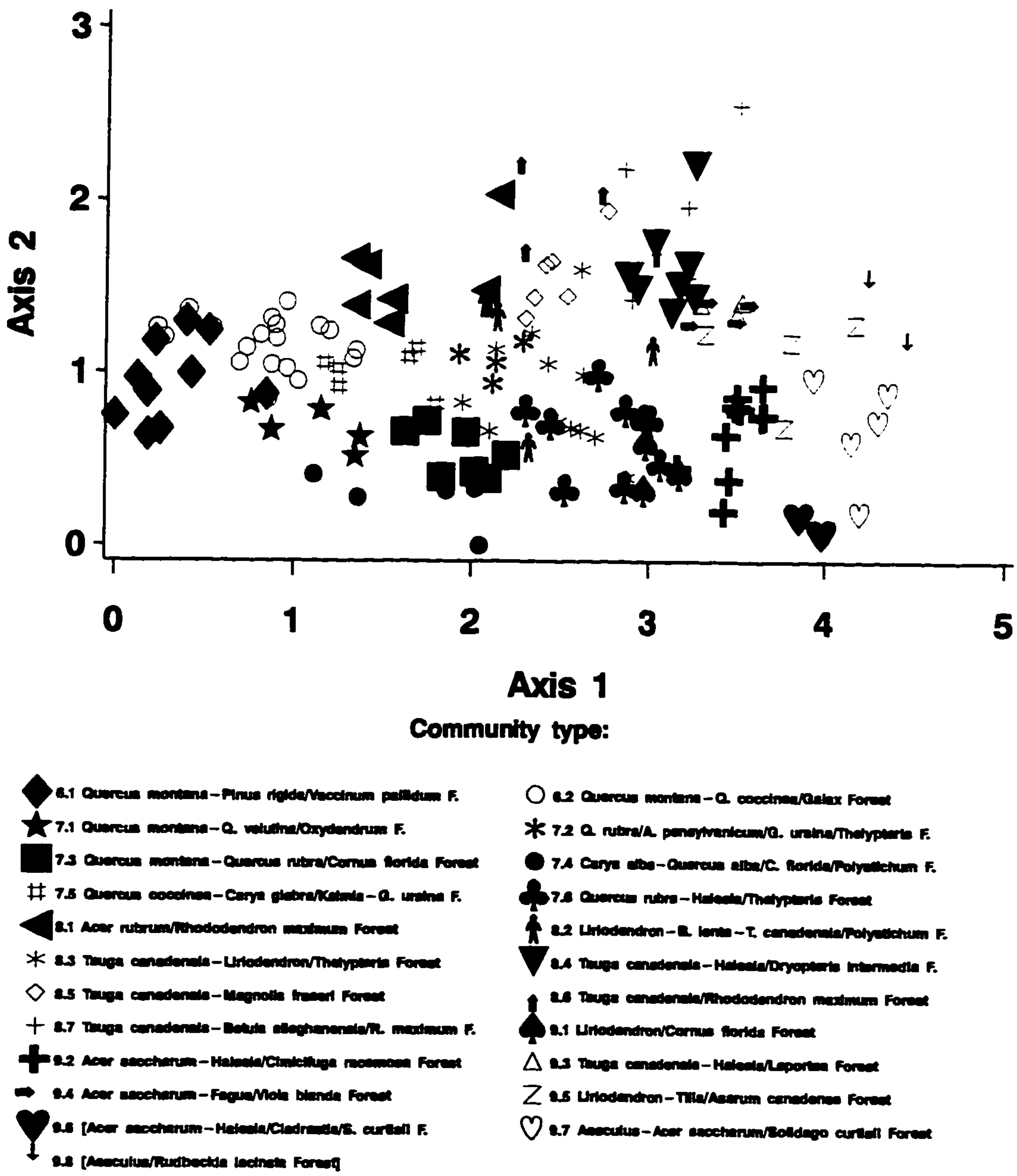
Quercus montana-Pinus rigida/Vaccinium pallidum Forest inhabits dryer, more exposed (higher solar radiation, lower TMI) sites than the **Quercus montana-Quercus coccinea/Galax Forest**. The three remaining vegetation classes were each analyzed separately in an attempt to clarify environmental differences between community types. The results of each ordination are reported at the beginning of the description for each respective vegetation class.

Figure 5.6. DCA ordination diagram showing the distribution of the **Acidic Cove and Slope Forests**, the **Montane Oak Forests**, the **Rich Cove and Slope Forests** and the **Xeric Evergreen Forests** on the two major compositional gradients.



3
2
1
0
Axis 2
0
1
2
3
4
5
Axis 1
Vegetation Class:
6. Xeric Evergreen Forests
7. Montane Oak Forests
8. Acidic Cove and Slope Forests
9. Rich Cove & Slope Forests

Figure 5.7. Diagram for DCA ordination showing the distribution of the community types in the **Acidic Cove and Slope Forests**, the **Montane Oak Forests**, the **Rich Cove and Slope Forests** and the **Xeric Evergreen Forests** on the two major compositional gradients.


3
2
1
0
Axis 2
0
1
2
3
4
5
Axis 1
Community type:
6.1 Quercus montana–Pinus rigida/Vaccinum pallidum F.
7.1 Quercus montana–Q. velutina/Oxydendrum F.
7.3 Quercus montana–Quercus rubra/Cornus florida Forest
7.5 Quercus coccinea–Carya glabra/Kalmia–G. ursina F.
8.1 Acer rubrum/Rhododendron maximum Forest
8.3 Tsuga canadensis–Liriodendron/Thelypteris Forest
8.5 Tsuga canadensis–Magnolia fraseri Forest
8.7 Tsuga canadensis–Betula alleghaniensis/R. maximum F.
9.2 Acer saccharum–Halesia/Cimicifuga racemosa Forest
9.4 Acer saccharum–Fagus/Viola blanda Forest
9.6 [Acer saccharum–Halesia/Cladrastis/S. curtisii F.
9.8 [Aesculus/Rudbeckia laciniata Forest]
6.2 Quercus montana–Q. coccinea/Galax Forest
7.2 Q. rubra/A. pensylvanicum/G. ursina/Thelypteris F.
7.4 Carya alba–Quercus alba/C. florida/Polystichum F.
7.6 Quercus rubra–Halesia/Thelypteris Forest
8.2 Liriodendron–B. lenta–T. canadensis/Polystichum F.
8.4 Tsuga canadensis–Halesia/Dryopteris intermedia F.
8.6 Tsuga canadensis/Rhododendron maximum Forest
9.1 Liriodendron/Cornus florida Forest
9.3 Tsuga canadensis–Halesia/Laportea Forest
9.5 Liriodendron–Tilia/Asarum canadense Forest
9.7 Aesculus–Acer saccharum/Solidago curtisii Forest

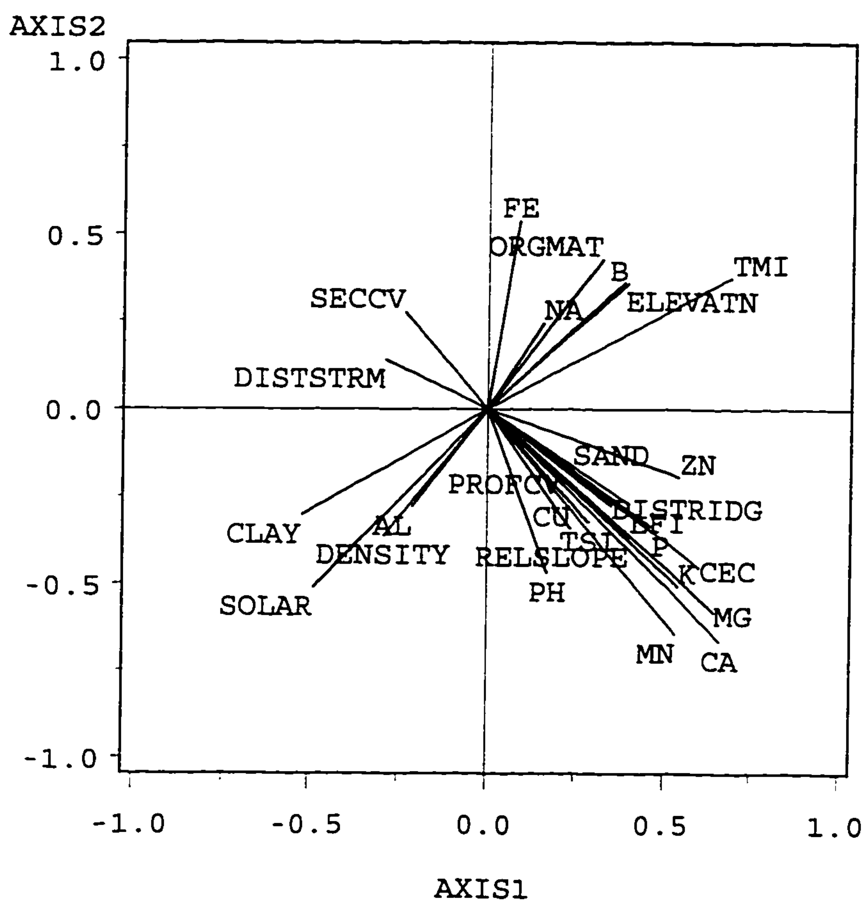


Figure 5.8. Vector diagram for DCA ordination of the **Acidic Cove and Slope Forests**, the **Montane Oak Forests**, the **Rich Cove and Slope Forests** and **Xeric Evergreen Forests** showing association between species composition and major environmental gradients. DISTRIDG=distance to ridge, DISTSTRM=distance downslope to cove, RELSLOPE=relative slope position, with increasing values corresponding to higher position, PROFCV=profile curvature, SECCV=section curvature. Small LFI values represent unprotected upper-slopes whereas high values representing concave lower-slopes. Increasing TMI values correspond with increasing site moisture potential. Low TSI values represent convex upper-slopes while high values represent concave lower-slopes.

COMMUNITY TYPE: Quercus montana-Pinus rigida/Vaccinium pallidum Forest (6.1)

Synonymy

Pine--Oak/Heath (Schafale & Weakley 1990), Xeric Pine Forests (Whittaker 1956), Pitch Pine-Scarlet Oak Scrub Cover type (Thomas 1966), Oak-Pine Cover type (Thomas 1966), Pine Community Type (Cooper & Hardin 1970), Oak-Pine type (Golden 1974), Xeric Pine Forests (McLeod 1988), *Pinus pungens/Kalmia* Forest (Chapter 3), *Pinus pungens-Quercus montana/Kalmia* Forest (Chapter 4).

Constant species

Acer rubrum var. *rubrum, Amelanchier arborea, Aureolaria laevigata, Coreopsis major* var. *rigida, Dichanthelium commutatum, Epigaea repens, Gaylussacia ursina, Kalmia latifolia, Nyssa sylvatica, Oxydendrum arboreum, Pinus rigida, Pinus strobus, Quercus coccinea* var. *coccinea, Quercus montana, Quercus velutina, Sassafras albidum, Smilax glauca* var. *glauca, Smilax rotundifolia, Schizachyrium scoparium, Tsuga canadensis, Vaccinium pallidum, Vaccinium stamineum*.

Listed species

Stewartia ovata, Vaccinium hirsutum.

Physiognomy

Quercus montana, Q. coccinea and *Acer rubrum* have consistently high cover in the canopy (21 m height) of this community type (Tables 5.28, 5.29, 5.30). Abundance of *Pinus rigida* and *Q. falcata* varies between sites, with both absent from the one Little Santeetlah stand. *Q. falcata* is present on the dry, off-ridge sites in lower Slickrock. *Nyssa sylvatica* and *Oxydendrum* are the major understory species. These two species are also components of the shrub stratum, which is dominated by *Gaylussacia ursina, Kalmia, Pinus strobus* and *Vaccinium stamineum*. *V. pallidum* is the most prominent ground species with *Aureolaria* *laevigata, Coreopsis major* var. *rigida, Dichanthelium commutatum, Epigaea repens, Smilax glauca* var. *glauca, S. rotundifolia* and *Schizachyrium scoparium* present with low, but consistent cover.

Habitat and Distribution

The **Quercus montana-Pinus rigida/Vaccinium pallidum Forest** inhabits moderate-sloped (25° average, 14 to 33° range), southeast- to southwest-facing upper-slopes and ridges in lower Slickrock (658 m mean elevation, 500 - 889 m range; Table 5.31). The one Little Santeetlah stand is situated on a dry, south-facing rock outcrop (909 m).

Soil nutrient status and texture are similar to the other **Xeric Evergreen Forests** type (Tables 5.7, 5.8). Roughly half of the sites in this type are underlain by arkosic metasandstone-slate (parent material type 10; Table 5.31).

Distinguishing Features

This community type has higher species richness at the five largest scales than the **Quercus montana-Quercus coccinea/Galax Forest**, reflecting higher shrub and ground-species diversity (Table 5.9).

Succession and Disturbance

All Slickrock plots have been logged, although the presence of scattered old canopy trees (e.g., *Quercus falcata* 38 cm diameter, >185 years in age, plot 543), indicates that logging was only partial. Chestnut was present only in 60% of the stands and the limited abundance of living chestnut sprouts and chestnut logs suggests that this species was only a minor component of the canopy. Charred stems and/or charcoal in the soil profile provide evidence of fire in 70% of plots. There is evidence of minor pine beetle activity in one of the ten plots.

Acer rubrum and *Oxydendrum* have highest saplings densities indicating that these shade-tolerant species will become an increasingly important component of this community type in the future. Less abundant numbers of *Quercus coccinea*, *Pinus rigida* and *P. virginiana* saplings point to the future decline in *Quercus* and *Pinus* canopy dominance (Table 5.29).

The trends described here appear to be the result of changes in fire regime. Before about 1940, *Pinus rigida* and *P. pungens*-dominated forests in the western Smoky Mountains burned with an average return interval of 10-12 years (Harmon 1982). Fire frequency dropped dramatically following fire suppression and most stands in the western Smoky Mountains (and probably Joyce Kilmer) have not burned in several decades. Long-term monitoring from the western Smoky Mountains indicates that basal area and canopy density have increased substantially since the onset of fire suppression. Since this time *Quercus montana* and *P. rigida* have regenerated poorly whereas the abundance of shade-tolerant species has increased (J. Harrod *in prep.*). Periodic fire may be necessary to restore and maintain the historic composition and structure of this community type.

COMMUNITY TYPE: Quercus montana-Quercus coccinea/Galax Forest (6.2)

Synonymy

Chestnut Oak Forest (Schafale & Weakley 1990), Chestnut Oak-Chestnut Heath (Whittaker 1956), Mixed Oak Cover Type p.p. (Thomas 1966), Chestnut Oak type (Golden 1974), Chestnut Oak Forests p.p. (McLeod 1988), Chestnut Oak Forest (Patterson 1994), *Quercus montana-Quercus coccinea/Kalmia* Forest p.p. (Chapter 3), *Quercus montana-Quercus rubra/Kalmia* Forests p.p. (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Castanea dentata*, *Chimaphila maculata* var. *maculata*, *Galax urceolata*, *Gaylussacia ursina*, *Kalmia latifolia*, *Nyssa sylvatica*, *Oxydendrum arboreum*, *Quercus coccinea* var. *coccinea*, *Quercus montana*, *Quercus* *velutina, Sassafras albidum, Smilax glauca* var. *glauca, Smilax rotundifolia, Tsuga canadensis, Vaccinium pallidum*.

Listed species

Carex lucorum var. *austrolucorum, Stewartia ovata, Vaccinium hirsutum*.

Physiognomy

Large-diameter *Quercus montana* (mostly 42 to 76 cm), *Q. coccinea* (42 to 57 cm), *Q. velutina* and *Acer rubrum* dominate the canopy (22m height) of this community type (Tables 5.28, 5.29, 5.30). *Oxydendrum* and *Nyssa sylvatica* are the major understory tree species. There is a dense 0.6 to 1.5 m tall *Gaylussacia ursina* shrub layer with *Kalmia* and *Tsuga canadensis* also present. *Galax urceolata* dominates the limited number of forest floor species, with *Chimaphila maculata* var. *maculata, Smilax glauca* var. *glauca, S. rotundifolia* and *Vaccinium pallidum* having low, but consistent cover.

There are two variants in this community type. There is more consistent *Quercus coccinea* and higher *Q. velutina* cover in the moister, upper-slope variant. *Cornus florida* and *Castanea dentata* have higher abundance in the shrub layer of this variant. In contrast, *Pinus rigida* is a component of the second, dryer, ridge variant with greater dominance by *Kalmia* and *Sassafras* in the shrub stratum. *Galax* has higher cover on the ground in this variant and *Vaccinium hirsutum* has more consistent cover.

Habitat and Distribution

The **Quercus montana-Quercus coccinea/Galax Forest** inhabits southeast- to northwest-facing, predominantly southwest- and west-facing upper-slopes and ridgelines (mean 19° slope, 3 to 31° range) at mid-elevations (826 m mean, 470 to 1030 range; Table 5.31). In mid-Slickrock, variant 1 inhabits upper-slopes with variant 2 situated above on ridgelines. The three plots in Little Santeetlah are ridge sites, with the single variant 1 site (927 m) situated at a higher elevation than the two plots in Variant 2 (770, 798 m).

The soils have similar texture to the other community type in this vegetation class. The **Quercus montana-Quercus coccinea/Galax Forest** has similar, but deeper soils than the **Quercus montana-Pinus rigida/Vaccinium pallidum Forest** (Tables 5.7, 5.8, 5.31).

Distinguishing Features

The **Quercus montana-Quercus coccinea/Galax Forest** has lower species richness than the **Quercus montana-Pinus rigida/Vaccinium pallidum Forest** at the five largest scales (Table 5.9), which probably reflects greater shrub cover in the former.

Succession and Disturbance

Twelve of the 19 plots have evidence of past chestnut presence. The presence of one or two logs per stand suggests that this species was at least a minor canopy component. Most stands in Slickrock also show evidence of logging, although the presence of old *Quercus montana* (e.g. >225 years, 67 cm diameter, plot 556) suggests that logging was partial at some sites. Three Little Santeetlah stands contain old canopy trees (e.g., *Q. montana* 55 cm diameter. aged 254 years, plot 540). There is evidence of recent pine beetle activity in 11% of plots.

Abundant *Acer rubrum* and *Oxydendrum arboreum* saplings suggest that this two species will dominate the future canopy of this community type (Table 5.29). The presence of *Quercus coccinea*, *Q. montana* and *Q. velutina* saplings indicates that the *Quercus* genus will be maintained at least to a limited extent in the canopy. Low *Q. montana* and *Pinus rigida* reproduction (Table 5.29) is probably the result of fire suppression. Periodic fires are probably necessary to restore the dominance of *Q. montana* and *P. rigida* in the canopy of this type.

Discussion

The <u>Xeric Evergreen Forests</u> vegetation class dominates the dry, low-elevation slopes and ridges in the lower Slickrock valley. In contrast, this class has limited distribution in Little Santeetlah, restricted to low-elevation areas of the ridgeline between the Little

Santeetlah and Horse Cove valleys. This class has finer-textured (higher clay component), infertile soils (low percent base saturation, Ca, cation exchange capacity, pH) in comparison to other major mid- and low-elevation vegetation classes in this Wilderness (the **Acidic Cove and Slope Forests**, the **Montane Oak Forests**, the **Rich Cove and Slope Forests**; Tables 5.7, 5.8). The dry, infertile conditions inhabited by the **Xeric Evergreen Forests** probably at least partly accounts for the low species diversity (Table 5.9), although the dense shrub layer, which limits light levels on the forest floor, may restrict species richness.

Although both community types in the **Xeric Evergreen Forests** class inhabit upper-slopes and ridgelines the **Quercus montana-Pinus rigida/Vaccinium pallidum Forest** inhabits dryer sites at lower-elevations nearer the northern-end of the Slickrock valley. More xeric conditions are indicated by the presence of *Schizachyrium scoparium, Vaccinium pallidum* and *V. stamineum*, more consistent *Pinus rigida* cover and the absence of *Quercus rubra* in this type in comparison to the other **Xeric Evergreen Forests** type. Although the **Quercus montana-Pinus rigida/Vaccinium pallidum Forest** inhabits dryer conditions than the **Quercus montana-Quercus coccinea/Galax Forest**, the former type has higher species richness at most spatial scales. This probably reflects the more open and patchy shrub cover in the former type which enables a greater diversity of species to persist on the forest floor.

At Joyce Kilmer the **Xeric Evergreen Forests** vegetation class inhabits similar site positions to examples of this class in other areas of the Southern Appalachian Mountains (e.g., Whittaker 1956, McLeod 1988, Schafale & Weakley 1990, Patterson 1994, Chapter 3). The composition of the types in Joyce Kilmer is similar to types described from other areas of the Southern Appalachians, with the exception of the composition of the ericaceous shrub stratum. *Kalmia latifolia*, the major shrub species at Linville Gorge and Shining Rock (Chapters 3 & 4), has only secondary importance in Joyce Kilmer where deciduous *Gaylussacia ursina* is dominant. This reflects biogeographic differences in species distribution rather than differences in the site characteristics, with *G. ursina* restricted to the mountains southwest of the Asheville Basin (Weakley 1997).

Table 5.28. Average cover class and constancy of species present in the **Xeric Evergreen Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 5.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	6.	6.1	6.2
Number of plots:	29	10	19
Homoteneity:	0.684	0.760	0.714
	Cov/Con	Cov/Con	Cov/Con
Species			
ACER PENSYLVANICUM	2 69	1 40	2 84
ACER RUBRUM VAR RUBRUM	6 100	6 100	7 100
ACER SACCHARUM VAR SACCHARUM	1 7	1 10	1 5
AGERATINA ALTISSIMA VAR ROANENSIS	2 3		2 5
AGROSTIS PERENNANS	1 7	1 10	1 5
AMELANCHIER ARBOREA	2 62	2 80	2 53
AMIANTHIUM MUSCAETOXICUM	2 7		2 11
ARISTOLOCHIA MACROPHYLLA	1 3		1 5
ASTER CORDIFOLIUS	1 3		1 5
ASTER DIVARICATUS	1 3		1 5
ASTER UNDULATUS	1 3	1 10	
ATHYRIUM ASPLENIOIDES	2 14		2 21
AUREOLARIA LAEVIGATA	1 34	1 80	1 11
BAPTISIA TINCTORIA	1 17	1 30	1 11
BETULA ALLEGHANIENSIS	1 3		1 5
BETULA LENTA	3 45	2 20	3 58
CALYCANTHUS FLORIDUS VAR GLAUCUS	2 24		2 37
CAMPANULA DIVARICATA	1 10	1 10	1 11
CAREX AESTIVALIS	1 3	1 10	
CAREX FLEXUOSA	1 3		1 5
CAREX LUCORUM VAR AUSTROLUCORUM*	2 3		2 5
CAREX NIGROMARGINATA	1 7	1 10	1 5
CARYA ALBA	2 14	3 20	2 11
CARYA CORDIFORMIS	2 3	2 10	
CARYA GLABRA	2 31	2 50	2 21
CARYA OVATA	2 7		2 11
CARYA PALLIDA	2 14	2 30	1 5
CASTANEA DENTATA	2 79	2 60	2 89
CHAMAELIRIUM LUTEUM	1 45	1 20	1 58
CHIMAPHILA MACULATA VAR MACULATA	1 79	1 70	1 84
CLITORIA MARIANA	1 17	1 50	
COMANDRA UMBELLATA VAR UMBELLATA	1 7	1 20	
CONOPHOLIS AMERICANA	1 3		1 5
COREOPSIS MAJOR VAR RIGIDA	1 45	2 90	1 21
CORNUS FLORIDA	3 38	2 30	3 42
CYPRIPEDIUM ACAULE	1 3	1 10	
DANTHONIA COMPRESSA	1 3		1 5
DANTHONIA SERICEA	2 3	2 10	
DANTHONIA SPICATA	1 3	1 10	
DENNSTAEDTIA PUNCTILOBULA	1 3		1 5

Group:	6.	6.1	6.2
	Cov/Con	Cov/Con	Cov/Con
DESMODIUM NUDIFLORUM	1 24	1 20	1 26
DESMODIUM ROTUNDIFOLIUM	2 3	2 10	
DICHANTHELIUM BOSCII	1 3		1 5
DICHANTHELIUM COMMUTATUM	1 52	1 100	1 26
DICHANTHELIUM DICHOTOMUM VAR DICHOTOMUM	1 28	1 50	1 16
DICHANTHELIUM DICHOTOMUM VAR 5 (=YADKINENSE)	1 3		1 5
DIOSCOREA QUATERNATA	1 17	1 10	1 21
DIOSPYROS VIRGINIANA	2 17	2 40	2 5
EPIGAEA REPENS	2 72	2 90	2 63
ERECHTITES HIERACIIFOLIA VAR HIERACIIFOLIA	1 3	1 10	
EUPHORBIA COROLLATA	1 10	1 30	
FAGUS GRANDIFOLIA	2 34	2 70	2 16
GALAX URCEOLATA	3 86	2 70	3 95
GAULTHERIA PROCUMBENS	2 21	2 50	1 5
GAYLUSSACIA BACCATA	3 28	3 40	3 21
GAYLUSSACIA URSINA	7 100	5 100	8 100
GOODYERA PUBESCENS	1 31	1 10	1 42
HALESIA TETRAPTERA VAR MONTICOLA	3 28		3 42
HAMAMELIS VIRGINIANA	5 3		5 5
HIERACIUM PANICULATUM	1 7	1 10	1 5
HIERACIUM VENOSUM	1 7	1 20	
HOUSTONIA PURPUREA VAR PURPUREA	1 10		1 16
HOUSTONIA TENUIFOLIA	1 3	1 10	
HYPERICUM STRAGULUM	1 7	1 20	
HYPOXIS HIRSUTA	1 7		1 11
ILEX BEADLEI	2 10	2 30	
ILEX MONTANA	2 41	1 50	2 37
ILEX OPACA VAR OPACA	2 14	2 10	2 16
IRIS CRISTATA	1 3		1 5
ISOTRIA VERTICILLATA	1 7		1 11
KALMIA LATIFOLIA	4 100	4 100	4 100
LESPEDEZA INTERMEDIA	1 10	1 30	
LEUCOTHOE FONTANESIANA	2 3		2 5
LILIUM MICHAUXII	1 10		1 16
LIRIODENDRON TULIPIFERA	1 45	1 50	1 42
LYONIA LIGUSTRINA VAR LIGUSTRINA	2 34	2 60	2 21
LYSIMACHIA QUADRIFOLIA	1 10		1 16
MAGNOLIA ACUMINATA	1 10	1 10	2 11
MAGNOLIA FRASERI	2 66	1 70	2 63
MAIANTHEMUM RACEMOSUM	1 7	1 10	1 5
MEDEOLA VIRGINIANA	1 24		1 37
MELAMPYRUM LINEARE	2 14		2 21
MITCHELLA REPENS	1 3	1 10	
MONOTROPA HYPOPITHYS	1 3	1 10	
MONOTROPA UNIFLORA	1 3		1 5
MUHLENBERGIA TENUIFLORA VAR VARIABILIS	1 3		1 5
NYSSA SYLVATICA	5 97	5 100	5 95
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	1 3		1 5
OXYDENDRUM ARBOREUM	6 100	5 100	6 100
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	2 7	2 10	1 5
PINUS ECHINATA	4 10	5 20	3 5
PINUS PUNGENS	6 3	6 10	
PINUS RIGIDA	4 72	4 90	4 63

Group:	6.		6.1		6.2	
	Cov/Con		Cov/Con		Cov/Con	
PINUS STROBUS	3	79	4	90	3	74
PINUS VIRGINIANA	2	31	2	70	2	11
PITYOPSIS GRAMINIFOLIA VAR LATIFOLIA	1	3	1	10		
PLATANTHERA CLAVELLATA	1	14	1	40		
POA COMPRESSA	1	3			1	5
POLYGONATUM BIFLORUM VAR BIFLORUM	1	14	1	10	1	16
POLYSTICHUM ACROSTICHOIDES	1	10			1	16
POTENTILLA CANADENSIS VAR CANADENSIS	1	10			1	16
PRENANTHES SP. #1	1	10			1	16
PRUNUS PENSYLVANICA	1	10			1	16
PTERIDIUM AQUILINUM	1	38	1	70	2	21
PYRULARIA PUBERA	2	31	2	10	2	42
QUERCUS ALBA	5	31	3	50	7	21
QUERCUS COCCINEA VAR COCCINEA	5	93	6	100	5	89
QUERCUS FALCATA	4	21	5	50	1	5
QUERCUS MONTANA	6	93	6	90	6	95
QUERCUS MARILANDICA	1	3	1	10		
QUERCUS RUBRA	4	31			4	47
QUERCUS VELUTINA	4	86	3	100	5	79
QUERCUS FALCATA X COCCINEA	4	7	4	10	4	5
RHODODENDRON CALENDULACEUM	2	48	2	40	2	53
RHODODENDRON MAXIMUM	3	28	3	30	4	26
RHUS COPALLINA VAR LATIFOLIA	1	3	1	10		
ROBINIA PSEUDOACACIA	3	59	2	30	3	74
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	1	3			1	5
RUBUS FLAGELLARIS	2	3	2	10		
SASSAFRAS ALBIDUM	3	100	2	100	3	100
SCHIZACHYRIUM SCOPARIUM	2	38	2	90	2	11
SMILAX GLAUCA VAR GLAUCA	2	100	2	100	2	100
SMILAX ROTUNDIFOLIA	2	100	2	100	2	100
SOLIDAGO SP. #1	1	21	1	60		
SOLIDAGO ARGUTA SSP CAROLINIANA	1	3	1	10		
SOLIDAGO CAESIA	2	7	1	10	2	5
SOLIDAGO CURTISII	1	10			1	16
SOLIDAGO ERECTA	1	7	1	10	1	5
SOLIDAGO ODORA VAR ODORA	1	24	1	60	1	5
SORGHASTRUM NUTANS	1	14	1	30	1	5
STELLARIA PUBERA	1	7			1	11
STENANTHIUM GRAMINEUM VAR MICRANTHUM	2	7			2	11
STEWARTIA OVATA*	2	7	1	10	2	5
TEPHROSIA VIRGINIANA	1	17	1	50		
THELYPTERIS NOVEBORACENSIS	1	17			1	26
TRILLIUM UNDULATUM	1	3			1	5
TSUGA CANADENSIS	3	93	3	90	4	95
VACCINIUM CORYMBOSUM	2	24			2	37
VACCINIUM HIRSUTUM*	3	62	2	60	3	63
VACCINIUM PALLIDUM	3	90	5	100	2	84
VACCINIUM SIMULATUM	2	7			2	11
VACCINIUM STAMINEUM	3	79	4	100	2	68
VIBURNUM ACERIFOLIUM	1	10	2	20	1	5
VIOLA BLANDA	1	3			1	5
VIOLA HASTATA	1	45	1	10	1	63
VIOLA SORORIA	1	7			1	11
VITIS AESTIVALIS VAR AESTIVALIS	1	10	2	20	1	5
VITIS CINEREA VAR BAILEYANA	1	3			1	5

Table 5.29. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Xeric Evergreen Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

6. Xeric Evergreen Forests

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	170.72	454.83	0.78	626.32	3.74	16.25	12.43	14.34
GAYLUSSACIA URSINA	745.32	0.34	0.00	745.66	0.02	11.97	0.06	6.02
KALMIA LATIFOLIA	1094.08	511.55	0.00	1605.63	0.87	21.91	2.92	12.41
OXYDENDRUM ARBOREUM	145.83	220.83	0.00	366.67	1.80	9.00	6.15	7.58
PINUS RIGIDA	5.86	110.78	4.45	121.09	3.71	2.42	12.48	7.45
QUERCUS COCCINEA VAR COCCINEA	22.04	79.89	9.63	111.55	4.62	2.78	16.97	9.87
QUERCUS MONTANA	11.72	80.63	14.43	106.78	6.03	2.78	20.01	11.39
ALL	3102.87	1935.55	46.18	5084.60	30.29	99.99	99.93	99.96

6.1 Quercus montana-Pinus rigida/Vaccinium pallidum Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	231.75	302.58	0.00	534.33	1.96	15.82	7.32	11.57
GAYLUSSACIA URSINA	308.00	0.00	0.00	308.00	0.01	8.61	0.03	4.32
KALMIA LATIFOLIA	912.67	158.75	0.00	1071.42	0.31	19.22	1.29	10.26
OXYDENDRUM ARBOREUM	189.92	198.17	0.00	388.08	1.36	11.22	5.63	8.43
PINUS RIGIDA	15.00	128.00	8.92	151.92	4.86	4.15	18.85	11.50
PINUS VIRGINIANA	35.00	72.25	3.00	110.25	2.45	3.23	7.46	5.34
QUERCUS COCCINEA VAR COCCINEA	28.17	109.92	4.25	142.33	4.28	3.92	17.53	10.72
QUERCUS MONTANA	4.67	70.33	9.92	84.92	4.15	2.53	17.72	10.12
ALL	2442.58	1425.50	34.58	3902.67	26.24	99.96	99.96	99.97

6.2 Quercus montana-Quercus coccinea/Galax Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	138.60	534.96	1.18	674.74	4.68	16.48	15.12	15.80
GAYLUSSACIA URSINA	975.48	0.53	0.00	976.01	0.02	13.75	0.08	6.91
KALMIA LATIFOLIA	1189.56	697.24	0.00	1886.80	1.17	23.32	3.77	13.54
NYSSA SYLVATICA	66.40	159.08	1.18	226.67	0.91	4.88	3.21	4.04
OXYDENDRUM ARBOREUM	122.63	232.76	0.00	355.39	2.03	7.83	6.43	7.13
PINUS RIGIDA	1.05	101.71	2.11	104.87	3.11	1.50	9.12	5.31
QUERCUS COCCINEA VAR COCCINEA	18.82	64.08	12.46	95.35	4.80	2.18	16.68	9.43
QUERCUS MONTANA	15.44	86.05	16.80	118.29	7.02	2.91	21.21	12.06
QUERCUS VELUTINA	10.88	35.22	5.79	51.89	2.43	1.46	7.17	4.32
ALL	3450.39	2203.99	52.28	5706.67	32.41	100.00	99.91	99.95

Table 5.30. Vertical structure of woody species in the **Xeric Evergreen Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

6. Xeric Evergreen Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	6	4	
CASTANEA DENTATA	1	1			
CORNUS FLORIDA	1	1			
GAYLUSSACIA URSINA	6	4			
KALMIA LATIFOLIA	1	4			
NYSSA SYLVATICA	1	3	4	1	
OXYDENDRUM ARBOREUM	1	2	4	3	
PINUS RIGIDA	1	1	1	2	
PINUS STROBUS	1	1	1		
QUERCUS ALBA	1	1	1	1	
QUERCUS COCCINEA VAR COCCINEA	1	1	3	4	
QUERCUS MONTANA	1	1	3	4	
QUERCUS RUBRA	1	1	1	1	
QUERCUS VELUTINA	1	1	1	2	
SASSAFRAS ALBIDUM	1	2	1		
SMILAX GLAUCA VAR GLAUCA	1	1			
SMILAX ROTUNDIFOLIA	1	2			
TSUGA CANADENSIS	1	2	1		
VACCINIUM STAMINEUM	1	2			

6.1 Quercus montana-Pinus rigida/Vaccinum pallidum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	5	3	
GAYLUSSACIA URSINA	4	3			
KALMIA LATIFOLIA	2	4			
NYSSA SYLVATICA	1	3	3	1	
OXYDENDRUM ARBOREUM	1	2	4	3	
PINUS RIGIDA	1	1	2	3	
PINUS STROBUS	1	2	1		
PINUS VIRGINIANA	1	1	1	1	
QUERCUS ALBA	1	1	1	1	
QUERCUS COCCINEA VAR COCCINEA	1	1	4	4	
QUERCUS FALCATA	1	1	1	1	
QUERCUS MONTANA	1	1	4	4	
QUERCUS VELUTINA	1	1	1	1	
SASSAFRAS ALBIDUM	1	1	1		
SMILAX GLAUCA VAR GLAUCA	1	1			
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	2			
VACCINIUM STAMINEUM	3	3			

6.2 Quercus montana-Quercus coccinea/Galax Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	6	5	
BETULA LENTA	1	1	1	1	
CASTANEA DENTATA	1	1			
CORNUS FLORIDA	1	1			
GAYLUSSACIA URSINA	7	5			
KALMIA LATIFOLIA	1	4			
NYSSA SYLVATICA	1	2	4	1	
OXYDENDRUM ARBOREUM	1	2	5	3	
PINUS RIGIDA	1	1	1	2	
PINUS STROBUS	1	1	1	1	
QUERCUS ALBA	1	1	1	1	
QUERCUS COCCINEA VAR COCCINEA	1	1	2	4	
QUERCUS MONTANA	1	1	2	4	
QUERCUS RUBRA	1	1	1	1	
QUERCUS VELUTINA	1	1	1	3	
RHODODENDRON MAXIMUM	1	1			
ROBINIA PSEUDOACACIA	1	1	1	1	
SASSAFRAS ALBIDUM	1	2	1		
SMILAX ROTUNDIFOLIA	1	2			
TSUGA CANADENSIS	1	2	1		
VACCINIUM STAMINEUM	1	1			

Table 5.31. Average site information for the **Xeric Evergreen Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**10**=arkosic metasandstone-slate), Landform type (representing micro-scale topographic units) (**SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**MS**=mid slopes, **US**=upper slopes).

6. Xeric Evergreen Forests

	Group		
	6.	6.1	6.2
Site Characteristics:			
Elevation (m)	777	683	827
Slope (o)	21	25	19
Aspect (o)	SE-NW	SE-SW	SE-NW
Parent material	10		10
Soil depth (cm)	55.3	45.4	60.5
Surface Substrate (%):			
Moss/Lichen	2	5	0
Wood	4	3	4
Rock	3	7	1
Organic Matter	92	88	94
Water	0	0	0
Topographic Characteristics:			
Relative slope (%)	41	30	47
LFI	0.19	0.20	0.19
TSI	-0.03	-0.03	-0.04
Landform type	SS	SS	SS
Topgraphic position	MS,US	MS	US

5.5.7 VEGETATION CLASS: 7. Montane Oak Forests

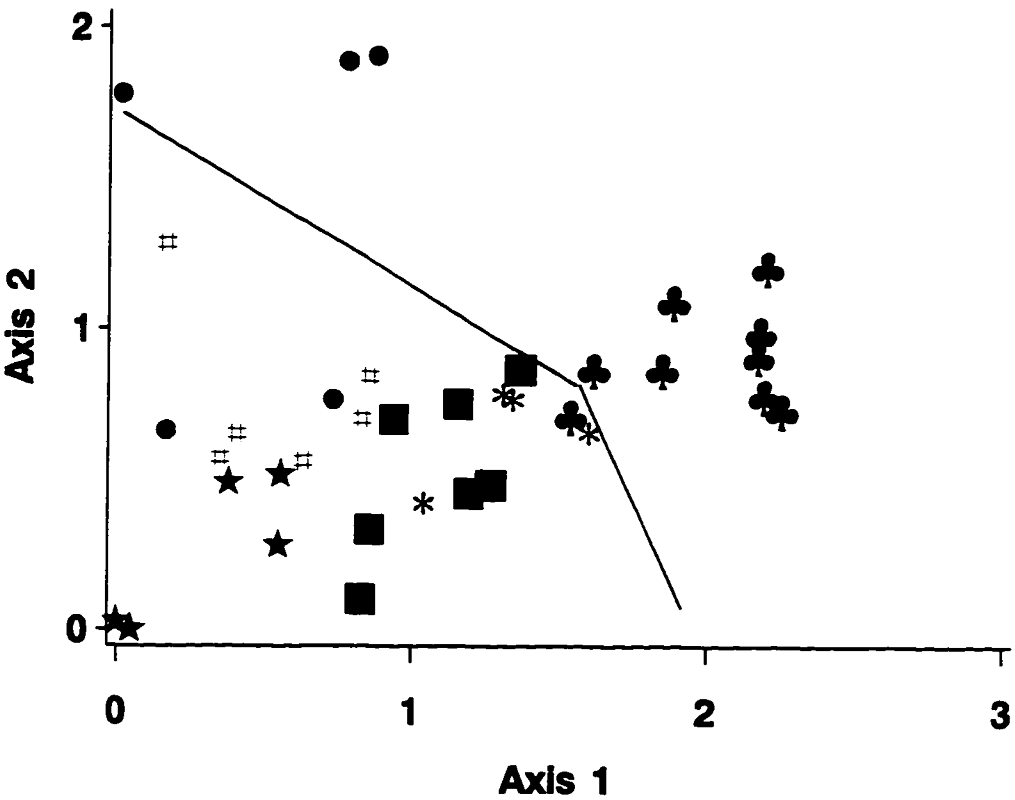
The **Montane Oak Forests** are widely distributed throughout the Southern Appalachian Mountains. In Joyce Kilmer this vegetation class dominates the mid- and-lower-elevation areas of the southeast-facing Little Santeetlah valley in conjunction with the **Rich Cove and Slope Forests** class. In this watershed these two classes are separated by topographic position and soil nutrients with the former inhabiting typically less fertile sites (though more fertile than the **Acidic Cove and Slope Forests**) with higher slope position (Figures 8,10). **Montane Oak Forests** are less widespread in the upper-portions of the north-facing Slickrock Creek valley, but dominate the lower-section of the valley in association with the **Xeric Evergreen Forests**. The **Montane Oak Forests** class accounts for 20% of the sites sampled in this study (Appendices 3, 6).

The **Montane Oak Forests** are characterized by *Quercus*-dominated canopies (typically *Quercus rubra*, *Q. montana*, *Q. coccinea*), a diversity of low-cover, but highly consistent forest floor species and dominance by deciduous species. High-elevation forests in Joyce Kilmer dominated by *Q. rubra* have been included in the **High-Elevation Mixed Hardwood Forests** vegetation class because of their closer floristic and environmental associations with high-elevation forests (Figures 5.2, 5.3, 5.4, 5.5). In Joyce Kilmer the **Montane Oak Forests** have highest species richness at larger scales (≥ 100 m^2) in comparison to other vegetation classes identified in this study (Table 5.9).

The ordination of the **Montane Oak Forests** class separated types by elevation, slope position, soil fertility and texture (Figures 5.9, 5.12). The **Carya alba-Quercus alba/Cornus florida/Polystichum Forest** inhabits sites with coarser-textured soils at much lower-elevations than other types in this class. This type and the **Quercus rubra-Halesia/Thelypteris Forest** also separate from the remaining types along the soil fertility-site moisture gradient by inhabiting more fertile (higher Mn, Ca), moister (high TMI) and cooler (low solar radiation) sites. The remaining community types were not well separated in this analysis and as a consequence were ordinated in a separate analysis in attempt to clarify patterns (Figures 5.11, 5.12).

The remaining four community types separate from one another by site position, site slope angle and soil fertility (Figures 5.11, 5.12). The **Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest** and the **Quercus montana-Quercus rubra/Cornus florida Forest** typically inhabit moister (low solar radiation, high TMI), more fertile (here represented by high Mn) sites than the remaining two types. The former type occurs on moister sites than the other three types. The **Quercus montana-Quercus velutina/Oxydendrum Forest** is positioned at the opposing, dry, infertile end of the moisture-soil fertility gradient.

Figure 5.9. DCA ordination diagram showing the distribution of the **Montane Oak Forests** vegetation class on the two major compositional gradients. The line shows separation of stands for future reordinations.



Community type:

- ★ 7.1 Quercus montana – Q. velutina/Oxydendrum Forest
- * 7.2 Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest
- ■ 7.3 Quercus montana – Quercus rubra/Cornus florida Forest
- ● 7.4 Carya alba – Quercus alba/Cornus florida/Polystichum Forest
- ⌗ 7.5 Quercus coccinea – Carya glabra/Kalmia – Gaylussacia ursina Forest
- ♣ 7.6 Quercus rubra – Halesia/Thelypteris Forest

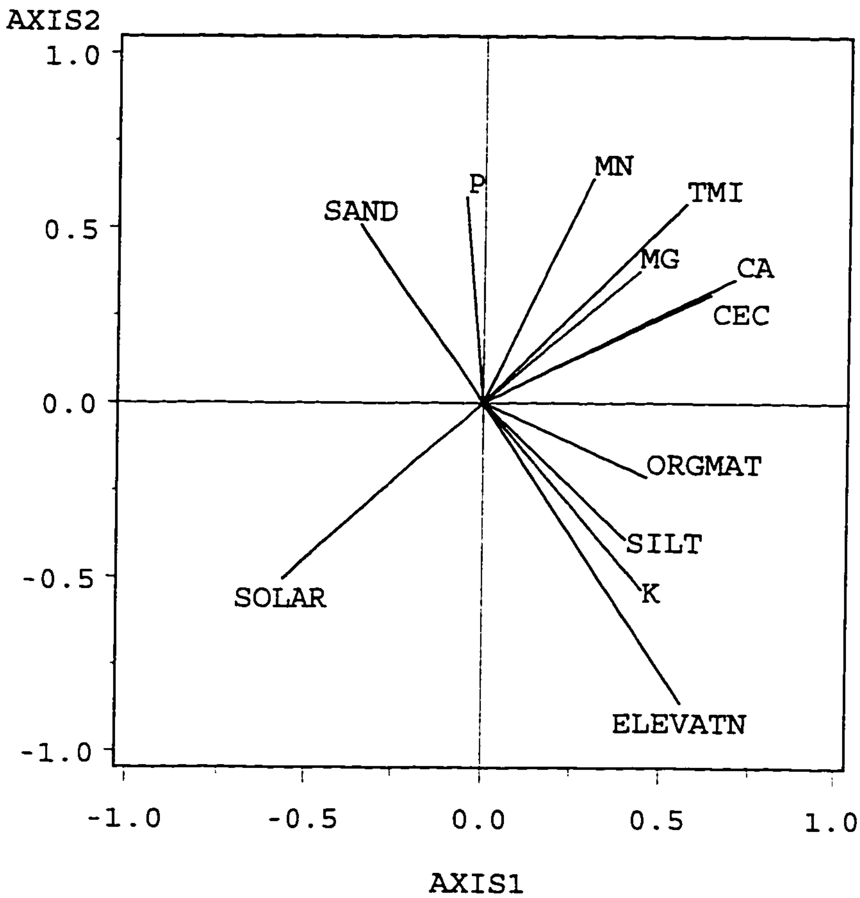
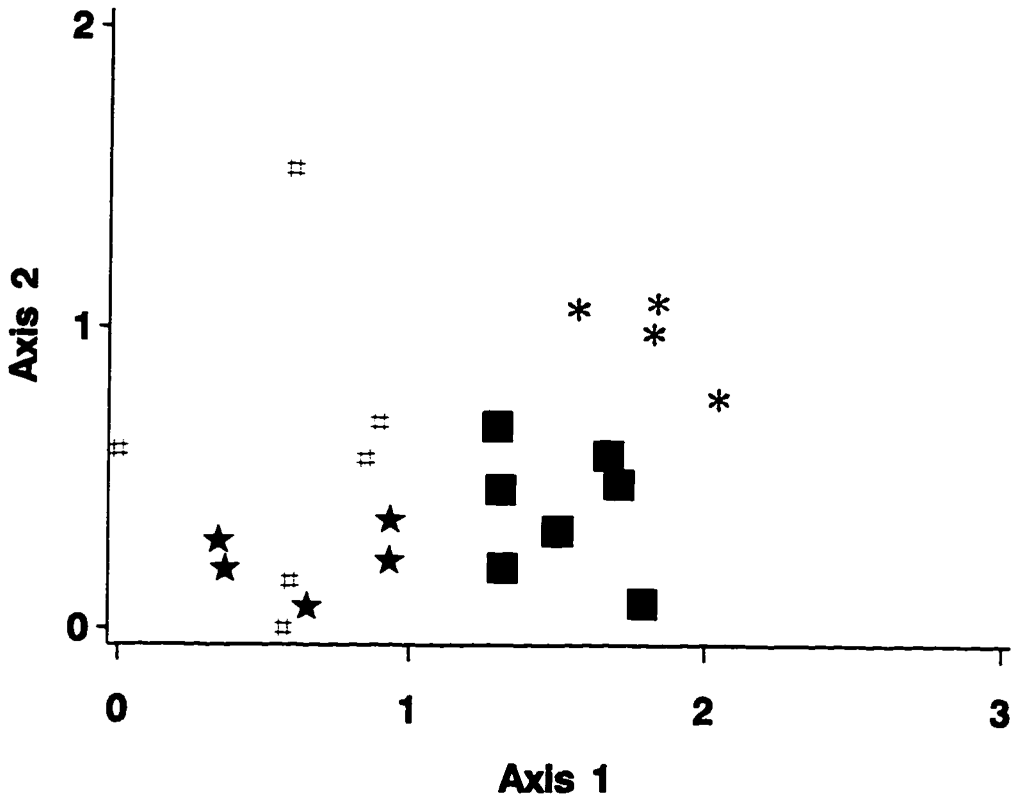


Figure 5.10. Vector diagram for DCA ordination of the **Montane Oak Forests** vegetation class showing association between species composition and major environmental gradients. Small TMI values represent low site moisture potential while large values represent high site moisture.

Figure 5.11. DCA ordination diagram showing the distribution of the **Quercus montana-Quercus velutina/Oxydendrum Forest**, the **Quercus rubra/Acer pensylvanicum/ Gaylussacia ursina/Thelypteris Forest**, the **Quercus montana-Quercus rubra/Cornus florida Forest** and the **Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest** in the **Montane Oak Forests** class on the two major compositional gradients.



Community type:

★ 7.1 Quercus montana – Q. velutina/Oxydendrum Forest.
* 7.2 Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest
■ 7.3 Quercus montana – Quercus rubra/Cornus florida Forest
7.5 Quercus coccinea – Carya glabra/Kalmia – Gaylussacia ursina Forest

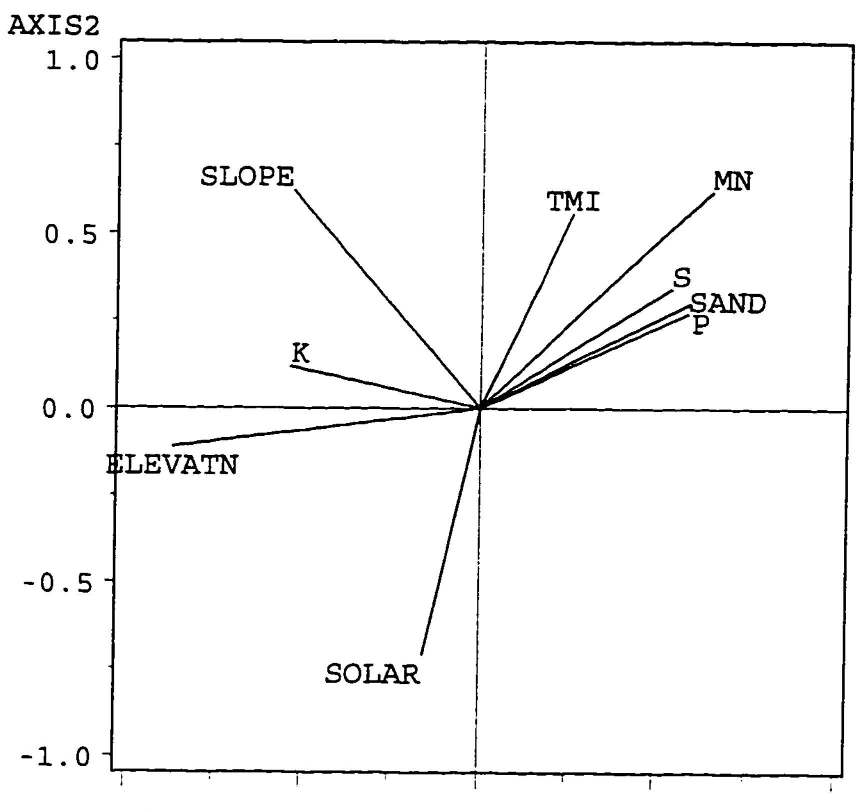


Figure 5.12. Vector diagram for DCA ordination of the **Quercus montana-Quercus velutina/Oxydendrum Forest**, the **Quercus rubra/Acer pensylvanicum/ Gaylussacia ursina/Thelypteris Forest**, the **Quercus montana-Quercus rubra/Cornus florida Forest** and the **Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest** in the **Montane Oak Forests** vegetation class showing association between species composition and major environmental gradients. Small TMI values represent low site moisture potential while large values represent high site moisture.

COMMUNITY TYPE: Quercus montana-Quercus velutina/Oxydendrum Forest (7.1)

Synonymy

Chestnut Oak Forest p.p. (Schafale & Weakley 1990), Montane Oak--Hickory Forest p.p. (Schafale & Weakley 1990), Chestnut Oak-Chestnut Forest (Whittaker 1956), Mixed Mesophytic Forest, Slope segregate p.p. (Cooper & Hardin 1970), Slope Community (Tucker 1973), Chestnut Oak Forests (McLeod 1988), Chestnut Oak Forest p.p. (Patterson 1994), *Quercus montana/Oxydendrum/Kalmia* Forest p.p. (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Amelanchier arborea*, *Aureolaria laevigata*, *Carya alba*, *Carya glabra*, *Castanea dentata*, *Chamaelirium luteum*, *Chimaphila maculata* var. *maculata*, *Coreopsis major* var. *rigida*, *Desmodium nudiflorum*, *Dichanthelium commutatum*, *Dichanthelium dichotomum* var. *dichotomum*, *Dioscorea quaternata*, *Epigaea repens*, *Fagus grandifolia*, *Galax urceolata*, *Gaylussacia ursina*, *Gentiana decora*, *Goodyera pubescens*, *Helianthus microcephalus*, *Hypoxis hirsuta*, *Kalmia latifolia*, *Liriodendron tulipifera*, *Lysimachia quadrifolia*, *Melampyrum lineare*, *Nyssa sylvatica*, *Oxydendrum arboreum*, *Pinus strobus*, *Polygonatum biflorum* var. *biflorum*, *Prenanthes* species, *Quercus alba*, *Quercus coccinea* var. *coccinea*, *Quercus montana*, *Quercus rubra*, *Quercus velutina*, *Rhododendron calendulaceum*, *Robinia pseudo-acacia*, *Sassafras albidum*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Solidago arguta* ssp. *caroliniana*, *Solidago curtisii*, *Tsuga canadensis*, *Vaccinium pallidum*, *Vaccinium stamineum*, *Viola hastata*.

Listed species

Vaccinium hirsutum.

Physiognomy

Quercus montana and *Acer rubrum* dominate the canopy (26 m mean height) in conjunction with varying levels of *Q. alba*, *Q. coccinea*, *Q. rubra* and *Q. velutina*. *Carya glabra* and scattered *C. alba* are also present in this stratum (Tables 5.32, 5.33, 5.34). *Oxydendrum* dominates the subcanopy association with *Nyssa sylvatica*. The shrub layer varies in density and composition with the major species including *Nyssa*, *Castanea dentata*, *Gaylussacia ursina* and *Kalmia latifolia*. *Rhododendron calendulaceum*, *Tsuga canadensis*, *Sassafras albidum* and *Smilax rotundifolia* are also present. *Cornus florida* and *Pyrularia pubera* have more variable distribution. The ground is dry and slightly rocky with scattered chestnut logs present. No individual species dominates this stratum. However, there is a diverse set of scattered, highly constant, low-cover species, including; *Aureolaria laevigata*, *Chamaelirium luteum*, *Chimaphila maculata* var. *maculata*, *Coreopsis major* var. *rigida*, *Desmodium nudiflorum*, *Dichanthelium commutatum*, *Dichanthelium dichotomum* var. *dichotomum*, *Dioscorea quaternata*, *Epigaea repens*, *Galax urceolata*, *Gentiana decora*, *Goodyera pubescens*, *Helianthus microcephalus*, *Hypoxis hirsuta*, *Lysimachia quadrifolia*, *Melampyrum lineare*, *Polygonatum biflorum* var. *biflorum*, *Prenanthes* species, *Smilax glauca* var. *glauca*, *Solidago arguta* ssp. *caroliniana*, *Solidago curtisii*, *Vaccinium pallidum* and *Viola hastata*. The highly scattered distribution of these species is indicated by lowest smallest-scale species richness values in comparison to other **Montane Oak** types (Table 5.9).

Habitat and Distribution

The **Quercus montana-Quercus velutina/Oxydendrum Forest** inhabits south- to southwest-facing, mid- and upper-slopes (23° average, range of 15 to 32°) in the Little Santeetlah valley (elevation range 836 to 1086 m, 994 m average; Table 5.35).

The soils are medium-textured. The **Quercus montana-Quercus velutina/ Oxydendrum Forest** soils have highest Al, base saturation and pH, and lowest Ca, cation exchange capacity, Mg, Mn, Na and P in comparison to other **Montane Oak** community types (Tables 5.7, 5.8). Eighty percent of the sites in this type are underlain by arkosic metasandstone-metaconglomerate (parent material type 13; Table 5.35).

Distinguishing Features

This community type and the **Quercus rubra/Thelypteris Forest** share highest chestnut sprout cover of any type in Joyce Kilmer. This suggests that chestnut was perhaps previously a common component of these community types.

The **Quercus montana-Quercus velutina/Oxydendrum Forest** inhabits a similar elevation range, slope position and orientation in Little Santeetlah to the **Quercus montana-Quercus coccinea/Galax Forest** in the **Xeric Evergreen Forests** vegetation class that is distributed in the Slickrock valley, suggesting that similar topographic conditions in Slickrock are inhabited by more xeric community types.

Succession and Disturbance

There is evidence of fire in only two plots. Although plots in this community type have not been logged, there has been substantial disturbance and change caused by the death of chestnut. The abundance and size of chestnut logs in each site (e.g., ≥ three 70 cm diameter logs, plot 505) indicates that chestnut was once (co)dominant in the canopy with *Quercus* species. Most sites have a few large, old, scattered *Quercus* (e.g., 71 cm diameter *Q. montana* aged 265 years, plot 531; 53 cm diameter *Q. velutina* aged 166 years, plot 505). The high abundance of small-tree sized (20 to 30 cm diameter) *Acer rubrum* and *Quercus* species (*Quercus* aged 60 to 90 years) suggests that both genera have regenerated as a consequence of chestnut death and have replaced chestnut in the canopy (Table 5.33).

Abundant *Quercus coccinea, Q. montana, Q. velutina* (18.67 stems/ha; not shown in Table 5.33), *Acer rubrum* and *Oxydendrum* saplings indicate that the present canopy and subcanopy composition will be maintained in the future (Table 5.33). Although there are high chestnut sapling numbers (178.67 stems/ha; not shown in Table 5.33), these will probably die of chestnut blight before reaching the subcanopy.

COMMUNITY TYPE: Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest (7.2)

Synonymy

Dry Oak--Hickory Forest (Schafale & Weakley 1990), Montane Oak--Hickory Forest p.p. (Schafale & Weakley 1990), Red Oak-Chestnut Forest p.p. (Whittaker 1956), Red Oak Cover Type p.p. (Thomas 1966), Red Oak Cover Type p.p. (Thomas 1966), Red Oak, Yellow Poplar, Chestnut Oak Forest (McLeod 1988), *Quercus rubra-Halesia/Acer saccharum* Forest p.p. (Chapter 4).

Constant species

Acer pensylvanicum, Acer rubrum var. *rubrum, Ageratina altissima* var. *roanensis, Aristolochia macrophylla, Aster divaricatus, Athyrium asplenioides, Betula lenta, Calycanthus floridus* var. *glaucus, Carex albolutescens, Carya glabra, Cornus florida, Dioscorea quaternata, Dryopteris marginalis, Eupatorium purpureum* var. *purpureum, Gaylussacia ursina, Halesia tetraptera* var. *monticola, Hamamelis virginiana, Houstonia purpurea* var. *purpurea, Hydrangea arborescens, Liriodendron tulipifera, Magnolia fraseri, Maianthemum racemosum, Medeola virginiana, Melanthium parviflorum, Monotropa uniflora, Nyssa sylvatica, Oxydendrum arboreum, Polygonatum biflorum* var. *biflorum, Polystichum acrostichoides, Prenanthes* species, *Quercus montana, Quercus rubra, Rhododendron maximum, Robinia pseudo-acacia, Sassafras albidum, Smilax glauca* var. *glauca, S. rotundifolia, Solidago curtisii, Stellaria pubera, Thelypteris novaeboracensis, Tilia americana* var. *heterophylla, Tsuga canadensis, Vitis vulpina.*

Listed species

Carex lucorum var. *austrolucorum, Carex manhartii, Stachys clingmanii, Vaccinium hirsutum.*

Physiognomy

Large *Quercus rubra* (mostly between 56 and 74 cm) and *Acer rubrum* dominate the canopy (27 mean height) (Tables 5.32, 5.33, 5.34). *Quercus montana* is codominant on drier ridge sites and upper-slope sites. *Acer rubrum* and *Halesia* are the major subcanopy species. *Acer pensylvanicum* dominates the strata below, in association with more limited levels of *Halesia* and *Tsuga canadensis*. *Gaylussacia ursina* is the most abundant shrub species with *Rhododendron maximum* also present. *Hamamelis virginiana* is a component of the two dryer sites. *Thelypteris novaeboracensis* is prominent on the forest floor with *Ageratina altissima* var. *roanensis*, *Aster divaricatus*, *Aristolochia macrophylla*, *Athyrium asplenioides*, *Carex albolutescens*, *Dioscorea quaternata*, *Dryopteris marginalis*, *Eupatorium purpureum* var. *purpureum*, *Houstonia purpurea* var. *purpurea*, *Hydrangea arborescens*, *Maianthemum racemosum*, *Melanthium parviflorum*, *Monotropa uniflora*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Smilax glauca* var. *glauca*, *S. rotundifolia*, *Solidago curtisii*, *Stellaria pubera*, *Vitis vulpina* providing consistent, but low cover.

Habitat and Distribution

The **Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest** inhabits steep (36° mean slope, 28 to 40° range), north- to east-facing upper-slopes and ridgelines between 815 and 1006 m elevation (890 m average, Table 5.35). This type is confined to the Slickrock valley and tends to grade into the **Quercus montana-Quercus coccinea/Galax Forest** in the **Xeric Evergreen Forests** class on more xeric sites.

Soils texture and fertility are similar to **Montane Oak** class average values (Tables 5.7, 5.8). All sites are underlain by parent material types with a slate component.

Distinguishing Features

The **Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest** has lowest mid-scale species richness (between 1.0 m^2 and 100 m^2) and lower than average values at the largest scale in comparison to other types in this class (Table 5.9). This reflects the prominence of the *Gaylussacia ursina* shrub layer and the limited set of sparsely distributed herbaceous species which survive under this shrub cover.

Succession and Disturbance

Chestnut stumps were only recorded in two sites and sprouts in one stand, suggesting that this species had at most a minor role in the canopy. There is evidence of fire in three of the four sites. Although all sites appear to have been logged, two 125 year old *Quercus rubra* (59 and 60 cm diameter, plot 508) indicate that logging was only partial on some sites.

The lack of *Quercus rubra* saplings indicates that the composition of the canopy will alter greatly in the future (Table 5.33). Abundant *Acer rubrum*, *Halesia* and *Tsuga* saplings assures the future presence of these species in this community type, probably replacing *Q. rubra* in the canopy.

COMMUNITY TYPE: Quercus montana-Quercus rubra/Cornus florida Forest (7.3)

Synonymy

Chestnut Oak Forest p.p. (Schafale & Weakley 1990), Montane Oak--Hickory Forest (Schafale & Weakley 1990), Red Oak-Pignut Hickory Forest (Whittaker 1956), Chestnut Oak Forests p.p. (McLeod 1988), Chestnut Oak Forest p.p. (Patterson 1994), *Quercus montana-Quercus rubra/Rhododendron calendulaceum* Forest (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Ageratina altissima* var. *roanensis*, *Amelanchier arborea*, *Amphicarpaea bracteata*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Aster undulatus*, *Athyrium asplenioides*, *Aureolaria laevigata*, *Campanula divaricata*, *Carya glabra*, *Castanea dentata*, *Chimaphila maculata* var. *maculata*, *Coreopsis major* var. *rigida*, *Cornus florida*, *Desmodium nudiflorum*, *Dichanthelium boscii*, *Dichanthelium dichotomum* var. *dichotomum*, *Dioscorea quaternata*, *Eupatorium purpureum* var. *purpureum*, *Fraxinus americana*, *Galium latifolium*, *Gentiana decora*, *Goodyera pubescens*, *Halesia tetraptera* var. *monticola*, *Helianthus microcephalus*, *Hieracium paniculatum*, *Houstonia purpurea* var. *purpurea*, *Hydrangea arborescens*, *Kalmia latifolia*, *Liriodendron tulipifera*, *Lysimachia quadrifolia*, *Magnolia acuminata*, *Magnolia fraseri*, *Nyssa sylvatica*, *Oxydendrum arboreum*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Poa compressa*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Potentilla canadensis* var. *canadensis*, *Prenanthes* species, *Quercus montana*, *Quercus rubra*, *Quercus velutina*, *Rhododendron calendulaceum*, *Robinia pseudo-acacia*, *Sassafras albidum*, *Smilax glauca* var. *glauca*, *Solidago curtisii*, *Stellaria pubera*, *Thelypteris novaeboracensis*, *Tsuga canadensis*, *Vaccinium pallidum*, *Vaccinium stamineum*, *Viburnum acerifolium*, *Viola hastata*, *Viola sororia*, *Vitis aestivalis* var. *aestivalis*, *Uvularia perfoliata*.

Listed species

Carex lucorum var. *austrolucorum*, *Panax quinquefolius*, *Stachys clingmanii*.

Physiognomy

Large *Quercus montana* (stems mostly 42 to 63 cm; largest 104 cm, plot 532), *Q. rubra* (45 to 57 cm) and smaller-sized *Acer rubrum* are the prominent canopy species (27 m height) in this community type with *Carya glabra* scattered throughout (Tables 5.32, 5.33, 5.34). *Oxydendrum* and *Liriodendron* are present in the subcanopy, and *Tsuga canadensis* and *Vitis aestivalis* var. *aestivalis* are scattered throughout the understory. *Cornus florida* dominates the shrub stratum in association with *Castanea dentata*, *Rhododendron calendulaceum* and *Smilax rotundifolia*. *Gaylussacia ursina* and *Pyrularia* have more variable cover. The ground is dry, slightly rocky in some sites and covered with a diverse range of low-cover species, with *Ageratina altissima* var. *roanensis*, *Amphicarpaea bracteata*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Aster undulatus*, *Athyrium asplenioides*, *Aureolaria laevigata*, *Campanula divaricata*, *Chimaphila maculata* var.

maculata, *Coreopsis major* var. *rigida*, *Desmodium nudiflorum*, *Dichanthelium boscii*, *Dichanthelium dichotomum* var. *dichotomum*, *Dioscorea quaternata*, *Eupatorium purpureum* var. *purpureum*, *Galium latifolium*, *Gentiana decora*, *Goodyera pubescens*, *Helianthus microcephalus*, *Hieracium paniculatum*, *Houstonia purpurea* var. *purpurea*, *Hydrangea arborescens*, *Lysimachia quadrifolia*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Poa compressa*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Potentilla canadensis* var. *canadensis*, *Prenanthes* species, *Smilax glauca* var. *glauca*, *Solidago curtisii*, *Stellaria pubera*, *Thelypteris novaeboracensis*, *Uvularia perfoliata*, *Vaccinium pallidum*, *Viola hastata* and *V. sororia* present with high constancy.

Habitat and Distribution

The **Quercus montana-Quercus rubra/Cornus florida Forest** is restricted to Little Santeetlah and Horse Cove, where it inhabits moderately steep (29° average, range of 20 to 38°), southeast- to southwest-facing mid- to upper-slopes (mostly mid) at elevations between 810 and 1170 m (average of 981 m; Table 5.35).

The soils have similar texture and nutrient status to average **Montane Oak** vegetation class values (Tables 5.7, 5.8). Fifty seven percent of stands are underlain by arkosic metasandstone-metaconglomerate (parent material type 13) and the parent material of the remainder is unknown (Table 5.35).

Distinguishing Features

The **Quercus montana-Quercus rubra/Cornus florida Forest** has highest species richness levels at the three largest spatial scales and also has high richness throughout the smaller scales in comparison to other **Montane Oak** types (Table 5.9). Richness at the two largest scales is highest of any community type or sub-type recognized in this study. Much of this richness is contributed by widely scattered, low-cover herbaceous species.

Succession and Disturbance

There is evidence of fire and logging in two of the seven plots. The majority of stands are old-growth with the medium-sized canopy trees over 100 years in age (e.g., 35 cm *Quercus montana* and 45 cm *Q. rubra* both aged 125 years, plot 674; 42 cm *Q. montana* aged 116 years, plot 532). Rotten centers prevented aging of the large-diameter canopy trees.

Chestnut logs are present in all sites. The abundance of small-tree-sized *Acer rubrum* and their clumped spatial distribution (*pers. obs.*) suggests that *Acer* has probably infilled gaps left by chestnut and that chestnut was at least codominant in the canopy of this community type (Table 5.35).

The absence of *Quercus rubra* saplings and the limited presence of *Q. montana* saplings suggests a general decline in *Quercus* canopy dominance (Table 5.35). High *Acer rubrum*, *Carya glabra* and *Liriodendron* sapling densities point to an increasing dominance by these species in the future canopy of this community type.

COMMUNITY TYPE: Carya alba-Quercus alba/Cornus florida/Polystichum Forest (7.4)

Synonymy

Dry Oak--Hickory Forest (Schafale & Weakley 1990), Red Oak-Pignut Hickory Forest p.p. (Whittaker 1956), Mixed Oak, Yellow Poplar, Hickory Forest (McLeod 1988), Xeric Oak-Hickory Forest (Patterson 1994), *Quercus rubra-Liriodendron-Carya glabra/ Hamamelis-Cornus florida* sub-type (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Aster divaricatus*, *Carya alba*, *Carya glabra*, *Chimaphila maculata* var. *maculata*, *Cornus florida*, *Desmodium nudiflorum*, *Dichanthelium boscii*, *Dichanthelium commutatum*, *Dioscorea quaternata*, *Eupatorium* *purpureum* var. *purpureum*, *Fraxinus americana*, *Gaylussacia ursina*, *Houstonia purpurea* var. *purpurea*, *Liriodendron tulipifera*, *Lysimachia quadrifolia*, *Magnolia fraseri*, *Nyssa sylvatica*, *Oxydendrum arboreum*, *Pinus strobus*, *Polystichum acrostichoides*, *Potentilla canadensis* var. *canadensis*, *Quercus alba*, *Quercus rubra*, *Quercus velutina*, *Robinia pseudo-acacia*, *Sassafras albidum*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Solidago curtisii*, *Tsuga canadensis*, *Viola sororia*, *Vitis rotundifolia*.

Listed species

Panax quinquefolius, *Stewartia ovata*, *Vaccinium hirsutum*.

Physiognomy

Carya alba and *Acer rubrum* are consistent canopy components throughout this community type (26 m height) (Tables 5.32, 5.33, 5.34). Levels of *Quercus alba*, *Q. montana*, *Q. rubra* and *Q. velutina* vary between sites, with *Carya glabra* and *Liriodendron* present in some sites. *Quercus alba*, *Q montana* and *Q. rubra* are the prominent canopy species of two steep mid- and lower-slope sites, whereas *Carya alba*, *Q. alba* and *Q. falcata* with an understory of *Stewartia ovata* and *Pinus strobus* dominate a toeslope. In contrast, *Carya alba*, *Quercus velutina* and *Q. alba* are the major canopy species on lower-slope sites at the junction of Slickrock Creek and Calderwood Lake. *Pinus strobus*, *Tsuga canadensis* and *Vitis rotundifolia* are present throughout the lower strata of all sites. *Cornus florida* is the major species of the open shrub strata, with *Gaylussacia ursina* and *Tsuga* also present. *Ilex opaca* occurs in sites adjacent to streams. *Polystichum acrostichoides* is the dominant forest floor species, with *Aster divaricatus*, *Chimaphila maculata* var. *maculata*, *Desmodium nudiflorum*, *Dichanthelium boscii*, *Dichanthelium commutatum*, *Dioscorea quaternata*, *Eupatorium purpureum* var. *purpureum*, *Houstonia purpurea* var. *purpurea*, *Lysimachia quadrifolia*, *Potentilla canadensis* var. *canadensis*, *Smilax glauca* var. *glauca*, *S. rotundifolia*, *Solidago curtisii* and *Viola sororia* present with consistent, but low cover. This type has lower than average species richness at the two smallest scales in comparison to other **Montane Oak** types (Table 5.9), reflecting the highly scattered distribution of ground-floor species.

Habitat and Distribution

The **Carya alba-Quercus alba/Cornus florida/Polystichum Forest** inhabits mostly warm, south-facing lower-slopes (20° average, range 8 to 42°) at low-elevations (441 m mean, 340 to 540m range) in the lower reaches of the Slickrock valley (Table 5.35). The dominance of *Polystichum acrostichoides*, coupled with the diverse range of herbaceous species present and comparatively high large-scale species richness (Table 5.9) present provides some indication of the sheltered position of these south-facing slopes. This type grades up into the **Quercus montana-Pinus rigida/Vaccinium pallidum Forest** in the **Xeric Evergreen Forests** class on more xeric, mid- and upper-slopes.

The soils are marginally coarser than other **Montane Oak Forests** types with higher sand content. The **Carya alba-Quercus alba/Cornus florida/Polystichum Forest** has marginally less fertile soils than average values for this vegetation class, with lowest Fe, K, pH values and organic matter content of any type in this class (Tables 5.7, 5.8).

Distinguishing Features

This is the only type in the **Montane Oak Forests** class where *Stewartia ovata*, a North Carolina Watch list species (Amoroso & Weakley 1995) is present. This species is only present in three other community types in the study, the two **Xeric Evergreen Forests** types and the **Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest** in the **Acidic Cove and Slope Forests** class (Tables 5.28, 5.36).

The presence of low-elevation piedmont species (e.g., *Carya alba*, *Ilex opaca*, *Quercus alba*, *Quercus falcata*, *Vitis rotundifolia*) gives this community type closer affiliation with piedmont vegetation communities than any other type in the study. The warm, south-facing position of sites inhabited by the **Carya alba-Quercus alba/Cornus florida/Polystichum Forest** probably increase the similarity of site conditions between this community type and lower-elevation piedmont vegetation.

Two of the plots in this type were sampled at higher elevations than the remaining plots and have some compositional similarities to the **Quercus coccinea-Carya glabra/ Kalmia-Gaylussacia ursina Forest** (Figures 5.9, 5.10). These two plots were not separated from their original type, because overall, their composition and site conditions were more similar to the **Carya alba-Quercus alba/Cornus florida/Polystichum Forest** than the former type.

Succession and Disturbance

There is no evidence for the past presence of chestnut in these plots. Only one plot has evidence of fire. All sites have been logged.

The absence of *Quercus* saplings suggests that the dominance of this genera in the canopy will decline in the future (Table 5.33). The limited numbers of *Carya alba* saplings and small-sized trees indicates that this species will continue to be a component of the canopy at least in the short term. Abundant *Acer rubrum*, *Pinus strobus* and *Tsuga canadensis* saplings suggest that these species will dominate the future canopy of this community type.

COMMUNITY TYPE: Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest (7.5)

Synonymy

Dry Oak--Hickory Forest (Schafale & Weakley 1990), Montane Oak--Hickory Forest p.p. (Schafale & Weakley 1990), Red Oak-Pignut Hickory Forest p.p. (Whittaker 1956), Mixed Oak Flats Cover Type (Thomas 1966), Oak-Hickory Cover Type p.p. (Thomas 1966), Mixed Oak Flats Cover Type (Thomas 1966), Oak-Hickory Cover Type p.p. (Thomas 1966), Mixed Oak, Yellow Poplar, Hickory Forest p.p. (McLeod 1988), Scarlet Oak, Red Maple Forest p.p. (McLeod 1988).

Constant species

Acer pensylvanicum, Acer rubrum var. *rubrum, Amelanchier arborea, Betula lenta, Carya glabra, Chamaelirium luteum, Chimaphila maculata* var. *maculata, Cornus florida, Gaylussacia ursina, Goodyera pubescens, Kalmia latifolia, Liriodendron tulipifera, Magnolia fraseri, Medeola virginiana, Mitchella repens, Nyssa sylvatica, Oxydendrum arboreum, Pinus strobus, Polygonatum biflorum* var. *biflorum, Polystichum acrostichoides, Pyrularia pubera, Quercus alba, Quercus velutina, Smilax glauca* var. *glauca, Smilax rotundifolia, Tsuga canadensis, Viola hastata.*

Listed species

Carex ruthii, Vaccinium hirsutum.

Physiognomy

Acer rubrum, Carya glabra and *Betula lenta* are the three most consistent species in the canopy (25 m height) of this community type (Tables 5.32, 5.33, 5.34). The abundance of *Quercus alba, Q. coccinea* and *Q. montana* varies with plot slope position. *Betula lenta, Carya glabra* and *Q. montana* dominate a small draw in the lower Little Santeetlah valley. In contrast, *Quercus coccinea* and *Q. montana* are the major species on the two upper-slope sites in Little Santeetlah and adjacent Horse Cove. *Quercus alba* and *C. glabra* are most abundant in the upper-slope Slickrock site. *Pinus strobus, C. glabra* and *C. alba* dominate the heavily disturbed lower-slope site adjacent to Slickrock Creek.

Composition of the understory strata is much more consistent. *Oxydendrum* is dominant in the subcanopy, in association with *Magnolia fraseri* and *Nyssa sylvatica. Tsuga* is present throughout the lower strata. Shrub density varies, but is typically dominated by *Kalmia latifolia* and *Gaylussacia ursina* with more scattered *Cornus florida.* The forest floor is sparsely covered with a range of low-cover species, including; *Chamaelirium luteum, Chimaphila maculata* var. *maculata, Goodyera pubescens, Medeola virginiana, Mitchella repens, Polygonatum biflorum, Polystichum acrostichoides, Smilax glauca* var. *glauca, S. rotundifolia* and *Viola hastata.*

Habitat and Distribution

This community type inhabits a range of slope positions, as described above, on east- to south-facing, lower-elevation (692 m average, 521 - 740 m range) slopes (range of 9 to 30°, 22° average) in Slickrock, Little Santeetlah and Horse Cove (Table 5.35).

The soils are moderately coarse-textured with lowest Al, Ca, S, Zn and highest B and Fe in comparison to other **Montane Oak** types (Tables 5.7, 5.8).

Distinguishing Features

This community type has lowest large-scale (≥400 m^2) species richness of any **Montane Oak** type (Table 5.9). The presence of a distinct shrub ericaceous stratum in this type may account for low richness.

Succession and Disturbance

The two Slickrock plots show evidence of past logging and this probably accounts for the dominance of *Pinus strobus* and *Acer rubrum* in the canopies of these sites. The presence of chestnut logs (e.g., 120 cm and 153 cm diameter in size, plot 504) in the two upper-slope sites dominated by *Quercus coccinea* suggests that chestnut was formerly at least a minor component in the canopy of upper-slope variants of this type. Canopy damage from a recent ice storm was also recorded in one of these stands.

The near absence of *Quercus* and *Carya* saplings and high *Acer rubrum*, *Oxydendrum*, *Pinus strobus* and *Tsuga canadensis* sapling numbers point to a major change in the composition of the future canopy. *Quercus* and *Carya* dominance will decline with *A. rubrum*, *P. strobus*, *Tsuga* and *Oxydendrum* gaining dominance of the canopy (Table 5.33).

COMMUNITY TYPE: Quercus rubra-Halesia/Thelypteris Forest (7.6)

Synonymy

High Elevation Red Oak Forest (Schafale & Weakley 1990), Red Oak-Chestnut Forest p.p. (Whittaker 1956), Red Oak, Yellow Poplar, Chestnut Oak Forest p.p. (McLeod 1988), *Quercus rubra-Halesia/Acer saccharum* Forest (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Ageratina altissima* var. *roanensis*, *Amelanchier arborea*, *Aristolochia macrophylla*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Betula lenta*, *Carya glabra*, *Cimicifuga racemosa*, *Collinsonia canadensis*, *Dichanthelium boscii*, *Dioscorea quaternata*, *Dryopteris marginalis*, *Eupatorium purpureum* var. *purpureum*, *Fraxinus americana*, *Halesia tetraptera* var. *monticola*, *Hydrangea arborescens*, *Liriodendron tulipifera*, *Lysimachia quadrifolia*, *Magnolia fraseri*, *Maianthemum racemosum*, *Medeola virginiana*, *Phegopteris hexagonoptera*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Prosartes lanuginosum*, *Quercus rubra*, *Robinia pseudo-acacia*, *Sanguinaria canadensis*, *Smilax rotundifolia*, *Solidago curtisii*, *Thelypteris novaeboracensis*, *Tilia americana* var. *heterophylla*, *Tsuga canadensis*, *Uvularia perfoliata*, *Viola hastata*, *Viola sororia*.

Listed species

Carex manhartii, *Panax quinquefolius*, *Stachys clingmanii*.

Physiognomy

The canopy (32 m mean height) of this community type is dominated by large-diameter *Quercus rubra* (stems mostly 42 to 66 cm; largest 126 cm, plot 679), in association with *Halesia*, *Acer rubrum* and large-diameter *Liriodendron* (41 to 63 cm; largest 109, plot 679) (Tables 5.32, 5.33, 5.34). Abundance of *Tilia americana* var.

heterophylla, *Magnolia fraseri* and *Acer saccharum* in this stratum varies between sites. *Halesia* and *Acer saccharum* dominate the lower-strata with *Acer pensylvanicum* also present in the shrub stratum. *Thelypteris novaeboracensis* is prominent on the forest floor. A diverse range of consistent, low-cover species persist, including; *Ageratina altissima* var. *roanensis*, *Aristolochia macrophylla*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Cimicifuga racemosa*, *Collinsonia canadensis*, *Dioscorea quaternata*, *Dichanthelium boscii*, *Dryopteris marginalis*, *Eupatorium purpureum* var. *purpureum*, *Hydrangea arborescens*, *Hydrophyllum canadense*, *Lysimachia quadrifolia*, *Maianthemum racemosum*, *Medeola virginiana*, *Phegopteris hexagonoptera*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Prosartes lanuginosum*, *Sanguinaria canadensis*, *Smilax rotundifolia*, *Solidago curtisii* var. *curtisii*, *Uvularia perfoliata*, *Viola hastata* and *V. sororia*.

Habitat and Distribution

The **Quercus rubra-Halesia/Thelypteris Forest** inhabits moderately steep (27° average, 22 to 34° range), northwest- to southeast-facing mid- to upper-slopes and secondary ridgelines at elevations between 773 and 1198 m (992 m average; Table 5.35). Most stands were sampled in Little Santeetlah valley (elevations between 861 and 1198 m) with two stands in Slickrock (773, 1018 m) and one in Horse Cove (803 m). The two Slickrock stands have moister, lower-slope positions. This suggests that equivalent upper-slope and ridge positions in Slickrock support more xeric vegetation than those in Little Santeetlah.

Soils in this type are organic and finer-textured than other **<u>Montane</u> <u>Oak</u>** types with higher silt content and organic matter levels (Tables 5.7, 5.8). The **Quercus rubra-Halesia/Thelypteris Forest** has higher Ca and cation exchange capacity than other types in this vegetation class but has comparatively low base saturation and pH levels.

Distinguishing Features

The **Quercus rubra-Halesia/Thelypteris Forest** has by far the highest species richness of any **Montane Oak** type at the four smallest spatial scales (Table 5.9) with levels similar to those in the **Rich Cove and Slope Forests**. This suggests that herbaceous species have less scattered distribution and higher packing per unit area in this type than in other **Montane Oak** types. Larger-scale diversity is also high indicating the broad array of species present in this type.

Succession and Disturbance

The three stands outside the Little Santeetlah watershed were logged, whereas 45% have evidence of past fire. Chestnut logs are present in 80% of the plots. The density of chestnut logs indicates that this species may have been a major canopy species (Table 5.35). The presence of small-tree-sized *Liriodendron* in this type is probably the result of high-light areas left by the death of chestnut.

The limited number of *Quercus rubra* saplings indicates that this species will decline in importance in the future canopy of this type. Abundant *Acer rubrum*, *Halesia* and *Tilia* saplings point to the future dominance of these species in the canopy. High *Liriodendron* sapling densities indicate that this species will continue to maintain its position in the canopy; however this light-demanding species will decline in prominence unless canopy disturbances continue.

Discussion

Although the **Montane Oak Forests** are widespread throughout the Southern Appalachians, few studies have quantified the composition and structure of specific types within this class (but see McLeod 1988, Chapters 3 & 4). Moreover, studies that have provided quantified information have typically been from areas supporting a limited range of **Montane Oak** types. However, in this present study I have identified a wide range of types that are distributed across a broad spectrum of environmental conditions, spanning both the moist Little Santeetlah valley and drier, lower-elevation Slickrock valley.

The types separate by watershed, elevation, slope position and subtle differences in soil texture and chemistry (Figures 5.9-5.12). The **Carya alba-Quercus alba/Cornus florida/Polystichum Forest** has lowest elevational range and is restricted to lower Slickrock where it is situated on warm, south-facing lower-slopes in steep draws. There is no equivalent **Montane Oak** type in Little Santeetlah, although the **Tsuga canadensis-Liriodendron/Thelypteris Forest** in the **Acidic Cove and Slope Forests** class inhabits similar topographic positions. The **Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest** inhabits low-elevation upper-slopes and ridgelines in both major watersheds, whereas the **Quercus montana-Quercus rubra/Cornus florida Forest** is restricted to similar, but mid-elevation sites in Little Santeetlah and Horse Cove. The **Quercus montana-Quercus velutina/Oxydendrum Forest** also occupies mid-elevations but on dryer, typically higher-slope positions than the former type and this is indicated by lower species diversity and higher abundance of *Oxydendrum*, *Nyssa* and *Gaylussacia ursina* in the latter. The **Quercus montana-Quercus velutina/Oxydendrum Forest** and the **Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest** inhabit similar elevations and slope positions but differ in site orientation and distribution. The former type is restricted to warmer, south- to southwest-facing sites in Little Santeetlah, whereas the latter is situated on north-to east-facing sites in Slickrock. In contrast, the **Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest** and the **Quercus rubra-Halesia/Thelypteris Forest** have similar site orientation and slope position, but the latter type inhabits higher-elevations. This type is restricted to the Little Santeetlah valley whereas the former is present only in Slickrock. Although in both types *Quercus rubra* dominates the canopy and the forest floor is dominated by *Thelypteris*, the Little Santeetlah type has higher species diversity and a selection of more mesic species (e.g., *Acer saccharum*, *Cimicifuga racemosa*, *Halesia*), reflecting higher-elevation and more mesic conditions.

Three of the six community types in the **Montane Oak Forests** are dominated by a distinctive ericaceous shrub stratum of *Gaylussacia* and *Kalmia* (the **Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest**, the **Quercus montana-Quercus**

velutina/Oxydendrum Forest and the **Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest**). In contrast, the shrub layer in the remaining three is dominated by the non-ericaceous species *Cornus florida*, *Halesia* and *Acer saccharum*. The non-ericaceous shrub types tend to have lower, mid- to lower-slope positions, or in the case of the **Quercus rubra-Halesia/Thelypteris Forest**, more mesic, higher-elevation, upper-slope positions. The latter three types also have higher species richness than the ericaceous-dominated types (Table 5.9). This probably reflects both the more mesic conditions and absence of ericaceous species in the non-ericaceous group. Stands with an ericaceous shrub layer tend to have low-light conditions beneath the dense shrub stratum, while the leaves of ericaceous species also tend to decompose slowly and produce infertile soils (Clinton & Vose 1996).

Table 5.32. Average cover class and constancy of species present in the **Montane Oak Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type. Each group is represented by its abbreviation code. For full group names see Table 5.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	7.	7.1	7.2	7.3	7.4	7.5	7.6
Number of plots:	36	5	4	7	5	6	9
Homoteneity:	0.637	0.794	0.750	0.777	0.721	0.737	0.736
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species							
ACALYPHA VIRGINICA	1 3				1 20		
ACER PENSYLVANICUM	3 100	2 100	7 100	2 100	1 100	2 100	6 100
ACER RUBRUM VAR RUBRUM	7 100	7 100	7 100	7 100	6 100	7 100	5 100
ACER SACCHARUM VAR SACCHARUM	3 53	1 40		2 100		4 17	3 100
ACER SPICATUM	1 3						1 11
ACTAEA PACHYPODA	2 3			2 14			
ADIANTUM PEDATUM VAR PEDATUM	2 11		2 50	1 14			2 11
AESCULUS FLAVA	2 14		2 25		1 20		3 33
AGERATINA ALTISSIMA VAR ROANENSIS	2 50		1 75	1 71	2 60		2 78
AGERATINA AROMATICA VAR AROMATICA	2 6				2 40		
AGRIMONIA GRYPOSEPALA	1 3				1 20		
AGROSTIS PERENNANS	1 25	1 20	1 25	1 43	1 60	1 17	
AMELANCHIER ARBOREA	2 69	2 80	2 25	2 71	1 20	2 83	3 100
AMIANTHIUM MUSCAETOXICUM	1 14		2 25	1 43			1 11
AMPHICARPAEA BRACTEATA	1 47	1 40		1 71	1 60	1 33	2 56
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	2 14			2 14			2 44
ANEMONELLA THALICTROIDES	1 14		1 25	1 14	1 20		2 22
ANGELICA VENOSA	1 14	1 40		1 14			2 22
ANTENNARIA PLANTAGINIFOLIA	2 14			1 14	2 40	2 33	
ARALIA RACEMOSA VAR RACEMOSA	2 11			2 14	1 20		2 22
ARALIA SPINOSA	1 3					1 17	
ARISTOLOCHIA MACROPHYLLA	2 44		2 75	2 57			2 100
ARISTOLOCHIA SERPENTARIA	1 8			1 14	1 20	1 17	
ARISAEMA TRIPHYLLUM SSP QUINATUM	1 3				1 20		
ARISAEMA TRIPHYLLUM VAR TRIPHYLLUM	2 53		1 50	1 71	2 60		2 100
ARNOGLOSSUM ATRIPLICIFOLIUM	2 3			2 14			
ARUNCUS DIOICUS VAR DIOICUS	2 14		1 50				2 33
ASARUM CANADENSE	1 3					1 17	
ASCLEPIAS EXALTATA	1 14			2 29			1 33
ASTERACEAE SP. #1	2 3						2 11
ASTER CORDIFOLIUS	2 14	2 40		2 29	2 20		
ASTER DIVARICATUS	2 75	1 20	2 100	2 86	2 80	1 50	2 100
ASTER INFIRMUS	1 3	1 20					
ASTER MACROPHYLLUS	2 6				2 20	1 17	
ASTER PATENS VAR PATENS	1 3			1 14			
ASTER PATERNUS	1 3	1 20					
ASTER RETROFLEXUS	1 11			1 29		1 33	
ASTER UNDULATUS	2 28	1 20		2 71	1 60	1 17	
ATHYRIUM ASPLENIOIDES	2 53		1 75	1 71	2 40	1 67	2 56
AUREOLARIA LAEVIGATA	1 33	1 80	2 25	1 86	1 20		
BAPTISIA TINCTORIA	1 3	1 20					

Group:	7.	7.1	7.2	7.3	7.4	7.5	7.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
BETULA ALLEGHANIENSIS	2 8						2 33
BETULA LENTA	4 72	3 20	4 75	4 57	2 60	5 100	4 100
BIGNONIA CAPREOLATA	2 8				2 60		
BOTRYCHIUM VIRGINIANUM	1 19			1 29	1 20		2 44
BRACHYELYTRUM ERECTUM	1 22			2 43	2 20		1 44
CALYCANTHUS FLORIDUS VAR GLAUCUS	2 28		2 75	3 29		2 33	3 33
CAMPANULA DIVARICATA	2 39	1 60	2 50	2 71	2 40		2 22
CARDAMINE DIPHYLLA	1 14		1 25				2 44
CAREX AESTIVALIS	1 8	1 20		1 14		1 17	
CAREX ALBOLUTESCENS	2 3					2 17	
CAREX AUSTROCAROLINIANA	1 6	1 20			1 20		
CAREX BLANDA	1 3			1 14			
CAREX DIGITALIS	1 39		2 50	2 57	2 40	1 17	1 56
CAREX FLEXUOSA	1 8		1 25	1 14			1 11
CAREX LUCORUM VAR AUSTROLUCORUM*	2 6		2 25	1 14			
CAREX LAXIFLORA VAR LAXIFLORA	1 17			1 43	1 20		1 22
CAREX MANHARTII*	1 19		1 25				1 67
CAREX NIGROMARGINATA	2 22	1 20		2 29	2 60	2 33	
CAREX PENSYLVANICA	1 22			2 29	1 60		1 33
CAREX PLATYPHYLLA	1 6						1 22
CAREX RUTHII*	2 3					2 17	
CAREX SWANII	1 14	1 20		2 14	2 20		1 22
CAREX VIRESCENS	1 3			1 14			
CARPINUS CAROLINIANA	2 3				2 20		
CARYA ALBA	4 47	3 80	2 25	3 29	6 100	6 17	3 44
CARYA CORDIFORMIS	1 8		1 25		2 20		1 11
CARYA GLABRA	4 89	4 100	2 75	4 100	3 80	6 100	2 78
CARYA OVATA	3 19	1 20	6 25	2 14	2 20		4 33
CARYA PALLIDA	2 3			2 14			
CASTANEA DENTATA	3 67	4 100	3 50	3 100		2 67	3 67
CAULOPHYLLUM THALICTROIDES	1 6						1 22
CERCIS CANADENSIS VAR CANADENSIS	5 3				5 20		
CHAMAELIRIUM LUTEUM	1 47	1 100	1 25	2 57		1 83	1 22
CHELONE GLABRA	2 3					2 17	
CHIMAPHILA MACULATA VAR MACULATA	1 58	1 80	1 25	1 71	1 100	1 100	
CIMICIFUGA RACEMOSA	2 19						2 78
CIRCAEA CANADENSIS	1 6						1 22
CLETHRA ACUMINATA	2 3		2 25				
CLINTONIA UMBELLULATA	2 22		1 25			1 17	2 67
COLLINSONIA CANADENSIS	2 31			2 43			2 89
CONOPHOLIS AMERICANA	1 31	1 20	1 50	1 43			2 56
CORALLORHIZA ODONTORHIZA VAR ODONTORHIZA	1 3				1 20		
COREOPSIS MAJOR VAR RIGIDA	1 36	1 100		1 71	1 20	1 17	1 11
CORNUS ALTERNIFOLIA	2 17	2 20		1 14			2 44
CORNUS FLORIDA	4 78	4 60	3 75	4 86	6 100	4 100	4 56
CRYPTOTAENIA CANADENSIS	1 3						1 11
CYPRIPEDIUM ACAULE	1 14	1 20		1 29		1 17	1 11
CYPRIPEDIUM PARVIFLORUM VAR PUBESCENS	1 11	1 20		1 29		1 17	
DANTHONIA COMPRESSA	1 8	1 20	1 25	2 14			
DANTHONIA SERICEA	1 3			1 14			
DANTHONIA SPICATA	1 3				1 20		
DENNSTAEDTIA PUNCTILOBULA	2 22		2 50	4 29	2 40		2 22
DESMODIUM GLUTINOSUM	1 8	1 20		1 14			2 11
DESMODIUM NUDIFLORUM	2 72	2 80	1 50	2 100	2 100	1 50	2 56
DESMODIUM PANICULATUM	1 3	1 20					
DESMODIUM ROTUNDIFOLIUM	1 6				1 40		
DICHANTHELIUM BOSCII	1 64	1 60	1 50	1 71	2 80	1 33	1 78
DICHANTHELIUM COMMUTATUM	1 39	1 100		2 29	1 80	1 33	1 11

Group:	7.	7.1	7.2	7.3	7.4	7.5	7.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
DICHANTHELIUM DICHOTOMUM VAR DICHOTOMUM	1 33	1 80		1 71	2 60		
DIOSCOREA QUATERNATA	2 86	1 80	2 100	2 100	1 80	1 67	2 89
DIOSPYROS VIRGINIANA	2 6				1 20	3 17	
DIPHYLLEIA CYMOSA	2 3						2 11
DRYOPTERIS INTERMEDIA	2 6						2 22
DRYOPTERIS MARGINALIS	2 31		2 75	1 14			2 78
ELEPHANTOPUS TOMENTOSUS	2 6				2 40		
EPIGAEA REPENS	1 22	2 80		1 14		1 50	
ERIGERON PULCHELLUS VAR PULCHELLUS	2 25	2 20		2 57	2 60	2 17	
EUONYMUS AMERICANA	2 25		1 25		2 40	2 67	2 22
EUPATORIUM PURPUREUM VAR PURPUREUM	1 78	1 40	1 100	2 86	1 80	1 67	2 89
EUPHORBIA COROLLATA	1 14	1 40		1 43			
FAGUS GRANDIFOLIA	2 47	1 80		3 43	3 40	2 67	2 44
FRAXINUS AMERICANA	2 58		1 25	2 86	2 80	4 17	2 100
GALAX URCEOLATA	2 33	2 80	2 50	2 14	2 20	3 67	
GALEARIS SPECTABILIS	1 3						1 11
GALIUM CIRCAEZANS VAR CIRCAEZANS	2 19	1 20		2 29	2 60		1 11
GALIUM LANCEOLATUM	2 3						2 11
GALIUM LATIFOLIUM	2 39	1 20		2 86	1 20		2 67
GALIUM TRIFLORUM	1 8						1 33
GAULTHERIA PROCUMBENS	2 6					2 33	
GAYLUSSACIA BACCATA	1 3				1 20		
GAYLUSSACIA URSINA	4 75	4 100	6 100	3 57	3 100	5 100	2 33
GENTIANA DECORA	1 44	1 100	1 25	1 71		1 50	1 22
GERANIUM MACULATUM	2 8						2 33
GOODYERA PUBESCENS	1 75	1 100	1 50	1 100	1 60	1 100	1 44
HALESIA TETRAPTERA VAR MONTICOLA	4 75	1 20	4 100	2 100	2 60	3 50	6 100
HAMAMELIS VIRGINIANA	3 22		5 75	1 14	6 20	2 17	1 22
HELIANTHUS MICROCEPHALUS	1 33	1 80		1 71	2 60		
HELIANTHUS STRUMOSUS	1 14			1 14			1 44
HEPATICA ACUTILOBA	2 6						2 22
HEUCHERA AMERICANA	1 3				1 20		
HEUCHERA VILLOSA VAR VILLOSA	1 8		1 25			1 17	1 11
HIERACIUM PANICULATUM	1 39	1 40	1 25	2 86	2 40		1 33
HIERACIUM VENOSUM	1 19	1 60		2 29	1 20	1 17	
HOUSTONIA CAERULEA	3 3					3 17	
HOUSTONIA PURPUREA VAR PURPUREA	2 69	1 60	2 75	2 100	2 80	1 50	2 56
HUPERZIA LUCIDULA	1 6			1 14			1 11
HYDRANGEA ARBORESCENS	2 58		2 75	2 86	2 20	1 33	2 100
HYPERICUM SP. #2	1 3			1 14			
HYPERICUM STRAGULUM	1 8				1 60		
HYPOXIS HIRSUTA	1 19	1 80			1 40	1 17	
ILEX MONTANA	2 31	1 40	4 25	2 43		1 17	3 44
ILEX OPACA VAR OPACA	3 22			1 14	4 60	3 50	1 11
IMPATIENS PALLIDA	1 3						1 11
IRIS CRISTATA	2 8				2 20		2 22
ISOTRIA VERTICILLATA	1 17	1 40		1 29		1 17	1 11
JUGLANS CINEREA	5 3				5 20		
KALMIA LATIFOLIA	3 56	4 100	1 25	2 86	2 40	5 100	
LACTUCA BIENNIS	1 3			1 14			
LAPORTEA CANADENSIS	2 6						2 22
LESPEDEZA REPENS	1 3				1 20		
LEUCOTHOE FONTANESIANA	2 8				3 40	1 17	
LILIUM MICHAUXII	1 31	1 60		1 57		1 17	2 33
LILIUM SUPERBUM	1 6						1 22
LINDERA BENZOIN	2 11			1 14		2 17	2 22
LIPARIS LILIIFOLIA	2 6			1 14			2 11
LIRIODENDRON TULIPIFERA	3 89	3 80	1 75	3 100	3 100	3 83	5 89

Group:	7.	7.1	7.2	7.3	7.4	7.5	7.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
LOBELIA PUBERULA	1 14	2 20		2 14	1 60		
LUZULA MULTIFLORA VAR CONGESTA	1 14	1 20		1 43		1 17	
LYONIA LIGUSTRINA VAR LIGUSTRINA	1 3	1 20					
LYSIMACHIA QUADRIFOLIA	1 81	1 100	2 50	2 100	2 100	1 50	2 78
MAGNOLIA ACUMINATA	2 50	3 40		2 100		1 50	3 67
MAGNOLIA FRASERI	3 86	2 40	3 75	2 100	2 80	4 100	4 100
MAGNOLIA TRIPETALA	1 3				1 20		
MAIANTHEMUM RACEMOSUM	2 56		1 100	2 57	1 20	1 33	2 100
MEDEOLA VIRGINIANA	2 64	1 40	1 75	2 43		2 100	2 100
MELAMPYRUM LINEARE	1 31	2 100	1 25	2 29		1 17	1 22
MELANTHIUM PARVIFLORUM	2 25		1 75	1 14			2 56
MELANTHIUM VIRGINICUM	1 11	1 20		1 29			2 11
MENISPERMUM CANADENSE	3 3				3 20		
MITCHELLA REPENS	1 33	1 40	1 25	2 29	2 20	1 100	
MONARDA CLINOPODIA	2 14				2 20		2 44
MONARDA DIDYMA	1 3						1 11
MONOTROPA HYPOPITHYS	1 8		1 25		1 20	1 17	
MONOTROPA UNIFLORA	1 31	1 20	1 100	1 29		1 17	1 33
MUHLENBERGIA TENUIFLORA VAR TENUIFLORA	2 3				2 20		
MUHLENBERGIA TENUIFLORA VAR VARIABILIS	2 17		2 25	1 43	2 20		2 11
NYSSA SYLVATICA	4 81	5 100	1 75	2 100	4 100	4 83	4 44
OSMORHIZA CLAYTONII	1 3						1 11
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	3 6		2 25			3 17	
OSMUNDA REGALIS VAR SPECTABILIS	3 3					3 17	
OSTRYA VIRGINIANA VAR VIRGINIANA	4 8				6 40	2 17	
OXALIS GRANDIS	1 3				1 20		
OXYDENDRUM ARBOREUM	5 86	6 100	5 100	4 100	3 100	6 100	3 44
OXYPOLIS RIGIDIOR	2 3					2 17	
PANAX QUINQUEFOLIUS*	1 19			1 43	1 20		1 33
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	2 50		2 50	1 86	2 60	1 17	2 67
PEDICULARIS CANADENSIS	1 3			1 14			
PHEGOPTERIS HEXAGONOPTERA	2 22				1 20		2 78
PHRYMA LEPTOSTACHYA	1 6				1 20		1 11
PINUS RIGIDA	6 3					6 17	
PINUS STROBUS	3 58	2 100		2 57	3 100	4 100	1 11
PLATANTHERA CLAVELLATA	1 3					1 17	
POA COMPRESSA	1 28	1 20		1 86	2 20	1 17	1 11
POA CUSPIDATA	1 14	1 20		1 14			1 33
PODOPHYLLUM PELTATUM	2 8						2 33
POLYGONATUM BIFLORUM VAR BIFLORUM	1 89	1 80	2 100	1 100	1 60	1 83	2 100
POLYPODIUM APPALACHIANUM	2 6		2 25				1 11
PORTERANTHUS TRIFOLIATUS	1 14	1 20		1 29		1 17	1 11
POLYSTICHUM ACROSTICHOIDES	2 89	1 20	2 100	2 100	3 100	2 100	2 100
POTENTILLA CANADENSIS VAR CANADENSIS	2 39	2 40		2 86	2 80	1 33	
PRENANTHES SP. #1	2 78	1 80	1 100	2 86	2 40	1 50	2 100
PROSARTES LANUGINOSA	1 31		1 25	1 14	1 20		2 89
PRUNUS PENSYLVANICA	1 36	1 40	1 50	2 57			2 56
PRUNUS SEROTINA	2 19	2 20		2 29			3 44
PRUNELLA VULGARIS	1 3				1 20		
PTERIDIUM AQUILINUM	1 3					1 17	
PYCNANTHEMUM PYCNANTHEMOIDES VAR PYCNANTHEMOIDES	1 8			1 14	1 40		
PYRULARIA PUBERA	3 53	3 40	1 25	4 57	2 20	3 100	3 56
QUERCUS ALBA	4 53	5 100		2 57	5 100	3 83	
QUERCUS COCCINEA VAR COCCINEA	5 28	4 100			1 20	6 67	

Group:	7.	7.1	7.2	7.3	7.4	7.5	7.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
QUERCUS FALCATA	4 6				6 20	2 17	
QUERCUS MONTANA	5 72	6 100	5 75	6 100	5 40	5 50	3 67
QUERCUS RUBRA	5 92	4 80	7 100	6 100	3 100	1 67	5 100
QUERCUS VELUTINA	3 67	5 100	3 50	2 86	4 100	2 83	1 11
QUERCUS X FONTANA	5 3	5 20					
RANUNCULUS HISPIDUS	1 17			1 29			1 44
RHODODENDRON CALENDULACEUM	3 42	3 100	3 25	3 86	1 20	4 17	2 11
RHODODENDRON MAXIMUM	3 33		5 100	2 29		3 67	3 22
RHODODENDRON MINUS	1 3				1 20		
RHODODENDRON PERICLYMENOIDES	2 6	2 20		2 14			
ROBINIA PSEUDOACACIA	3 92	3 100	2 100	3 100	2 80	3 83	2 89
ROSACEAE SPECIES # 1	1 3			1 14			
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	2 25	1 20	1 25	2 57		1 33	2 11
RUBUS ARGUTUS	2 11		1 50		2 20		2 11
RUBUS CANADENSIS	2 22		2 25		2 40		2 56
RUDBECKIA HIRTA	2 6			2 29			
SANGUINARIA CANADENSIS	1 19						1 78
SANICULA CANADENSIS VAR CANADENSIS	1 22			1 29	2 40		1 44
SASSAFRAS ALBIDUM	2 86	3 100	2 100	3 100	2 100	2 67	1 67
SAXIFRAGA MICRANTHIDIFOLIA	1 3					1 17	
SCHIZACHYRIUM SCOPARIUM	1 3				1 20		
SCUTELLARIA ELLIPTICA VAR ELLIPTICA	1 22		1 50	1 14	1 40		1 33
SCUTELLARIA INCANA VAR PUNCTATA	1 3			1 14			
SENECIO OBOVATUS	2 3				2 20		
SILENE STELLATA	1 22		2 50	1 29	1 20		1 33
SILENE VIRGINICA VAR VIRGINICA	1 14		2 25	1 43			1 11
SMILAX GLAUCA VAR GLAUCA	2 83	2 100	1 75	2 100	2 100	1 100	1 44
SMILAX HERBACEA	2 19			2 14			2 67
SMILAX ROTUNDIFOLIA	2 97	3 100	2 100	3 100	2 100	2 100	2 89
SOLIDAGO SP. #2	2 3			2 14			
SOLIDAGO ARGUTA SSP CAROLINIANA	1 36	1 80	1 50	1 43	1 20	1 50	
SOLIDAGO CAESIA	1 6		1 25		1 20		
SOLIDAGO CURTISII	2 75	1 80	1 75	2 86	2 80	1 17	2 100
SOLIDAGO ERECTA	1 8			2 14	1 20		1 11
SOLIDAGO FLACCIDIFOLIA	2 6						2 22
SOLIDAGO ODORA VAR ODORA	1 8	1 20			1 20	1 17	
SOLIDAGO SPECIOSA	1 3				1 20		
SPHENOPHOLIS PENSYLVANICA	1 3					1 17	
STACHYS CLINGMANII*	1 17		1 25	1 14			2 44
STELLARIA PUBERA	1 56	1 20	1 75	1 86	1 60	1 17	2 67
STENANTHIUM GRAMINEUM VAR MICRANTHUM	1 17	1 20	1 25	1 14		1 33	1 11
STEWARTIA OVATA*	3 8				3 60		
TEPHROSIA VIRGINIANA	1 3				1 20		
THALICTRUM CLAVATUM	2 6					2 17	1 11
THALICTRUM CORIACEUM	1 8		1 25	1 14			1 11
THALICTRUM DIOICUM	2 25		1 25	1 57			2 44
THALICTRUM REVOLUTUM	2 3						2 11
THASPIUM BARBINODE	2 3						2 11
THELYPTERIS NOVEBORACENSIS	3 81	2 60	5 100	2 100	2 40	2 67	3 100
TIARELLA CORDIFOLIA VAR CORDIFOLIA	2 11		1 25				2 33
TILIA AMERICANA VAR HETEROPHYLLA	2 53	1 20	1 75	2 43		1 50	4 100
TOXICODENDRON RADICANS	2 31			2 43	2 60	2 50	2 22
TRADESCANTIA SUBASPERA	2 3				2 20		
TRILLIUM ERECTUM	2 6				1 20		2 11
TRILLIUM GRANDIFLORUM	2 8						2 33
TRILLIUM LUTEUM	1 17			1 29	1 20		1 33
TRILLIUM UNDULATUM	1 28		1 50	1 14	2 20	1 17	2 56

Group:	7.	7.1	7.2	7.3	7.4	7.5	7.6
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
TRILLIUM VASEYI	1 14			1 29			2 33
TSUGA CANADENSIS	4 97	3 100	5 100	3 100	4 100	5 100	3 89
UVULARIA PERFOLIATA	2 58		1 25	2 71	2 60	1 50	2 100
UVULARIA PUBERULA	1 6		1 25			1 17	
VACCINIUM CORYMBOSUM	2 14	1 20		1 14		2 33	2 11
VACCINIUM HIRSUTUM*	2 14	3 40	1 25		2 20	1 17	
VACCINIUM PALLIDUM	2 53	2 100	1 50	2 86	2 20	3 50	2 22
VACCINIUM SIMULATUM	2 22		2 25	2 43		2 17	2 33
VACCINIUM STAMINEUM	2 42	2 100		2 86	1 20	2 50	
VIBURNUM ACERIFOLIUM	2 53	2 40	3 50	2 71	1 60	2 33	2 56
VIOLA BLANDA	2 17		2 50	1 14	2 40		2 11
VIOLA CANADENSIS VAR CANADENSIS	1 3			1 14			
VIOLA HASTATA	2 81	2 100	1 50	2 71	2 60	2 83	2 100
VIOLA PALMATA VAR PALMATA	1 17		1 25	2 57		1 17	
VIOLA ROTUNDIFOLIA	2 14						2 56
VIOLA SORORIA	2 72	2 40	1 50	2 86	2 100	1 33	2 100
VITIS AESTIVALIS VAR AESTIVALIS	2 31	1 60		3 86		1 17	2 11
VITIS AESTIVALIS VAR BICOLOR	2 17	2 20	2 25	2 14	2 20	2 17	2 11
VITIS CINEREA VAR BAILEYANA	3 14			2 14	1 20		4 33
VITIS ROTUNDIFOLIA	2 14				3 80	1 17	
VITIS VULPINA	1 22	2 40	2 75	1 14		1 17	1 11

Table 5.33. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Montane Oak Forests** vegetation class and associated community types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

7. Montane Oak Forests

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	92.08	286.60	2.41	381.09	4.45	13.55	14.73	14.14
CARYA GLABRA	7.69	34.42	5.02	47.13	1.96	1.65	6.53	4.09
HALESIA TETRAPTERA VAR MONTICOLA	93.15	46.16	1.02	140.32	0.99	5.34	2.67	4.01
LIRIODENDRON TULIPIFERA	35.14	16.46	6.25	57.85	2.26	2.13	7.12	4.62
OXYDENDRUM ARBOREUM	48.94	66.27	0.00	115.21	1.24	3.93	4.07	4.00
QUERCUS MONTANA	6.02	29.63	7.64	43.29	3.32	1.52	9.70	5.61
QUERCUS RUBRA	1.11	20.53	18.75	40.39	8.04	1.72	19.99	10.85
ALL	1580.32	1241.30	58.31	2879.93	32.94	100.00	100.00	100.00

7.1 Quercus montana-Quercus velutina/Oxydendrum Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	253.33	430.00	0.00	683.33	6.16	19.55	22.42	20.99
CARYA GLABRA	19.33	45.67	13.67	78.67	3.56	2.13	12.40	7.26
KALMIA LATIFOLIA	307.33	70.00	0.00	377.33	0.14	9.52	0.46	4.99
NYSSA SYLVATICA	96.67	155.33	5.00	257.00	1.75	6.66	5.61	6.14
OXYDENDRUM ARBOREUM	138.67	157.33	0.00	296.00	2.46	8.24	8.64	8.44
QUERCUS COCCINEA VAR COCCINEA	18.00	61.33	2.00	81.33	3.17	2.13	10.92	6.53
QUERCUS MONTANA	28.00	88.33	8.00	124.33	5.45	3.05	18.70	10.87
RHODODENDRON CALENDULACEUM	424.67	23.67	0.00	448.33	0.08	10.49	0.25	5.37
SMILAX ROTUNDIFOLIA	357.33	0.00	0.00	357.33	0.01	8.77	0.02	4.40
ALL	2437.33	1334.33	33.67	3805.33	29.24	100.00	99.99	100.00

7.2 Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
ACER PENSYLVANICUM	451.67	197.29	0.00	648.96	0.71	21.63	2.07	11.85
ACER RUBRUM VAR RUBRUM	21.67	139.79	7.50	168.96	4.74	6.41	14.87	10.64
HALESIA TETRAPTERA VAR								
MONTICOLA	205.00	103.13	6.67	314.79	1.75	11.83	4.83	8.33
HAMAMELIS VIRGINIANA	169.38	154.38	0.00	323.75	0.36	13.02	1.04	7.03
QUERCUS RUBRA	0.00	43.96	46.25	90.21	19.08	3.48	47.14	25.31
RHODODENDRON MAXIMUM	57.50	217.50	0.00	275.00	0.83	11.76	2.99	7.38
TSUGA CANADENSIS	30.63	118.75	0.00	149.38	0.91	6.14	3.11	4.62
ALL	1356.87	1265.21	67.92	2690.00	36.02	100.00	100.00	100.00

7.3 Quercus montana-Quercus rubra/Cornus florida Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
ACER RUBRUM VAR RUBRUM	65.24	394.64	5.24	465.12	6.56	18.30	20.80	19.55
CARYA GLABRA	11.43	49.05	10.36	70.83	3.01	2.63	8.90	5.76
CORNUS FLORIDA	35.12	134.64	0.00	169.76	0.68	9.04	2.35	5.69
LIRIODENDRON TULIPIFERA	69.05	7.62	5.24	81.90	2.20	3.20	5.80	4.50
PYRULARIA PUBERA	374.76	6.67	0.00	381.43	0.03	12.65	0.11	6.38
QUERCUS MONTANA	8.10	43.57	23.10	74.76	8.06	3.12	22.93	13.02
QUERCUS RUBRA	0.00	27.86	21.07	48.93	6.98	2.20	18.92	10.56
RHODODENDRON CALENDULACEUM	182.86	24.29	0.00	207.14	0.21	7.77	0.57	4.17
ALL	1512.38	970.36	75.36	2558.10	33.89	99.99	100.00	100.01

7.4 Carya alba-Quercus alba/Cornus florida/Polystichum Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
ACER RUBRUM VAR RUBRUM	60.00	224.00	0.00	284.00	1.73	14.36	6.53	10.44
CARYA ALBA	2.00	136.00	4.00	142.00	3.57	7.43	13.51	10.47
CORNUS FLORIDA	50.00	188.00	0.00	238.00	0.97	12.50	3.70	8.10
LIRIODENDRON TULIPIFERA	0.00	26.00	4.00	30.00	2.01	1.72	7.59	4.65
PINUS STROBUS	130.00	100.00	0.00	230.00	0.36	10.29	1.35	5.82
QUERCUS ALBA	0.00	60.00	10.00	70.00	5.89	3.68	21.70	12.69
QUERCUS RUBRA	0.00	20.00	10.00	30.00	3.69	2.30	14.16	8.23
QUERCUS VELUTINA	0.00	16.00	8.00	24.00	2.85	1.27	10.56	5.92
TSUGA CANADENSIS	94.00	128.00	0.00	222.00	1.21	12.19	4.62	8.41
ALL	794.00	1144.00	42.00	1980.00	26.62	100.01	99.99	100.00

7.5 Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	69.17	407.08	0.00	476.25	5.32	15.29	18.78	17.04
CARYA GLABRA	0.00	63.75	0.00	63.75	2.81	1.91	9.91	5.91
KALMIA LATIFOLIA	487.92	747.08	0.00	1235.00	1.38	26.84	4.17	15.51
OXYDENDRUM ARBOREUM	43.33	133.33	0.00	176.67	2.10	5.42	7.12	6.27
PINUS STROBUS	90.00	123.75	10.00	223.75	5.00	4.95	13.63	9.29
PYRULARIA PUBERA	230.83	5.00	0.00	235.83	0.02	8.51	0.06	4.29
QUERCUS ALBA	0.00	38.33	5.00	43.33	2.47	1.32	8.69	5.00
QUERCUS COCCINEA VAR COCCINEA	1.67	26.25	2.08	30.00	1.95	1.11	7.81	4.46
TSUGA CANADENSIS	80.00	143.75	0.00	223.75	0.97	6.73	3.46	5.10
ALL	1539.58	2019.17	27.50	3586.25	29.49	100.00	100.00	100.00

7.6 Quercus rubra-Halesia/Thelypteris Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	287.78	95.19	0.00	382.96	0.50	14.56	1.34	7.95
ACER RUBRUM VAR RUBRUM	87.78	142.59	2.22	232.59	2.64	8.07	7.55	7.81
BETULA LENTA	20.37	70.00	2.22	92.59	1.38	3.47	4.58	4.03
HALESIA TETRAPTERA VAR MONTICOLA	214.44	120.00	1.11	335.56	3.01	12.54	8.02	10.28
LIRIODENDRON TULIPIFERA	75.56	31.11	17.78	124.44	5.45	4.12	17.25	10.69
PYRULARIA PUBERA	362.96	9.26	0.00	372.22	0.05	13.85	0.11	6.98
QUERCUS RUBRA	4.44	18.89	31.11	54.44	15.60	1.94	34.11	18.02
TILIA AMERICANA VAR HETEROPHYLLA	45.93	21.11	6.67	73.70	1.63	2.89	5.37	4.13
ALL	1720.37	925.19	84.07	2729.63	38.68	99.99	100.00	100.00

Table 5.34. Vertical structure of woody species in the **Montane Oak Forests** vegetation class and associated community types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

7. Montane Oak Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	1		
ACER RUBRUM VAR RUBRUM	1	2	5	6	
ACER SACCHARUM VAR SACCHARUM	1	1			
BETULA LENTA	1	1	1	1	
CARYA ALBA	1	1	1	1	
CARYA GLABRA	1	1	1	2	
CASTANEA DENTATA	1	1			
CORNUS FLORIDA	1	2	1		
GAYLUSSACIA URSINA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1	1	
KALMIA LATIFOLIA	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	1	
NYSSA SYLVATICA	1	1	1	1	
OXYDENDRUM ARBOREUM	1	1	2	2	
PYRULARIA PUBERA	1	1			
QUERCUS ALBA	1	1	1	2	
QUERCUS COCCINEA VAR COCCINEA	1	1	1	1	
QUERCUS MONTANA	1	1	1	3	
QUERCUS RUBRA	1	1	2	3	
QUERCUS VELUTINA	1	1	1	1	
ROBINIA PSEUDOACACIA	1	1	1	1	
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	2	1		

7.1 Quercus montana-Quercus velutina/Oxydendrum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	6	7	
CARYA ALBA	1	1	1	1	
CARYA GLABRA	1	1	1	2	
CASTANEA DENTATA	1	3	1		
CORNUS FLORIDA	1	2			
GAYLUSSACIA URSINA	3	2			
KALMIA LATIFOLIA	1	4			
NYSSA SYLVATICA	1	4	2	2	
OXYDENDRUM ARBOREUM	1	2	3	3	
PINUS STROBUS	1	1			
PYRULARIA PUBERA	1	1			
QUERCUS ALBA	1	1	1	4	
QUERCUS COCCINEA VAR					
COCCINEA	1	1	1	4	
QUERCUS MONTANA	1	1	2	6	
QUERCUS RUBRA	1	1	1	2	
QUERCUS VELUTINA	1	1	1	4	
RHODODENDRON CALENDULACEUM	1	2			
ROBINIA PSEUDOACACIA	1	1	1	2	
SASSAFRAS ALBIDUM	1	2			
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	2	1		
VACCINIUM STAMINEUM	1	1			

7.2 Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	5	4		
ACER RUBRUM VAR RUBRUM	1	2	5	5	
BETULA LENTA	1	1	2	1	
CALYCANTHUS FLORIDUS VAR					
GLAUCUS	1	1			
CARYA GLABRA	1	1	1	1	
CARYA OVATA	1	1	1	1	
CASTANEA DENTATA	1	1			
CORNUS FLORIDA	1	1	1		
HALESIA TETRAPTERA VAR					
MONTICOLA	1	3	3	2	
HAMAMELIS VIRGINIANA	1	3	1		
MAGNOLIA FRASERI	1	1	1	1	
OXYDENDRUM ARBOREUM	1	1	2	3	
QUERCUS MONTANA	1	1	2	3	
QUERCUS RUBRA	1	1	4	7	
QUERCUS VELUTINA	1	1	1	1	
RHODODENDRON MAXIMUM	1	4	1		
SASSAFRAS ALBIDUM	1	1	1	1	
TSUGA CANADENSIS	1	4	1		

7.3 Quercus montana-Quercus rubra/Cornus florida Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	6	7	
ACER SACCHARUM VAR SACCHARUM	1	1			
BETULA LENTA	1	1	1		
CARYA GLABRA	1	1	1	1	
CARYA OVATA	1	1	1	1	
CASTANEA DENTATA	1	2			
CORNUS FLORIDA	1	1	1		
FRAXINUS AMERICANA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	1	
MAGNOLIA FRASERI	1	1			
OXYDENDRUM ARBOREUM	1	1	1	2	
PYRULARIA PUBERA	1	2			
QUERCUS MONTANA	1	1	2	5	
QUERCUS RUBRA	1	1	2	5	
QUERCUS VELUTINA	1	1	1	1	
RHODODENDRON CALENDULACEUM	1	2			
ROBINIA PSEUDOACACIA	1	1	1	1	
SASSAFRAS ALBIDUM	1	1	1		
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	2	1		
VITIS AESTIVALIS VAR AESTIVALIS	1	1	1	1	

7.4 Carya alba-Quercus alba/Cornus florida/Polystichum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	2	6	5	
BETULA LENTA	1	1	1		
CARYA ALBA	1	1	5	5	
CARYA GLABRA	1	1	1	1	
CORNUS FLORIDA	1	5	3		
HALESIA TETRAPTERA VAR MONTICOLA	1	1			
HAMAMELIS VIRGINIANA	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	2	
NYSSA SYLVATICA	1	2	3	2	
OXYDENDRUM ARBOREUM	1	1	2	1	
PINUS STROBUS	1	2			
QUERCUS ALBA	1	1	4	4	
QUERCUS FALCATA	1	1	1	1	
QUERCUS MONTANA	1	1	1	1	
QUERCUS RUBRA	1	1	1	2	
QUERCUS VELUTINA	1	1	2	3	
ROBINIA PSEUDOACACIA	1	1	1	1	
SMILAX GLAUCA VAR GLAUCA	1	1			
STEWARTIA OVATA	1	1			
TSUGA CANADENSIS	1	3	2		

7.5 Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1		
ACER RUBRUM VAR RUBRUM	1	1	5	6	
BETULA LENTA	1	1	1	3	
CARYA ALBA	1	1	1	1	
CARYA GLABRA	1	1	2	5	
CORNUS FLORIDA	1	2	2		
GAYLUSSACIA URSINA	2	2			
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1		
KALMIA LATIFOLIA	1	4			
MAGNOLIA FRASERI	1	1	1	1	
NYSSA SYLVATICA	1	1	2	1	
OXYDENDRUM ARBOREUM	1	1	3	4	
PINUS RIGIDA	1	1	1	1	
PINUS STROBUS	1	1	1	2	
PYRULARIA PUBERA	1	2	1		
QUERCUS ALBA	1	1	1	2	
QUERCUS COCCINEA VAR COCCINEA	1	1	1	3	
QUERCUS VELUTINA	1	1	1	1	
RHODODENDRON MAXIMUM	1	1			
ROBINIA PSEUDOACACIA	1	1	1	1	
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	4	2		

7.6 Quercus rubra-Halesia/Thelypteris Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	5	2		
ACER RUBRUM VAR RUBRUM	1	2	4	4	
ACER SACCHARUM VAR SACCHARUM	1	2	1	1	
AMELANCHIER ARBOREA	1	1			
BETULA LENTA	1	1	2	2	
CARYA OVATA	1	1	1	1	
CASTANEA DENTATA	1	1			
CORNUS FLORIDA	1	1	1		
FRAXINUS AMERICANA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	2	3	3	
ILEX MONTANA	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	3	1
MAGNOLIA ACUMINATA	1	1	1	1	
MAGNOLIA FRASERI	1	1	1	1	
NYSSA SYLVATICA	1	1			
PYRULARIA PUBERA	1	1			
QUERCUS MONTANA	1	1		1	
QUERCUS RUBRA	1	1	2	5	2
ROBINIA PSEUDOACACIA	1	1	1	1	
SMILAX ROTUNDIFOLIA	1				
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	1	
TSUGA CANADENSIS	1	1			
VITIS CINEREA VAR BAILEYANA	1	1	1	1	

Table 5.35. Average site information for the **Montane Oak Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**1**=cobble arkosic metasandstone, **3**=metasandstone-metaconglomerate, **13**=arkosic metasandstone-metaconglomerate, **15**=arkosic metasandstone-phyllite), Landform type (representing micro-scale topographic units) (**SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**LS**=lower slopes, **MS**=mid slopes, **US**=upper slopes).

7. Montane Oak Forests

	Group						
	7.	7.1	7.2	7.3	7.4	7.5	7.6
Site Characteristics:							
Elevation (m)	852	994	890	981	441	692	992
Slope (o)	26	23	36	29	20	22	27
Aspect (o)	SE-SW	S-SW	N-E	SE-SW	S	E-S	NW-SE
Parent material	13	13		13	1,3	15	13,15
Soil depth (cm)	58.1	52.8	42.6	60.7	51.8	59.8	68.6
Surface Substrate (%):							
Moss/Lichen	4	7	4	6	1	4	4
Wood	7	11	5	8	4	4	8
Rock	7	11	9	9	2	4	7
Organic Matter	82	78	83	81	79	89	82
Water	0	0	0	0	0	1	0
Topographic Characteristics:							
Relative slope (%)	62	64	56	71	78	45	59
LFI	0.24	0.23	0.22	0.27	0.29	0.21	0.23
TSI	0.00	0.02	0.02	-0.02	0.05	-0.04	-0.01
Landform type	SS	SS	SS	SS	SS	SS	SS
Topgraphic position	LS,MS,US	US	MS,US	LS,MS	MS	US	LS,MS,US

5.5.8 VEGETATION CLASS: 8. Acidic Cove and Slope Forests

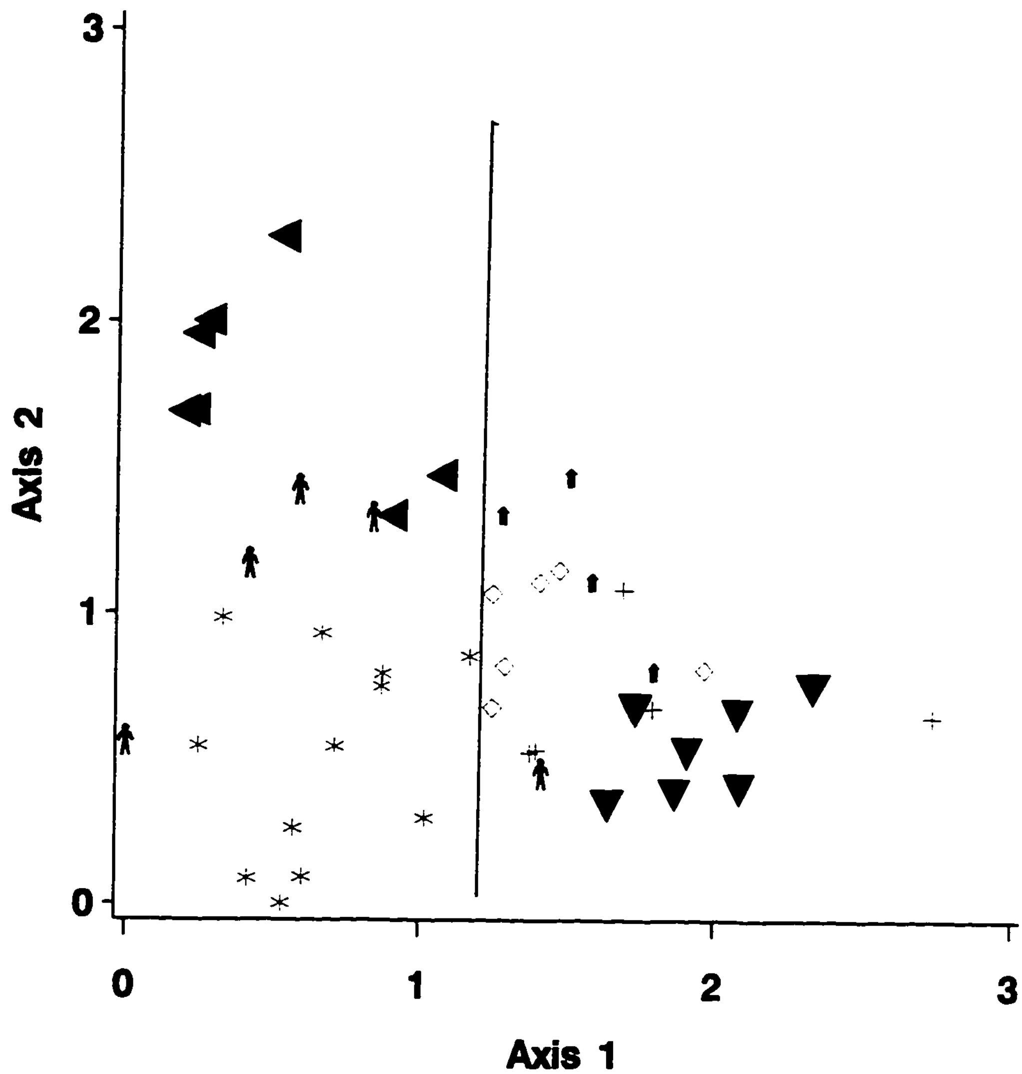
The **Acidic Cove and Slope Forests** are widespread throughout the Southern Appalachian Mountains, occurring in "narrow gorges, steep ravines and low gentle ridges within coves" at low- and moderate-elevations (Schafale and Weakley 1990).

This vegetation class has uneven distribution throughout Joyce Kilmer. In the Little Santeetlah watershed this vegetation class is restricted to sheltered lower-slope and lower-elevation areas, whereas it is dominant across a broad range of elevations and topographic positions in the cooler, northerly-facing and more highly disturbed Slickrock valley. In Joyce Kilmer the **Acidic Cove and Slope Forests** account for 26% of stands sampled in this study (Appendices 3, 6). Stands have low to moderate diversity (Table 5.9) and are characterized by a canopy dominated by *Tsuga canadensis* and/or the presence of an evergreen shrub layer, typically dominated or codominated by *Rhododendron maximum*.

The **Acidic Cove and Slope Forests** community types separate by soil fertility, elevation and microtopographic shape (Figures 5.13, 5.14). The **Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest** and the **Tsuga canadensis-Liriodendron/ Thelypteris Forest** inhabit more concave (high TSI), lower-elevation sites with higher soil fertility (high pH, Ca, Mn and low Fe) than the remaining types. The **Acer rubrum /Rhododendron maximum Forest** also occurs at low-elevations, but inhabits less fertile sites with higher slope position than the former two types. The remaining four types inhabit less fertile, organic soils. These types are not well separated from one another and were reordinated separately in an attempt to clarify environmental differences.

The remaining four community types (the **Tsuga canadensis-Magnolia fraseri Forest**, the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest**, the **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** and the **Tsuga canadensis/Rhododendron maximum Forest**) separate by elevation, soil texture (sand, silt, soil density) and slope position. The **Tsuga canadensis-Betula alleghaniensis/ Rhododendron maximum Forest** and the **Tsuga canadensis/Rhododendron maximum Forest** have coarser-textured soils (high sand and soil density) than the other two types and inhabit lower-elevation, lower-slope positions (Figures 5.15, 5.16). The former type is situated with closer proximity to watercourses than the latter type. The remaining two types also separate by slope position, with the **Tsuga canadensis-Magnolia fraseri Forest** occurring on higher-slope positions than the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest**.

Figure 5.13. DCA ordination diagram showing the distribution of the **Acidic Cove and Slope Forests** class on the two major compositional gradients. The line shows separation of stands for future reordinations.



Community type:

- 8.1 Acer rubrum/Rhododendron maximum Forest
- 8.2 Liriodendron – Betula lenta – T. canadensis/Polystichum Forest
- 8.3 Tsuga canadensis – Liriodendron/Thelypteris Forest
- 8.4 Tsuga canadensis – Halesia/Dryopteris intermedia Forest
- 8.5 Tsuga canadensis – Magnolia fraseri Forest
- 8.6 Tsuga canadensis/Rhododendron maximum Forest
- 8.7 Tsuga canadensis – Betula alleghanensis/R. maximum Forest

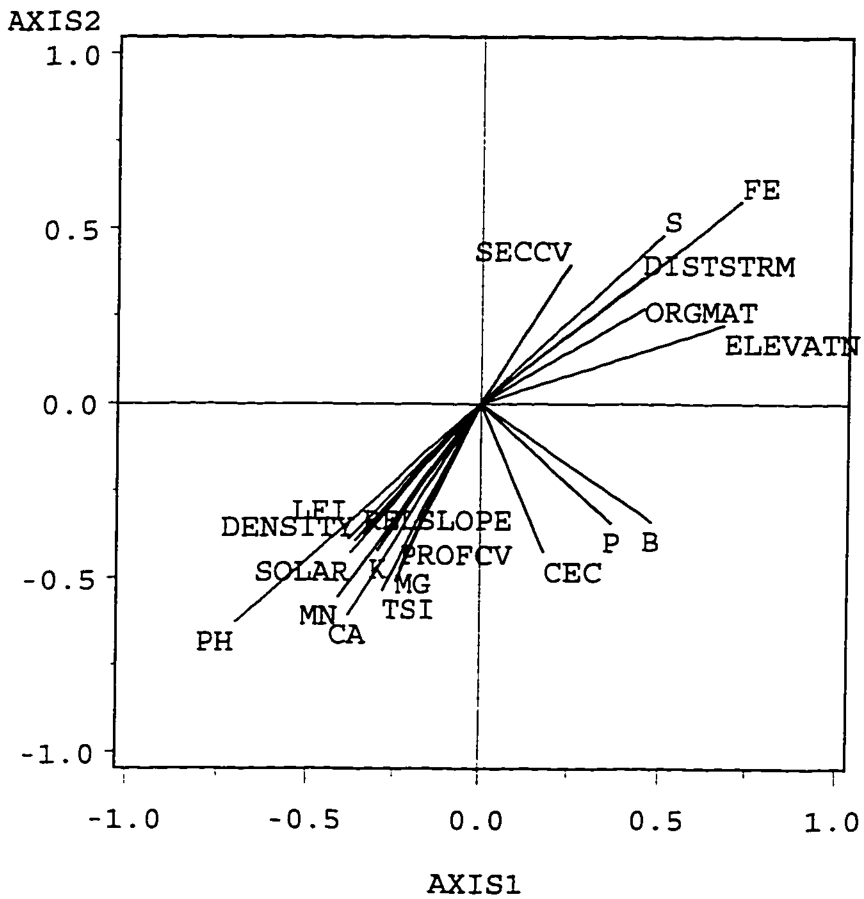
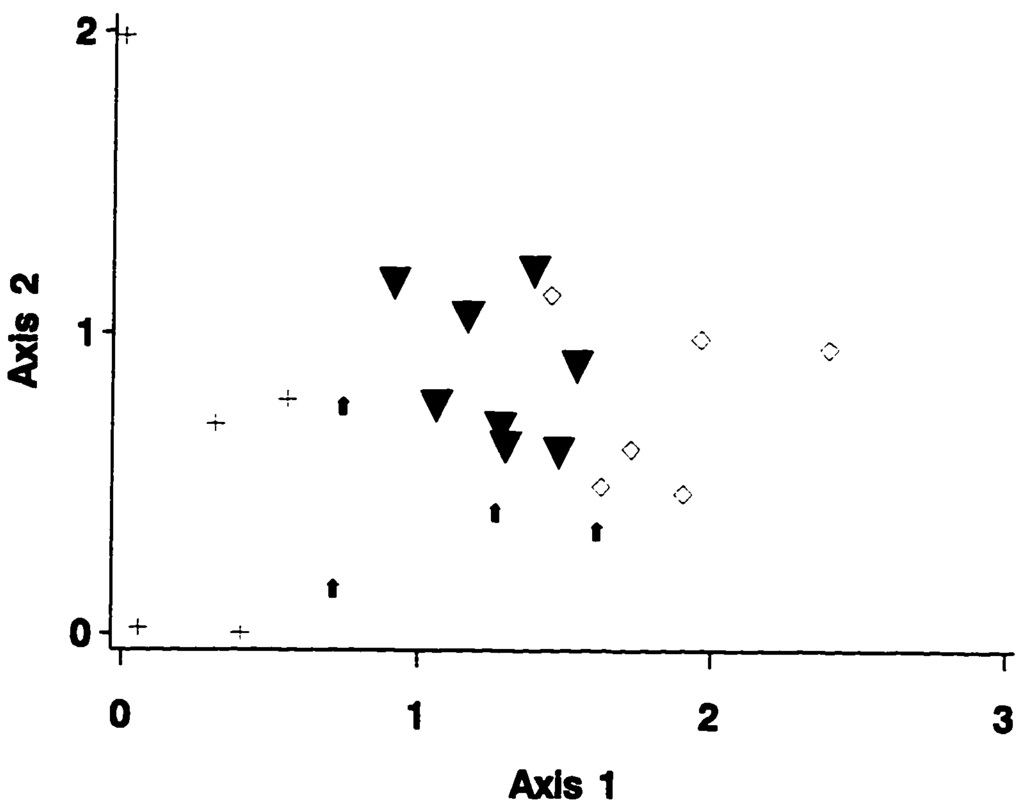


Figure 5.14. Vector diagram for DCA ordination of the **Acidic Cove and Slope Forests** class showing association between species composition and major environmental gradients. DISTSTRM=distance downslope to cove, RELSLOPE=relative slope position, with increasing values corresponding to higher position, PROFCV=profile curvature. Small LFI values represent unprotected upper-slopes progressing through to high values representing concave lower-slopes. Low TSI values represent convex upper-slopes while high values represent concave lower-slopes.

Figure 5.15. DCA ordination diagram showing the distribution of the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest**, the **Tsuga canadensis-Magnolia fraseri Forest**, the **Tsuga canadensis/Rhododendron maximum Forest** and the **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** in the **Acidic Cove and Slope Forests** class on the two major compositional gradients.



Community type:

- ▼ 8.4 *Tsuga canadensis*–*Halesia*/*Dryopteris intermedia* Forest
- ◇ 8.5 *Tsuga canadensis*–*Magnolia fraseri* Forest
- ⬆ 8.6 *Tsuga canadensis*/*Rhododendron maximum* Forest
- \+ 8.7 *Tsuga canadensis*–*Betula alleghanensis*/*R. maximum* Forest

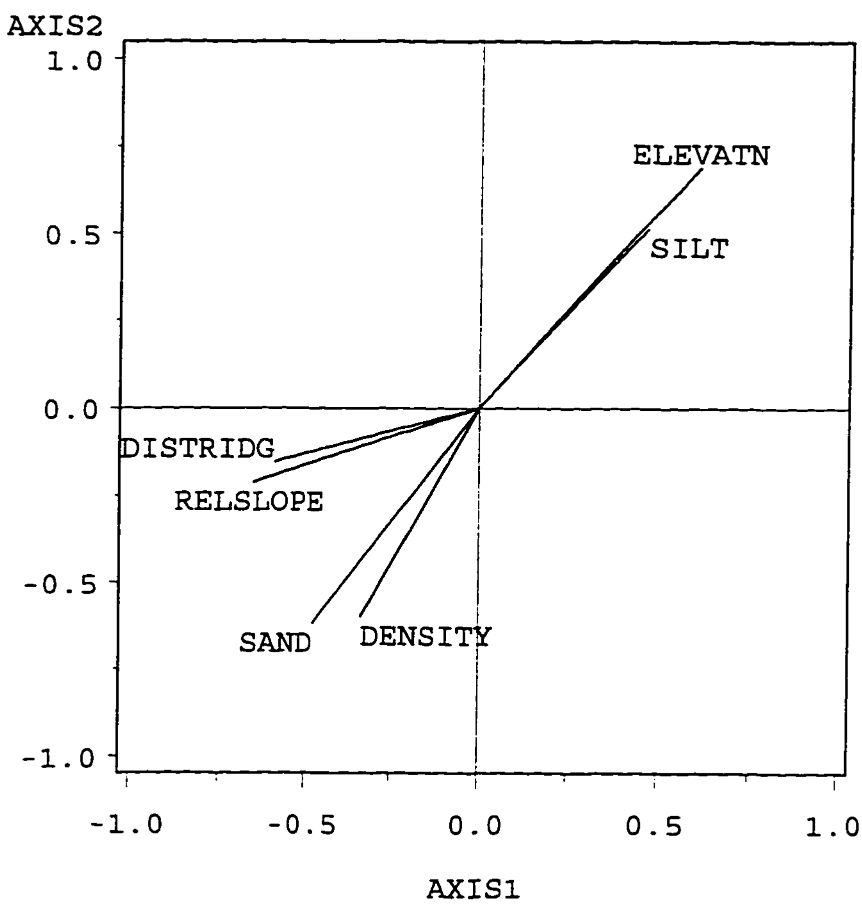


Figure 5.16. Vector diagram for DCA ordination of the **Tsuga canadensis-Halesia/ Dryopteris intermedia Forest**, the **Tsuga canadensis-Magnolia fraseri Forest**, the **Tsuga canadensis/Rhododendron maximum Forest** and the **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** in the **Acidic Cove and Slope Forests** class showing association between species composition and major environmental gradients. DISTRIDG=distance to ridge, RELSLOPE=relative slope position, with increasing values corresponding to higher position.

COMMUNITY TYPE: Acer rubrum/Rhododendron maximum Forest (8.1)

Synonymy

Acidic Cove Forest (Schafale & Weakley 1990), Chestnut Oak-Chestnut Heath p.p. (Whittaker 1956), Red maple-northern oak type p.p. (Golden 1974), Chestnut Oak Forest p.p. (McLeod 1988), Chestnut Oak Forest (Patterson 1994), Red Oak Slope Forest p.p. (Patterson 1994), *Quercus montana/Rhododendron maximum* Forest p.p. (Chapter 3), *Quercus montana-Quercus rubra/Kalmia* Forest p.p. (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Betula lenta*, *Galax urceolata*, *Gaylussacia ursina*, *Kalmia latifolia*, *Liriodendron tulipifera*, *Magnolia fraseri*, *Oxydendrum arboreum*, *Quercus rubra*, *Rhododendron maximum*, *Sassafras albidum*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Tsuga canadensis*.

Listed species

Carex lucorum var. *austrolucorum*.

Physiognomy

Canopy composition of this community type varies between stands. *Acer rubrum* and *Betula lenta* are most consistent throughout, with *Betula* typically subdominant. The five Slickrock stands are dominated by one or a combination of *Quercus coccinea*, *Q. montana* and *Q. rubra*. *Pinus strobus* is a major species in one of these stands. *Tsuga canadensis* is consistently the major subcanopy and understory species across all Slickrock sites. There is a distinct *Rhododendron maximum* shrub layer with *Gaylussacia ursina* also present (Tables 5.36, 5.37, 5.38).

The two Little Santeetlah stands differ in composition from one another. *Tsuga* is prominent in the canopy of the lower-valley, lower-slope stand whereas *Tsuga* is a minor component of the other stand with *Betula lenta*, *Quercus rubra* and *Q. montana* dominant in the canopy (Tables 5.36, 5.37, 5.38). Both stands have a dense *Rhododendron maximum* shrub with only very limited *Gaylussacia* cover. In both watersheds the forest floor is sparsely distributed with *Galax urceolata*, *Smilax glauca* var. *glauca* and *Smilax rotundifolia*.

Habitat and Distribution

The **Acer rubrum/Rhododendron maximum Forest** inhabits west- to north-facing, moderately sloped (27° average slope, range of 1 to 34°), mid- and lower-slopes. Stands range in elevation between 491 and 870 m in Slickrock, and between 721 and 988 m in the Little Santeetlah watershed (Table 5.39).

The soils have moderate texture, with similar nutrient levels to average **Acidic Cove and Slope Forests** class averages (Tables 5.7, 5.8).

Distinguishing Features

This community type has low species richness levels at all scales in comparison to most **Acidic Cove and Slope Forests** types. The richness levels of this type are most similar to other two **Acidic Cove and Slope Forests** types with a distinct *Rhododendron maximum* shrub stratum (Table 5.9).

Succession and Disturbance

The constant presence of *Betula lenta* and variable composition of other canopy species provides some evidence for past disturbance. Cut stumps in four Slickrock stands indicate that these sites were logged. There is evidence of fire in two sites. Chestnut logs are absent from all Slickrock sites. In contrast, chestnut logs are present in the *Betula lenta-Quercus rubra-Q. montana* stand in Little Santeetlah described above. Lorimer (1980) and other authors (e.g., Woods & Shanks 1959) have suggested that *B. lenta* regenerates in gaps left by chestnut. The age of small-tree *B. lenta* stems (20 cm; aged 67 and 68 years) in these stands is consistent with such a hypothesis. Charred stumps provide evidence for disturbance in the Little Santeetlah-*Tsuga* stand mentioned above.

The dominance of small-tree-sized *Quercus* species in the four Slickrock sites suggests that trees of this genus resprouted after logging and therefore were probably formerly dominant on these sites. However, the absence of *Quercus* regeneration indicates a future decline in the presence of this genus (Table 5.37). In contrast, abundant *Tsuga* saplings in Slickrock stands, points to the future dominance of this species in the canopy of stands in this watershed.

The presence of *Tsuga* saplings in the *Tsuga* stand in Little Santeetlah indicates that the present canopy will be maintained. In contrast, limited *Tsuga* saplings in the *Quercus*-Little Santeetlah stand and presence of small-diameter *Quercus* stems suggests that this genus will continue to dominate the canopy.

COMMUNITY TYPE: Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest (8.2)

Synonymy

Acidic Cove Forest (Schafale & Weakley 1990).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Aster divaricatus*, *Betula lenta*, *Carya glabra*, *Cornus florida*, *Euonymus americana*, *Fagus grandifolia*, *Goodyera pubescens*, *Halesia tetraptera* var. *monticola*, *Liriodendron tulipifera*, *Mitchella repens*, *Polystichum acrostichoides*, *Quercus rubra*, *Rhododendron maximum*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Tsuga canadensis*, *Viola hastata*.

Listed species

Carex lucorum var. *austrolucorum*, *Carex manhartii*, *Stewartia ovata*.

Physiognomy

Large-diameter *Liriodendron tulipifera* (mostly 41 to 66 cm) dominate the canopy (31 m height) in conjunction with *Betula lenta* and *Tsuga canadensis* and more scattered *Fagus* (Tables 5.36, 5.37, 5.38). *Tsuga canadensis* dominates the lower-strata and in the shrub stratum is joined by scattered *Rhododendron maximum* and variable levels of *Ilex opaca* and *Gaylussacia ursina*. *Polystichum acrostichoides* is the only consistent major ground species in all sites. *Leucothoe fontanesiana* has dense, but patchy distribution in the three sites adjacent to creeks or on associated toeslopes. *Thelypteris novaeboracensis* is present on the drier sites. *Aster divaricatus*, *Euonymus americana*, *Goodyera pubescens*, *Mitchella repens*, *Smilax glauca*, *S. rotundifolia* and *Viola hastata* are present with low, but consistent cover.

Habitat and Distribution

The **Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest** inhabits southeast- and northwest-facing coves, toeslope and lower-slopes (19° average slope, range of 7 to 40°) in the mid- and lower-reaches of the Slickrock valley (350 to 764 m elevational range, 602 m mean; Table 42).

The soils are similar in texture to average **Acidic Cove and Slope Forests** values, but are less fertile with lower than average base saturation, Ca and pH levels (Tables 5.7, 5.8).

Succession and Disturbance

The dominance of *Liriodendron* and *Betula lenta* in the canopy of this type provides an indication of past disturbance. All sites in this type have been logged, with two sites on broad, shallow toeslopes possibly cultivated. Canopy trees average 55 to 75 years in age across all sites. There is no evidence of the past presence of chestnut. One site has evidence of fire.

An absence of *Liriodendron* and *Betula lenta* saplings and a limited number of *Acer rubrum* saplings suggests that the composition of the canopy will alter greatly in the future

(Table 5.37). High *Tsuga* sapling numbers indicate the dominance of this species in the future canopy. Such a prediction points to the future convergence of this community type with the **Tsuga canadensis-Liriodendron/Thelypteris Forest**, although differences in soil fertility and slope position will maintain compositional differences between the two types. I expect that *Tsuga* will dominate the canopy of the **Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest** and that *Polystichum* will continue to be the major floor species.

COMMUNITY TYPE: Tsuga canadensis-Liriodendron/Thelypteris Forest (8.3)

Synonymy

Acidic Cove Forest (Schafale & Weakley 1990), Canada Hemlock Forests p.p. (Schafale & Weakley 1990), Hemlock Forest-Herb type (Oosting & Bourdeau 1955), Hemlock type p.p. (Golden 1974), Hemlock/herb Forest (Lorimer 1980).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Athyrium asplenioides*, *Betula lenta*, *Carya glabra*, *Chimaphila maculata* var. *maculata*, *Cornus florida*, *Desmodium nudiflorum*, *Dioscorea quaternata*, *Euonymus americana*, *Eupatorium purpureum* var. *purpureum*, *Fagus grandifolia*, *Goodyera pubescens*, *Halesia tetraptera* var. *monticola*, *Liriodendron tulipifera*, *Maianthemum racemosum*, *Medeola virginiana*, *Mitchella repens*, *Oxydendrum arboreum*, *Polystichum acrostichoides*, *Polygonatum biflorum* var. *biflorum*, *Prenanthes* species, *Pyrularia pubera*, *Quercus rubra*, *Smilax glauca* var. *glauca*, *Smilax rotundifolia*, *Thelypteris novaeboracensis*, *Tilia americana* var. *heterophylla*, *Viburnum acerifolium*, *Viola hastata*.

Listed species

Carex lucorum var. *austrolucorum*, *Carex manhartii*, *Juncus gymnocarpus*, *Panax quinquefolius*.

Physiognomy

Large-diameter *Tsuga canadensis* (stems mostly 41 to 58 cm) dominate the canopy (29 m height) of this community type in conjunction with *Liriodendron*, *Quercus rubra* and *Acer rubrum* (Tables 5.36, 5.37, 5.38). *Betula lenta* and *Tsuga* are the major subcanopy species the latter also dominant throughout the lower-strata. *Tsuga* is joined in the shrub stratum by *Cornus florida* and scattered *A. pensylvanica* and *Halesia*. The forest floor is dry and rocky in some sites. *Thelypteris novaeboracensis* and *Mitchella repens* are the dominant ground species. There is a diverse range of sparsely scattered low-cover species, including; *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Athyrium asplenioides*, *Chimaphila maculata* var. *maculata*, *Desmodium nudiflorum*, *Dioscorea quaternata*, *Euonymus americana*, *Eupatorium purpureum* var. *purpureum*, *Goodyera pubescens*, *Maianthemum racemosum*, *Medeola virginiana*, *Polystichum acrostichoides*, *Polygonatum biflorum*, *Prenanthes* species, *Smilax glauca* var. *glauca*, *S. rotundifolia*, *Viburnum acerifolium* and *Viola hastata*.

There are two sub-types which separate by composition and site position.

Community sub-types:

Tsuga canadensis-Liriodendron/Mitchella sub-type (8.3.1)

Synonymy: Acidic Cove Forest (Schafale & Weakley 1990), Canada Hemlock Forests p.p. (Schafale & Weakley 1990), Hemlock Forest-Herb type (Oosting & Bourdeau 1955), Hemlock type p.p. (Golden 1974), Hemlock/herb Forest (Lorimer 1980).

Tsuga canadensis and *Liriodendron* dominate the canopy of this sub-type in association with *Acer rubrum* and *Betula lenta* (Tables 5.36, 5.37, 5.38). *Tsuga* is scattered throughout the lower-strata of some sites. The shrub layer is open with *A. pensylvanicum*, *Castanea dentata*, *Gaylussacia ursina* and *Rhododendron maximum* varying in abundance between sites. The forest floor is dry, with scattered *Mitchella repens* and *Thelypteris novaeboracensis*.

Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type (8.3.2)
Synonymy: Acidic Cove Forest (Schafale & Weakley 1990).

Quercus rubra, *Liriodendron*, *Acer rubrum* and *Betula lenta* are the major canopy species. *Tsuga canadensis* is a canopy codominant in some sites (Tables 5.36, 5.37, 5.38). This species is the major understory species. There is variable shrub cover from *Cornus florida* and *Hamamelis virginiana*. *Parthenocissus quinquefolia* var. *quinquefolia* is a consistent component of the somewhat rocky ground stratum.

Habitat and Distribution

This community type inhabits shallow- to moderate-slopes (range of 8 to 32°, 20° average) across a range of aspects. Apart from one site in Horse Cove the ***Tsuga canadensis-Liriodendron/Mitchella sub-type*** is restricted to Little Santeetlah where it inhabits dryer, lower-slope ridges and mid- to lower-slopes between 727 and 830 m. In contrast, 43% of sites in the ***Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type*** are present in Horse Cove, with 29% in Little Santeetlah and the remainder in Slickrock valley. This sub-type is distributed between 390 and 830 m in elevation on mostly southwest-facing toeslopes and steep lower-slopes adjacent to watercourses (Table 5.39).

The soils of both sub-types are more fertile than other **<u>Acidic</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** types, with the ***Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type*** having highest base saturation, Ca, Mg, Mn and pH levels of any type or sub-type in this vegetation class (Tables 5.7, 5.8). This sub-type also has deeper soils than the other sub-type (Table 5.39).

Distinguishing Features

The **Tsuga canadensis-Liriodendron/Thelypteris Forest** has high species richness levels (Table 5.9). The ***Tsuga canadensis-Liriodendron/Mitchella sub-type*** has highest richness at the three smallest scales in comparison to other **Acidic Cove and Slope Forests** types or sub-types, reflecting dominance of small-sized herbaceous species, such as *Mitchella repens*. The ***Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type*** has highest diversity at the four largest spatial scales.

High species richness and fertile site conditions give the **Tsuga canadensis-Liriodendron/Thelypteris Forest** some resemblance to **Rich Cove and Slope Forests** types. However, this type is dominated by species such as *Mitchella repens* and *Gaylussacia ursina* that are typically associated with more infertile conditions than those inhabited by **Rich Cove and Slope Forests** types.

Succession and Disturbance

The presence of *Betula lenta* throughout suggests a history of canopy disturbance for this community type (Lorimer 1980). There is evidence for chestnut in 8 of the 11 plots. The young, even-age of the canopy in the ***Tsuga canadensis-Liriodendron/Mitchella sub-type*** (*Tsuga* 90 years old) and size of chestnut logs suggests that chestnut perhaps once (co)dominated the canopy. Lorimer (1976) describes a ridge site, that is probably the site of plot 526, as virtually a 'graveyard' of chestnut logs and suggests that this was the site where Braun (1950) noted high chestnut canopy dominance. In the ***Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type*** 5 of the 7 plots were logged (all located in Slickrock or Horse Cove). Three of the 7 have evidence of scattered large diameter chestnuts (125 cm, plot 513; 160 cm, plot 522) .

The presence of *Liriodendron* and abundant *Tsuga* saplings in the ***Tsuga canadensis-Liriodendron/Mitchella sub-type*** suggests that these two species will continue to be the major canopy species of this sub-type (Table 5.37). The high *Tsuga* saplings numbers in the ***Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type*** and more limited densities of *Quercus rubra* and *Liriodendron* point to greater *Tsuga* dominance of this sub-type in the future. These projections indicate the future convergence of canopy composition of the two sub-types, although differences in topographic position and surface substrate of these two groups should maintain subtle compositional differences between them.

COMMUNITY TYPE: Tsuga canadensis-Halesia/Dryopteris intermedia Forest (8.4)

Synonymy

Acidic Cove Forest (Schafale & Weakley 1990), Hemlock Forest-Polycodium type p.p. (Oosting & Billings 1939), Canada Hemlock Forests p.p. (Schafale & Weakley 1990), Hemlock Forest-Herb type (Oosting & Bourdeau 1955), Silverbell-Hemlock type (Golden 1974), Hemlock/herb Forest (Lorimer 1980).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Aesculus flava*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Betula lenta*, *Dryopteris intermedia*, *Halesia tetraptera* var. *monticola*, *Laportea canadensis*, *Magnolia fraseri*, *Medeola virginiana*, *Mitchella repens*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Prosartes lanuginosum*, *Prunus pensylvanica*, *Quercus rubra*, *Rhododendron maximum*, *Rubus canadensis*, *Smilax rotundifolia*, *Solidago curtisii*, *Stellaria pubera*, *Tiarella cordifolia* var. *cordifolia*, *Tsuga canadensis*, *Viola blanda*, *Viola hastata*, *Viola rotundifolia*.

Listed species

Carex manhartii, *Panax quinquefolius*.

Physiognomy

The canopy (30 m height) of this community type is dominated by large-diameter *Tsuga canadensis* (mostly 44 to 84 cm; largest 125 cm, plot 570) and *Halesia* (42 to 68 cm) (Tables 5.36, 5.37, 5.38). *Magnolia fraseri* and *Betula lenta* have lower cover in this strata. *Tsuga* dominates the mid-strata. *Acer pensylvanicum* forms a distinct, but open shrub layer. The presence of *Rhododendron maximum* in this stratum varies between sites. The forest floor is somewhat lush, with *Dryopteris intermedia* most prominent and *Mitchella repens*, *Polystichum acrostichoides* and *Viola blanda* also highly abundant. Low-cover species present throughout most sites include; *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Laportea canadensis*, *Medeola virginiana*, *Polygonatum biflorum*, *Prenanthes* species, *Prosartes lanuginosum*, *Smilax rotundifolia*, *Solidago curtisii*, *Stellaria pubera*, *Tiarella cordifolia* var. *cordifolia* and *Viola hastata*.

Habitat and Distribution

The **Tsuga canadensis-Halesia/Dryopteris intermedia Forest** inhabits moderately sloping (26° average, 5 to 36° range), mid-elevation (1041 m average, 885 to 1290 range) sites. Stands are situated on north- to east-facing mid- and lower-slopes (found at elevations between 885 to 1080 m) and sheltered, lower-slope tertiary ridgelines and upper-slopes (found between 1060 and 1290 m elevation) in the upper Slickrock valley (Table 5.39). All sites except one (located in Little Santeetlah) were sampled in the mid- to upper-reaches of Slickrock.

The soils have similar soil texture to average **<u>Acidic Cove</u> and <u>Slope Forests</u>** class values. However, apart from the **Tsuga canadensis-Magnolia fraseri Forest**, the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest** are less fertile than other types in this class lacking a dense *Rhododendron maximum* shrub layer (Tables 5.7, 5.8).

Distinguishing Features

This community type has a high basal area (51.91m^2) and has the highest density of stems ≥40 cm (121.67 stems/ha), reflecting the dominance of large-sized trees in the canopy

(Table 5.37). The presence of a broad array of herbaceous species in the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest** accounts for the higher small-scale species richness (1m^2 and 0.1m^2) in this type in comparison to other **Acidic Cove and Slope Forests** types (Table 5.9).

Succession and Disturbance

Chestnut logs and stumps were recorded in the two ridge plots. There is evidence for logging in three stands. Increment cores from the remaining three Slickrock plots placed canopy *Tsuga* ages between 130 and approximately 350 years (57 and 63 cm diameter respectively) indicating that these plots were only partially logged or not logged.

Summary information suggests that *Tsuga*, *Halesia* and *Magnolia fraseri* will continue to dominate the canopy and maintain the community type in its present form (Table 5.37).

COMMUNITY TYPE: Tsuga canadensis-Magnolia fraseri Forest (8.5)

Synonymy

Acidic Cove Forest (Schafale & Weakley 1990), Canada Hemlock Forests p.p. (Schafale & Weakley 1990), Hemlock Forest-Herb type (Oosting & Bourdeau 1955), Hemlock/herb Forest (Lorimer 1980).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Aster divaricatus*, *Betula lenta*, *Fagus grandifolia*, *Gaylussacia ursina*, *Halesia tetraptera* var. *monticola*, *Magnolia fraseri*, *Medeola virginiana*, *Mitchella repens*, *Polystichum acrostichoides*, *Prenanthes* species, *Prunus pensylvanica*, *Rhododendron maximum*, *Smilax rotundifolia*, *Solidago curtisii*, *Tsuga canadensis*, *Viola hastata*, *Viola rotundifolia*.

Listed species

Carex lucorum var. *austrolucorum*, *Carex manhartii*, *Panax quinquefolius*.

Physiognomy

Large-diameter *Tsuga canadensis* (stems mostly 42 to 78 cm; largest 111 cm, plot 588), *Halesia* and *Magnolia fraseri* dominate the canopy (25 m height) of this community type (Tables 5.36, 5.37, 5.38). *Fagus*, *Liriodendron* and *Sassafras albidum* are present at some sites. *Tsuga* dominates the lower-strata and is joined by *Acer pensylvanicum* in the shrub layer. The forest floor is dry and open with a scattering of sparsely distributed, but highly consistent species, including; *Aster divaricatus*, *Medeola virginiana*, *Mitchella repens*, *Polystichum acrostichoides*, *Prenanthes* species, *Smilax rotundifolia*, *Solidago curtisii*, *Viola hastata* and *V. rotundifolia*.

Community sub-types:

Magnolia fraseri-Halesia/Acer pensylvanicum sub-type (8.5.1)

Synonymy: Acidic Cove Forest (Schafale & Weakley 1990).

The canopy is dominated by *Magnolia fraseri*, *Halesia*, *Sassafras* and *Liriodendron* (Tables 5.36, 5.37, 5.38). *Tsuga canadensis* is present with varying abundance. *Tsuga* dominates the lower-strata in conjunction with *Oxydendrum*, *Acer pensylvanicum* and *Vitis vulpina*. There is an open shrub layer dominated by *A. pensylvanicum* with scattered *Rhododendron maximum* also present. There is no single dominant ground species, but *Dryopteris intermedia*, *Medeola virginiana*, *Polystichum acrostichoides*, *Solidago curtisii*, *Viola blanda*, *V. hastata* and *V. rotundifolia* are scattered throughout.

Tsuga canadensis-Fagus-Halesia sub-type (8.5.2)

Synonymy: Acidic Cove Forest (Schafale & Weakley 1990), Canada Hemlock Forests p.p. (Schafale & Weakley 1990), Hemlock Forest-Herb type (Oosting & Bourdeau 1955), Hemlock Type (Golden 1974), Hemlock/herb Forest p.p. (Lorimer 1980).

Fagus and/or *Tsuga canadensis* dominate the canopy of this sub-type in conjunction with *Halesia* and *Magnolia fraseri* (Tables 5.36, 5.37, 5.38). *Quercus rubra* is also scattered throughout the canopy. *Tsuga* dominates the understory and forms an open shrub layer. The presence of *Ilex montana* and *Fagus* in this stratum varies. Cover on the forest floor varies with *Mitchella repens* and *Carex lucorum* var. *austrolucorum* each dominating a ridge site. *Aster divaricatus, Gaylussacia ursina, Medeola virginiana, Smilax rotundifolia, Solidago curtisii*, and *Vaccinium erythrocarpum* have low but constant cover throughout most sites.

Habitat and Distribution

This community type inhabits moderately sloping (30° average, 19 to 35° range), mid-elevation (1043 m average, 836 to 1271 m range) secondary ridgelines and associated upper-slopes (Table 5.39). The two sub-types differ in elevation and slope position. The ***Magnolia fraseri-Halesia/Acer pensylvanicum sub-type*** occurs between 836 and 960 m on west- and northwest-facing upper-slopes in the mid-section of the Slickrock valley. In contrast, the ***Tsuga canadensis-Fagus-Halesia sub-type*** inhabits warmer, higher-elevation southeast- to-south-facing ridges in the upper Slickrock valley, Deep Creek (1085 to 1145 m) and mid-slopes of Little Santeetlah (1271 m).

The soils are finer-textured with higher silt content than other **<u>Acidic</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** types and sub-types. The soils are less fertile than most types in this class. The ***Magnolia fraseri-Halesia/Acer pensylvanicum sub-type*** has higher Fe and S and lower base saturation and pH levels. The ***Tsuga canadensis-Fagus-Halesia sub-type*** has more organic soils than other types and sub-types in this class (Tables 5.7, 5.8).

Succession and Disturbance

This community type has been heavily disturbed in the past. Four stands were logged with the remaining two (plots 588, 663) containing canopy trees ages over 140 years. Three plots, including one of the old-growth stands (plot 663), have evidence of chestnut (co)dominance. Stand structure suggests that *Tsuga* is replacing chestnut. Only one stand has no signs of past disturbance.

High numbers of *Tsuga* saplings suggest that the present canopy composition of the ***Magnolia fraseri-Halesia/Acer pensylvanicum sub-type*** will change subtly with *Tsuga* gaining greater abundance (Table 5.37). In contrast, high *Fagus*, *Halesia*, *Magnolia fraseri* and *Tsuga* sapling densities in the ***Tsuga canadensis-Fagus-Halesia sub-type*** indicate that the present canopy will be maintained. Increasing dominance of *Tsuga* in the former sub-type suggests that the canopy composition of the two sub-types will converge, however, differences in site orientation should maintain compositional differences between these two groups.

COMMUNITY TYPE: Tsuga canadensis/Rhododendron maximum Forest (8.6)

Synonymy

Acidic Cove Forest, Canada Hemlock forest (Schafale & Weakley 1990), Hemlock Forest - Rhododendron type (Oosting & Bourdeau 1955), Eastern Hemlock Forest (Whittaker 1956), Hemlock Forest p.p. (Racine & Hardin 1975), Hemlock type (Golden 1974), Hemlock/rhododendron forest (Lorimer 1980), Hemlock-Red Maple forest (Golden 1981), the Black and Craggy Mountains north-facing slope and gorge variant of Eastern Hemlock forests (McLeod 1988), Hemlock White Pine subtype II p.p. (Patterson 1994), *Tsuga canadensis/Rhododendron maximum* Forest (Chapter 3), *Tsuga canadensis-Betula lenta/Rhododendron maximum* Forest p.p. (Chapter 4), *Tsuga canadensis-Quercus rubra/Rhododendron maximum* Forest (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Betula alleghaniensis*, *Betula lenta*, *Dryopteris intermedia*, *Halesia tetraptera* var. *monticola*, *Hydrangea arborescens*, *Magnolia fraseri*, *Medeola virginiana*, *Quercus rubra*, *Rhododendron maximum*, *Smilax rotundifolia*, *Tsuga canadensis*, *Viola rotundifolia*.

Physiognomy

Large, mostly 60 to 87 cm diameter *Tsuga canadensis* (largest 105, plot 652) dominate the canopy (31 m mean height, 26 to 40 m range) of this community type (Tables 5.36, 5.37, 5.38). *Halesia* is also present in this stratum. *Tsuga* dominates the subcanopy, in conjunction with *Halesia*. *Betula alleghaniensis* and *Magnolia fraseri* are also present in this stratum. Below this *Rhododendron maximum* forms a distinct, dense shrub stratum. The forest floor contains a thick litter layer with only limited vascular cover. *Leucothoe fontanesiana* has patchy, high abundance in some sites. *Dryopteris intermedia*, *Hydrangea arborescens*, *Medeola virginiana* and *Viola rotundifolia* have sparse distribution across most sites.

Habitat and Distribution

The **Tsuga canadensis/Rhododendron maximum Forest** inhabits steep (36° average, 33 to 37° range), northwest- through north- to east-facing sites at elevations between 705 and 1060 m (mean of 919 m; Table 42). The three higher-elevation stands (two in Slickrock, one in Deep Creek; 900 to 1060 m respectively) inhabit mid- to upper-slope positions, whereas the lower-elevation stand (705 m) inhabits a lower-slope in Little Santeetlah. Differences in elevation and slope position may reflect environmental differences between the two major watersheds, with stands in the lower-rainfall, cooler north- to northeast-facing Slickrock and Deep Creek watersheds able to inhabit higher-elevations and slope positions than those in the warmer, southeast-facing Little Santeetlah valley. Such differences may also reflect disturbance history differences.

The soils are less fertile than average **<u>Acidic</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** vegetation class values and have highest Al, Fe and lowest Cu, and Zn values of any type in this class (Tables 5.7, 5.8). This type has lowest base saturation and pH levels in comparison to other types in this class with a dense *Rhododendron maximum* shrub layer, suggesting that it is less fertile than other *Rhododendron*-dominated types.

Distinguishing Features

The **Tsuga canadensis/Rhododendron maximum Forest** has lowest species richness at all species scales, that at least in part reflects the dominance by a dense evergreen canopy and shrub layer (Table 5.9). Abundant *Halesia* and *Magnolia fraseri* give this type some affiliation with the **Tsuga canadensis-Magnolia fraseri Forest** and distinction from the **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** where these two species are absent.

Succession and Disturbance

One of the Slickrock plots and the Deep Creek plot have evidence of past logging and have canopy trees aged between 55 and 60 years. The two old-growth stands (plot 568 in Slickrock, plot 652 in Little Santeetlah) have *Tsuga* aged between 180 and 200 years (75 and 94 cm diameter respectively).

The dominance of *Tsuga* saplings indicates that this species will continue to be the major canopy species and maintain this community type in its present form (Table 5.37).

COMMUNITY TYPE: Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest (8.7)

Synonymy

Acidic Cove Forest, Canada Hemlock forest (Schafale & Weakley 1990), Hemlock Forest - Rhododendron type (Oosting & Bourdeau 1955), Tsuga canadensis-Betula alleghaniensis variant of the Cove Forests p.p., Eastern Hemlock Forest (Whittaker 1956), Yellow birch-Hemlock type (Golden 1974), Hemlock/rhododendron forest (Lorimer 1980), the Black and Craggy Mountains north-facing slope and gorge variant of Eastern Hemlock forests

(McLeod 1988), *Tsuga canadensis/Rhododendron maximum* Forest (Chapter 3), *Tsuga canadensis-Betula lenta/Rhododendron maximum* Forest (Chapter 5).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Arisaema triphylla* var. *triphylla*, *Betula alleghaniensis*, *Laportea canadensis*, *Liriodendron tulipifera*, *Rhododendron maximum*, *Smilax rotundifolia*, *Tilia americana* var. *heterophylla*, *Tsuga canadensis*.

Physiognomy

Large-diameter *Tsuga canadensis* (stems mostly 59 to 91 cm; largest 112 cm, plot 630) dominate the tall canopy (32 m height) of this community type in conjunction with *Betula alleghaniensis* (41 to 61 cm) (Tables 5.36, 5.37, 5.38). *Liriodendron* and *Tilia* are less abundant in the canopy. There is a dense 5 to 7 m tall *Rhododendron maximum* shrub stratum. The ground is thickly covered with litter, with low, but consistent cover by *Arisaema triphylla*, *Laportea canadensis*, *Smilax rotundifolia* and *Tiarella cordifolia* var. *cordifolia*. In one higher-elevation Slickrock site *Liriodendron* and *Tilia* are replaced in the canopy by *Fagus* and *Dryopteris intermedia* and *Oxalis montana* are abundant on the forest floor.

Habitat and Distribution

The **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** inhabits shallow-sloping (9° average, 4 to 18° range) west- to north-facing lower- slopes and toeslopes adjacent to creeks. This type is distributed at elevations between 630 and 818 m, with the higher-elevation site described above at 1000 m (Table 5.39). This type is present in both major watersheds. Eighty percent of the sites in this type are underlain by colluvium and alluvium.

The soils are shallow, medium-textured and less fertile than average **Acidic Cove and Slope Forests** vegetation class values, with lowest Al and highest P (Tables 5.7, 5.8). The **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** has higher Ca, K, Mn, Mg and lower Fe levels in comparison to the other two types in this class with a dense *Rhododendron* shrub layer, suggesting that the soils have slightly higher fertility. This may be the consequence of its lower-slope and toeslope site position.

Distinguishing Features

This community type has highest basal area measurements of any community type described in this study of Joyce Kilmer. Such high measurements reflects the dominance of large-diameter *Tsuga* and *Betula alleghaniensis* in the canopy.

The **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** shows some affinity to the **Platanus-Betula alleghaniensis Forest** in the **Alluvial Forests** class in both species composition, site position and parent material (Figure 5.1, Tables 5.36, 5.39, 5.44, 5.47). However, sites inhabited by the **Alluvial Forests** are subject to more frequent flooding and higher flooding intensity.

Succession and Disturbance

There is no evidence of fire or past chestnut presence in any of the stands in this type. Two sites have been logged. Three stands (plots 545, 630 in Little Santeetlah and plot 569, the high-elevation Slickrock stand) are old-growth with 74 to 81 cm diameter *Tsuga* trees aged between 162 and 180 years.

Abundant *Tsuga* and *Betula alleghaniensis* saplings indicate that these two species will continue to dominate the canopy and maintain the present structure and composition of this community type (Table 5.37).

Discussion

Community types within the **Acidic Cove and Slope Forests** vegetation class divide into two major subclasses by composition and structure. In the *Rhododendron*-subclass, types are dominated by a dense evergreen, typically *R. maximum* shrub layer. These types generally have low species richness (Table 5.9). The dense ericaceous shrub stratum is absent from the herbaceous-subclass types that contain a comparatively diverse range of herbaceous species with *Mitchella repens* and *Polystichum acrostichoides* often dominant. Although some species are dominant in only one subclass *Tsuga canadensis* is consistently the dominant canopy or understory species throughout both subclasses. The site characteristics of each subclass differ. The *Rhododendron*-subclass typically inhabits cool, northwest- to northeast-facing slopes and coves whereas the herbaceous-subclass is generally situated on warmer, south- to southwest-facing slopes and coves.

Types within the *Rhododendron*-subclass have similar structure to the **Betula alleghaniensis-Fagus/Rhododendron maximum Forest** in the **High-Elevation Mixed Hardwood Forests** class. The **Betula alleghaniensis-Fagus/Rhododendron maximum Forest** inhabits similar lower- and mid-slope positions to the **Tsuga canadensis/ Rhododendron maximum Forest** in particular, but is situated at much higher elevations. This perhaps accounts for the dominance of *Fagus* and absence of *Tsuga* in the former type. The **Acer rubrum/Rhododendron maximum Forest** inhabits dryer, higher-slope positions than the two *Tsuga canadensis-Rhododendron maximum* types. The presence of *Rhododendron maximum* in the **Acer rubrum/Rhododendron maximum Forest** may be an artifact of logging. However, the presence of the old-growth **Quercus montana/ Rhododendron maximum-Kalmia Forest** at Linville Gorge (Chapter 3) suggests that similar forests can develop in the absence of an intense disturbance such as logging, although *Quercus montana* may require fire for regeneration.

Whereas forests dominated by *Tsuga canadensis* and *Rhododendron maximum* have been documented extensively throughout the Southern Appalachians (e.g., Whittaker 1956, Schafale & Weakley 1990, Chapter 3), there has been only limited quantification of the structure and compositional variation of these forests (but see Oosting & Bourdeau 1955, McLeod 1988, Patterson 1994, Newell *et al. in press*, Chapters 3 & 4). The two types dominated by these species in Joyce Kilmer separate by composition, reflecting differences in site position and microclimate. In Little Santeetlah the **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** dominates the broad, low-elevation toeslopes and riverflats flanking the major creek system, whereas the **Tsuga canadensis/Rhododendron maximum Forest** extends up adjacent steep sideslopes. A similar pattern is present in the upper-section of the Slickrock valley. *Tsuga* is the major canopy species in the latter type whereas the codominance of *Betula alleghaniensis* in the **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** probably reflects cooler temperatures and cold air drainage that pervade the main riverflats for prolonged periods (*pers. obs.*). This pattern contrasts to that reported by Golden (1974) who described the dominance of *Betula alleghaniensis-Tsuga canadensis/Rhododendron maximum* forests on steep, north-facing slopes at considerably higher-elevations (1220 to 1400 m) than the **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest**. Golden also noted the absence of these forests from cove sites. Contrasting topographic positions perhaps reflect subtle microclimatic differences between the central Smoky Mountains and the main valleys of Joyce Kilmer and the high-light, but cool temperatures encountered in the low-elevation riverflats in the present study. The restriction of the **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** and the **Tsuga canadensis/Rhododendron maximum Forest** to the upper-portion of the Slickrock valley suggests the presence of a warmer climate in the low-elevation riverflats and coves in the lower-half of this valley.

The **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** and **Tsuga canadensis/Rhododendron maximum Forest** have close structural and compositional similarities with the old-growth **Tsuga canadensis/Rhododendron maximum Forest** of Linville Gorge (Chapter 3). All three types have higher *Rhododendron maximum* densities than those recorded in similar, but second-growth forests at Shining Rock Wilderness (Chapter 4), although some Slickrock stands in the two Joyce Kilmer types are second-growth. The two old-growth types have higher basal area measurements than the equivalent, but second-growth forests at Shining Rock (Tables 3.18, 4.32, 5.37). Marginally higher basal area measurements in the Linville Gorge **Tsuga canadensis/ Rhododendron maximum Forest** than the Joyce Kilmer **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest** probably reflects differences in stand age, with canopy trees in the former landscape well over 275 years of age. The two Joyce Kilmer types also have higher species richness at all spatial scales than the similar types at

Shining Rock and Linville Gorge described above. The Linville type is underlain by highly acidic bedrock and has less fertile soils (pH of 3.65; Chapter 3) than the Joyce Kilmer types (Table 5.7). Low soil fertility and possibly lower rainfall levels at Linville Gorge might account for this. The higher elevational distribution of the two Shining Rock types (994 and 1394 m; Table 4.34) might explain lower species richness in this Wilderness (Newell & Peet *unpub. data*).

Subtle differences in site moisture and topographic position separate types in the **Acidic Cove and Slope Forests** herbaceous-subclass. Within this subclass the ***Tsuga canadensis-Liriodendron/Mitchella sub-type*** inhabits the most fertile, lower-slope and cove sites. In Little Santeetlah this subtype occurs on topographic positions similar to the **Tsuga-Halesia/Laportea Forest** in the **Rich Cove and Slope Forests** class. The former type, however, extends further up-slope reflecting its inhabitance of typically dryer sites. The past (co) dominance of chestnut in the ***Tsuga canadensis-Liriodendron/Mitchella sub-type*** (Braun 1950, Lorimer 1976) suggests that there were greater compositional differences between these two groups in the past. The ***Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type*** inhabits fertile, rocky toeslopes and lower-slopes in Little Santeetlah and Slickrock, whereas the **Liriodendron-Betula lenta/Polystichum Forest** occurs on dryer, less fertile lower-slopes in Slickrock. In contrast, the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest** is situated on mid- and lower-slopes in both major watersheds. This type also inhabits upper-slopes in the upper-section of the Slickrock valley in association with the **Tsuga canadensis-Magnolia fraseri Forest** present on dryer sites. The contrasting site conditions of these two types are reflected by differences in composition. The presence of a lush herbaceous layer in the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest**, including species such as *Laportea*, contrasts with the dry **Tsuga canadensis-Magnolia fraseri Forest** that has a sparsely scattered herbaceous layer. The presence of *Quercus rubra* and *Gaylussacia ursina* also reflects the dryer conditions of the latter type.

Descriptions from past Southern Appalachian Mountain studies indicate that herbaceous-dominated *Tsuga* forests are restricted to the Great Smoky Mountains and the

Joyce Kilmer area (see Oosting & Bourdeau 1955, Whittaker 1956, Golden 1974, Lorimer 1976), although Oosting & Billings (1939) described *Tsuga* forests dominated by *Vaccinium stamineum*, *Mitchella repens* and *Dryopteris intermedia* formerly present near Highlands, Macon County, NC (subsequently logged). In comparison to all previous accounts of herbaceous-dominated *Tsuga* forests, Golden's (1974, 1981) Silverbell-Hemlock forest has closest affinities with the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest**. Both types inhabit mid- and lower-slopes and are dominated by *Dryopteris intermedia*, *Laportea canadensis*, *Mitchella repens*, *Aster divaricatus* and *Tiarella cordifolia*.

The **Acidic Cove and Slope Forests** class typically inhabits infertile coves and slopes and has soils with similar average fertility to those in the **Xeric Evergreen Forests** class, but less fertile conditions than types in the **Montane Oak Forests** and the **Rich Cove and Slope Forests** classes. The soils of the **Tsuga canadensis-Magnolia fraseri Forest** and the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest** are less fertile than other **Acidic Cove and Slope Forests** types. The pH and base saturation levels are lower than values in the *Tsuga canadensis-Rhododendron maximum* dominated types (Table 4.4), that are generally considered very infertile due to slow decomposition of abundant evergreen leaf litter (Clinton & Vose 1996). However, although Oosting & Bourdeau (1955) found different soil structure for the Hemlock-*Rhododendron* forests and Hemlock-herb forests, soils in these two types had similar fertility, water holding capacity and organic content. The higher-elevation distribution of the **Tsuga canadensis-Magnolia fraseri Forest** and the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest** might account for lower soil pH and percent base saturation levels in comparison to other **Acidic Cove and Slope Forests** types. Slow decomposition rates at higher elevations might impede nutrient availability. Nutrients may also leach down-slope from these mid- and upper-slope positions. Oosting & Bourdeau (1955) suggested that soils in herbaceous *Tsuga* stands were better drained than the *Rhododendron* stands, which they related to the higher topographic position of the former. This, however, does not account for the presence of species-rich **Tsuga-Halesia/Laportea Forest** in the **Rich Cove and Slope Forests** class on toeslopes adjacent to similar slope positions dominated by the **Tsuga canadensis/ Rhododendron maximum Forest**.

Three of the community types in the **Acidic Cove and Slope Forests** class (the **Acer rubrum/Rhododendron maximum Forest**, the **Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest**, the **Tsuga canadensis-Liriodendron/Thelypteris Forest**) have closer compositional affinities with the **Montane Oak Forests** (see Figures 5.6, 5.13) than other **Acidic Cove and Slope Forests** types. The dryer conditions of the three former types partly accounts for closer florisitic association with the **Montane Oak Forests**. Moreover, it is possible that prior to broad-scale disturbances associated with logging, chestnut death and subsequent fire suppression, these **Acidic Cove and Slope Forests** types were closely allied with the **Montane Oak Forests**. Prior to logging and cessation of low-intensity ground fires sites in the **Acer rubrum/Rhododendron maximum Forest** most likely were inhabited by forests resembling the **Montane Oak Forests**. The **Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest** has also been disturbed by logging, but the composition of the former canopy in uncertain. In contrast, evidence indicates that chestnut was formerly at least codominant in the **Tsuga canadensis-Liriodendron/Thelypteris Forest** which would account for its close ties with the **Montane Oak Forests** class. The inclusion of these four community types in the **Acidic Cove and Slope Forests** class was based on the present dominance of species characteristic of this class, most importantly *Rhododendron maximum* and *Tsuga canadensis*.

Table 5.36. Average cover class and constancy of species present in the **Acidic Cove and Slope Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type and sub-type. Each group is represented by its abbreviation code. For full group names see Table 5. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	8.	8.1	8.2	8.3	8.3.1	8.3.2	8.4	8.5	8.5.1	8.5.2	8.6	8.7
Number of plots:	47	7	5	12	5	7	8	6	3	3	4	5
Homoteneity:	0.557	0.706	0.653	0.673	0.725	0.718	0.752	0.718	0.826	0.719	0.721	0.640
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species												
ACER PENSYLVANICUM	3 94	3 86	2 100	3 92	4 80	2 100	4 100	4 100	6 100	2 100	2 75	1 100
ACER RUBRUM VAE RUBRUM	4 96	6 100	5 100	5 100	5 100	5 100	2 88	4 100	4 100	3 100	5 100	1 80
ACER SACCHARUM VAR SACCHARUM	3 53		3 40	3 75	3 60	2 86	4 100	1 83	2 67	1 100		4 20
ACER SPICATUM	2 2											2 20
ACTAEA PACHYPODA	2 13			2 25		2 43	2 25	1 17		1 33		
ADIANTUM PEDATUM VAR PEDATUM	2 6			2 25		2 43						
AESCULUS FLAVA	2 30			2 25		2 43	2 75	2 33	1 33	2 33	2 25	4 40
AGERATINA ALTISSIMA VAR ROANENSIS	1 19		1 40	1 25		1 43	1 25	2 17		2 33		1 20
AGROSTIS PERENNANS	2 4			2 8		2 14		1 17		1 33		
AMELANCHIER ARBOREA	2 38	2 57	1 20	2 67	2 80	2 57	2 25	3 33		3 67		1 20
AMIANTHIUM MUSCAETOXICUM	1 4			1 17	1 20	1 14						
AMPHICARPAEA BRACTEATA	2 9			2 33		2 57						
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	2 6		2 40	1 8		1 14						
ANEMONELLA THALICTROIDES	2 6			2 25		2 43						
ANGELICA TRIQUINATA	1 2			1 8		1 14						
AQUILEGIA CANADENSIS	1 2			1 8		1 14						
ARALIA RACEMOSA VAR RACEMOSA	2 4			2 17	2 20	2 14						
ARALIA SPINOSA	1 2			1 8		1 14						
ARISTOLOCHIA MACROPHYLLA	2 49		1 40	1 67	1 60	1 71	2 63	1 67	1 100	1 33	3 50	2 40
ARISAEMA TRIPHYLLUM SSP QUINATUM	1 2											1 20
ARISAEMA TRIPHYLLUM VAR TRIPHYLLUM	1 66	1 29	2 40	1 75	1 60	1 86	1 100	1 67	1 67	1 67	2 50	1 80
ARUNCUS DIOICUS VAR DIOICUS	2 2			2 8	2 20							
ASCLEPIAS EXALTATA	1 2			1 8		1 14						

Group:	8.	8.1	8.2	8.3	8.3.1	8.3.2	8.4	8.5	8.5.1	8.5.2	8.6	8.7
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
ASIMINA TRILOBA	3 4		2 20	3 8		3 14						
ASTER CHLOROLEPIS	2 2						2 13					
ASTER DIVARICATUS	2 66		2 80	2 83	1 60	2 100	2 88	2 100	2 100	2 100	1 25	1 60
ASTER MACROPHYLLUS	1 4			1 17	1 20	1 14						
ASTER RETROFLEXUS	1 2			1 8		1 14						
ASTER UNDULATUS	1 2							1 17		1 33		
ATHYRIUM ASPLENIOIDES	1 57	1 57	1 20	2 100	2 100	2 100	2 50	1 50	1 67	1 33	1 25	2 40
AUREOLARIA LAEVIGATA	1 2			1 8	1 20							
BETULA ALLEGHANIENSIS	4 43	5 29	1 20	3 42	3 40	2 43	2 38	3 17		3 33	4 75	6 100
BETULA LENTA	4 94	6 86	6 100	5 100	5 100	5 100	4 100	3 100	2 100	3 100	3 100	3 60
BIGNONIA CAPREOLATA	2 6		2 40	2 8		2 14						
BOTRYCHIUM VIRGINIANUM	1 19		1 20	1 58	1 60	1 57						1 20
BRACHYELYTRUM ERECTUM	1 17		1 20	1 42		1 71	1 13	1 17	1 33			
BRACHYELYTRUM SEPTENTRIONALE	2 6						2 38					
CALYCANTHUS FLORIDUS VAR GLAUCUS	2 26	2 43		2 58	2 60	2 57	1 13	3 17	3 33			
CAMPANULA DIVARICATA	1 9	1 14		1 8	1 20			1 33	1 33	1 33		
CARDAMINE DIPHYLLA	1 19	1 14	1 40	1 25		1 43						1 60
CAREX AESTIVALIS	1 11						2 13	1 67	1 100	1 33		
CAREX APPALACHICA	1 4			1 17		1 29						
CAREX AUSTROCAROLINIANA	1 2		1 20									
CAREX BLANDA	1 2			1 8	1 20							
CAREX CEPHALOPHORA	1 2			1 8		1 14						
CAREX DIGITALIS	1 26		1 40	1 67	1 60	1 71	2 13	1 17	1 33			
CAREX FLEXUOSA	1 4			1 17		1 29						
CAREX LUCORUM VAR AUSTROLUCORUM*	3 11	2 14	6 20	1 17	1 20	1 14		3 17		3 33		
CAREX LURIDA	1 2			1 8		1 14						
CAREX LAXIFLORA VAR LAXIFLORA	1 6			1 8		1 14	2 13					1 20
CAREX MANHARTII*	1 9		1 20	2 8		2 14	1 13	1 17	1 33			
CAREX NIGROMARGINATA	1 13		2 20	1 42	1 20	1 57						
CAREX PENSYLVANICA	2 21		1 20	1 17	1 20	1 14	2 38	2 67	2 67	2 67		
CAREX PLATYPHYLLA	2 4		1 20	2 8		2 14						
CAREX RUTHII*	1 2			1 8		1 14						
CAREX SWANII	1 9		1 20	1 17	1 20	1 14		1 17	1 33			
CAREX UMBELLATA	1 2			1 8		1 14						
CAREX VIRESCENS	1 6			1 25		1 43						
CARPINUS CAROLINIANA	5 2		5 20									
CARYA ALBA	2 21		1 20	3 58	3 60	3 57	1 13					1 20
CARYA CORDIFORMIS	2 13		1 20	5 17		5 29	1 13	1 17	1 33		1 25	
CARYA GLABRA	2 34	3 29	4 80	2 75	3 80	1 71		1 17	1 33			
CARYA OVATA	3 11		4 20	3 33	3 40	3 29						

Group:	8.	8.1	8.2	8.3	8.3.1	8.3.2	8.4	8.5	8.5.1	8.5.2	8.6	8.7
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
CASTANEA DENTATA	2 19			2 58	3 80	1 43		2 33	2 33	1 33		
CAULOPHYLLUM THALICTROIDES	1 9			1 8		1 14	1 38					
CERCIS CANADENSIS VAR CANADENSIS	1 2			1 8		1 14						
CHAMAELIRIUM LUTEUM	1 6	1 14		1 8		1 14		1 17		1 33		
CHELONE GLABRA	1 2											1 20
CHIMAPHILA MACULATA VAR MACULATA	1 38	1 71	2 40	1 75	1 40	1 100						1 40
CIMICIFUGA RACEMOSA	2 17	1 14		1 25	1 40	1 14	2 38					2 20
CLADRASTIS KENTUKEA	1 2										1 25	
CLETHRA ACUMINATA	2 13	1 43		3 17	3 40						1 25	
CLINTONIA UMBELLULATA	2 21	1 14		2 42	2 80	1 14	2 13	2 33	1 33	2 33	1 25	
COLLINSONIA CANADENSIS	1 13			1 50	1 40	1 57						
CORNUS ALTERNIFOLIA	1 15			1 42	2 40	1 43	1 13				2 25	
CORNUS FLORIDA	3 36	2 43	2 80	4 75	3 40	4 100						1 20
CYMOPHYLLUS FRASERI	2 15		2 20				2 25	1 33	1 67			2 40
CYPRIPEDIUM ACAULE	1 2							1 17		1 33		
CYPRIPEDIUM PARVIFLORUM VAR PUBESCENS	1 2			1 8	1 20							
CYSTOPTERIS PROTRUSA	1 2						1 13					
DENNSTAEDTIA PUNCTILOBULA	2 15	2 29	2 40	2 17	2 40			2 17		2 33		
DESMODIUM GLUTINOSUM	1 2			1 8		1 14						
DESMODIUM NUDIFLORUM	2 21	1 14		2 75	2 80	1 71						
DICHANTHELIUM BOSCII	1 11		1 20	1 25	1 20	1 29		1 17		1 33		
DIOSCOREA QUATERNATA	1 40	1 14	2 40	1 92	2 100	1 86	2 25	1 50	1 33	2 67		
DRYOPTERIS INTERMEDIA	3 49		1 20	3 25	3 60		4 100	2 67	2 100	3 33	2 100	3 60
DRYOPTERIS MARGINALIS	2 11		2 20	4 8		4 14	2 25	2 17	2 33			
EPIFAGUS VIRGINIANA	1 4		1 40									
ERIGERON PULCHELLUS VAR PULCHELLUS	1 4			1 17	1 20	1 14						
EUONYMUS AMERICANA	2 47	1 43	2 100	2 83	2 80	2 86	2 13	1 17	1 33			2 40
EVONYMUS OBOVATA	2 2											2 20
EUPATORIUM PURPUREUM VAR PURPUREUM	1 30			1 83	2 80	1 86	1 13	1 50	1 33	1 67		
EVONYMUS AMERICANA	2 2			2 8		2 14						
FAGUS GRANDIFOLIA	3 57	4 14	6 80	3 92	3 100	2 86	2 25	4 83	2 67	6 100	2 25	3 60
FRAXINUS AMERICANA	3 47	1 14	3 40	3 67	1 40	3 86	3 50	1 50	1 67	1 33	1 25	5 60
GALAX URCEOLATA	2 28	2 100	3 40	1 25	2 40	1 14		2 17	2 33			
GALEARIS SPECTABILIS	1 6			1 17	1 20	1 14						1 20
GALIUM APARINE	1 2			1 8		1 14						

Group:	8.	8.1	8.2	8.3	8.3.1	8.3.2	8.4	8.5	8.5.1	8.5.2	8.6	8.7
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
GALIUM CIRCAEZANS VAR CIRCAEZANS	1 13		1 20	1 42	1 20	1 57						
GALIUM LANCEOLATUM	1 2						1 13					
GALIUM LATIFOLIUM	1 15		1 20	1 25	1 20	2 29	2 13	1 33	1 33	1 33		
GALIUM TRIFLORUM	1 15		1 20	2 25	1 20	2 29	1 13					1 40
GAYLUSSACIA URSINA	3 47	4 86	4 40	3 58	3 100	4 29	2 13	2 83	2 67	2 100	2 25	
GENTIANA DECORA	2 4			1 8	1 20			2 17		2 33		
GERANIUM MACULATUM	1 9			1 33		1 57						
GOODYERA PUBESCENS	1 62	1 71	1 100	1 100	2 100	1 100	1 38	2 33	2 33	1 33		1 40
HALESIA TETRAPTERA VAR MONTICOLA	4 85	2 43	3 80	3 100	3 100	3 100	7 100	6 100	6 100	6 100	5 100	1 60
HAMAMELIS VIRGINIANA	3 26	4 29	1 20	3 50	6 20	3 71	2 13	1 17	1 33			2 20
HEPATICA ACUTILOBA	2 9		2 40	2 8		2 14	2 13					
HEUCHERA AMERICANA	1 2			1 8		1 14						
HEUCHERA VILLOSA VAR VILLOSA	2 4						2 13					1 20
HEXASTYLIS ARIFOLIA	2 2	2 14										
HIERACIUM PANICULATUM	2 2			2 8	2 20							
HOUSTONIA CAERULEA	1 2			1 8		1 14						
HOUSTONIA PURPUREA VAR PURPUREA	1 21	1 14		1 58	1 20	1 86		1 33	1 33	1 33		
HUPERZIA LUCIDULA	1 32			1 42	1 60	1 29	2 50	1 33		1 67	2 25	2 60
HYDRANGEA ARBORESCENS	2 30	1 14		2 58	2 60	2 57	2 38				1 75	
ILEX MONTANA	2 40	1 57		2 33	3 40	2 29	1 50	5 33		5 67	1 50	2 60
ILEX OPACA VAR OPACA	3 43	2 43	5 60	2 50	2 20	2 71	2 38	4 33	6 33	2 33		2 60
IMPATIENS CAPENSIS	1 2			1 8		1 14						
IRIS CRISTATA	2 21		2 60	1 42	2 40	1 43		3 17		3 33		2 20
IRIS VERNA	1 2			1 8		1 14						
JUGLANS CINEREA	1 2			1 8		1 14						
JUNCUS GYMNOCARPUS*	1 2			1 8		1 14						
KALMIA LATIFOLIA	2 28	3 86		2 50	2 60	2 43						1 20
LAPORTEA CANADENSIS	2 38		1 20	2 33		2 57	2 88				1 25	1 100
LEUCOTHOE FONTANESIANA	4 28	2 57	6 60	6 8		6 14	1 13				6 50	4 40
LINDERA BENZOIN	2 9			2 17		2 29	1 13					2 20
LIPARIS LILIIFOLIA	1 4			1 17		1 29						
LIQUIDAMBAR STYRACIFLUA	5 6	4 14	5 40									
LIRIODENDRON TULIPIFERA	4 77	2 86	6 100	5 92	6 100	5 86	2 63	4 67	5 100	1 33	7 25	5 80
LISTERA SMALLII	1 2											1 20
LUZULA ACUMINATA	1 9			1 17		1 29	1 13	1 17	1 33			
LUZULA MULTIFLORA VAR CONGESTA	1 9			1 33		1 57						
LYSIMACHIA QUADRIFOLIA	1 21	2 29	1 20	1 42	2 40	1 43		2 33		2 67		
MAGNOLIA ACUMINATA	3 32	2 14		4 42	4 60	4 29	3 50	3 50		3 100	6 25	1 20
MAGNOLIA FRASERI	4 66	2 86		2 58	1 60	2 57	5 88	6 100	7 100	6 100	5 100	2 20

Group:	8.	8.1	8.2	8.3	8.3.1	8.3.2	8.4	8.5	8.5.1	8.5.2	8.6	8.7
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
MAGNOLIA TRIPETALA	2 2	2 14										
MAIANTHEMUM RACEMOSUM	1 40		2 40	1 92	2 80	1 100	2 25	1 50	1 33	1 67		1 20
MEDEOLA VIRGINIANA	2 81	1 71	2 60	1 83	2 80	1 86	2 100	2 100	2 100	2 100	1 100	1 40
MELAMPYRUM LINEARE	1 2			1 8		1 14						
MELANTHIUM PARVIFLORUM	1 19	2 14		2 33	2 60	1 14	1 25	1 33	1 33	1 33		
MITCHELLA REPENS	2 77	1 43	2 100	3 75	4 100	2 57	3 100	2 100	2 100	3 100	2 50	1 60
MONARDA CLINOPODIA	2 4			2 17		2 29						
MONARDA DIDYMA	1 4			1 17		1 29						
MONOTROPA UNIFLORA	1 26	2 29		1 42	1 60	1 29	1 38				2 50	
NYSSA SYLVATICA	2 32	3 71	1 20	2 67	3 60	2 71						1 20
ORCHIDACEAE SPECIES #1	1 2			1 8	1 20							
OSMORHIZA CLAYTONII	1 9			1 17		1 29		1 17		1 33		1 20
OSMUNDA CINNAMOMEA VAR CINNAMOMEA	1 11			1 42	2 20	1 57						
OSTRYA VIRGINIANA VAR VIRGINIANA	2 6			2 25	2 20	2 29						
OXALIS MONTANA	2 13			1 8		1 14	2 25					3 60
OXALIS STRICTA	2 2										2 25	
OXYDENDRUM ARBOREUM	4 55	5 100	4 60	4 83	3 80	4 86	2 25	4 50	4 100		6 25	
OXYPOLIS RIGIDIOR	1 2			1 8		1 14						
PANAX QUINQUEFOLIUS*	1 15			1 42	1 40	1 43	1 13	1 17		1 33		
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	2 30		2 40	2 67	1 40	3 86	1 13				2 50	1 20
PASSIFLORA LUTEA	1 2			1 8		1 14						
PHACELIA BIPINNATIFIDA	2 2			2 8		2 14						
PHEGOPTERIS HEXAGONOPTERA	1 13			1 50	1 20	1 71						
PHRYMA LEPTOSTACHYA	1 2			1 8		1 14						
PINUS RIGIDA	4 2	4 14										
PINUS STROBUS	2 26	3 71	3 60	2 33		2 57						
PLATANTHERA CLAVELLATA	1 2	1 14										
POA COMPRESSA	1 15			1 42		1 71	2 25					
POA CUSPIDATA	1 2			1 8		1 14						
PODOPHYLLUM PELTATUM	1 2			1 8		1 14						
POLYGONATUM BIFLORUM VAR BIFLORUM	1 62	1 29	1 60	1 100	1 100	1 100	1 88	2 33	1 33	2 33		1 60
POLYGONATUM PUBESCENS	1 2		1 20									
POLYGONUM VIRGINIANUM	1 2			1 8		1 14						
POLYPODIUM APPALACHIANUM	1 6						1 25					1 20
POLYPODIUM VIRGINIANUM	1 6		1 20	2 8	2 20							1 20
POLYSTICHUM ACROSTICHOIDES	2 74	2 57	3 80	2 100	2 100	2 100	3 75	2 83	2 100	1 67	1 50	2 40

Group:	8.	8.1	8.2	8.3	8.3.1	8.3.2	8.4	8.5	8.5.1	8.5.2	8.6	8.7
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
POTENTILLA CANADENSIS VAR CANADENSIS	2 4			2 17		2 29						
PRENANTHES SP. #1	2 57	1 14	1 60	2 75	2 60	2 86	2 88	2 83	2 100	2 67	1 25	1 20
PROSARTES LANUGINOSA	1 38	1 14	1 20	1 67	2 80	1 57	2 75	1 17		1 33	1 25	
PRUNUS PENSYLVANICA	1 36	1 14	1 20	2 17	2 40		2 75	1 100	1 100	1 100	1 25	
PRUNUS SEROTINA	3 11	1 14	6 20	2 8		2 14	3 25					
PYRULARIA PUBERA	2 40	2 71	1 20	2 75	2 100	2 57	2 13	2 17		2 33	2 25	1 20
QUERCUS ALBA	3 19	7 29	4 40	2 42	5 20	1 57						
QUERCUS COCCINEA VAR COCCINEA	5 13	5 57		3 17	1 20	5 14						
QUERCUS MONTANA	4 28	6 57	1 20	4 50	3 80	6 29		2 17	2 33			1 20
QUERCUS RUBRA	3 83	4 86	2 100	4 92	4 80	5 100	2 75	4 83	3 100	6 67	3 75	1 60
QUERCUS VELUTINA	2 21	2 29	3 40	3 42	1 40	4 43						1 20
RANUNCULUS HISPIDUS	2 6			2 25		2 43						
RHODODENDRON CALENDULACEUM	2 6			2 17	2 20	1 14		2 17		2 33		
RHODODENDRON MAXIMUM	4 81	6 100	3 80	2 58	3 80	2 43	3 75	3 83	5 100	1 67	8 100	7 100
RHODODENDRON MINUS	5 4	6 14	3 20									
ROBINIA PSEUDOACACIA	2 28	3 43		2 33	3 40	2 29	1 13	2 67	2 100	3 33	3 25	
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	2 6			2 17		2 29						2 20
RUBUS ARGUTUS	2 9			1 8		1 14		1 17		1 33	1 25	5 20
RUBUS CANADENSIS	2 53	2 29	2 40	1 42	2 40	1 43	2 100	2 67	2 100	2 33	2 50	1 40
RUBUS ODORATUS VAR ODORATUS	2 2			2 8		2 14						
SAMBUCUS RACEMOSA VAR PUBENS	2 2											2 20
SANICULA CANADENSIS VAR CANADENSIS	1 9		1 20	1 25		1 43						
SASSAFRAS ALBIDUM	3 45	3 86	1 60	3 50	1 40	4 57	1 13	5 67	6 100	1 33	2 25	
SCUTELLARIA ELLIPTICA VAR ELLIPTICA	1 6		2 20	1 17	1 20	1 14						
SEDUM TERNATUM	2 2			2 8		2 14						
SILENE STELLATA	1 2							1 17	1 33			
SILENE VIRGINICA VAR VIRGINICA	1 2			1 8		1 14						
SMILAX GLAUCA VAR GLAUCA	1 53	1 86	2 100	1 75	1 60	1 86	1 13	1 17	1 33		1 25	1 40
SMILAX HERBACEA	1 2							1 17		1 33		
SMILAX ROTUNDIFOLIA	2 98	2 100	2 100	2 100	2 100	2 100	2 100	2 100	3 100	2 100	2 100	1 80
SOLIDAGO ARGUTA SSP CAROLINIANA	1 11			1 25	1 20	1 29		2 33		2 67		
SOLIDAGO CURTISII	2 57	1 14	1 60	1 67	1 60	1 71	2 100	2 100	1 100	2 100		2 20
SOLIDAGO ERECTA	1 2			1 8	1 20							
SOLIDAGO SPECIOSA	2 2		2 20									
SORBUS AMERICANA	2 2											2 20
STELLARIA PUBERA	1 43	1 14	2 40	1 50		1 86	2 88	1 17	1 33			1 60

Group:	8.	8.1	8.2	8.3	8.3.1	8.3.2	8.4	8.5	8.5.1	8.5.2	8.6	8.7
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
STEWARTIA OVATA*	2 4		2 40									
THALICTRUM CLAVATUM	1 2			1 8	1 20							
THALICTRUM CORIACEUM	1 4			1 17		1 29						
THASPIUM TRIFOLIATUM VAR TRIFOLIATUM	1 2			1 8		1 14						
THELYPTERIS NOVEBORACENSIS	2 57	2 57	4 60	3 92	3 100	2 86	2 50	3 50	3 67	2 33	1 25	1 20
TIARELLA CORDIFOLIA VAR CORDIFOLIA	2 40		2 40	2 33		2 57	2 100				1 25	2 80
TILIA AMERICANA VAR HETEROPHYLLA	3 51		3 60	3 100	2 100	4 100	5 25	1 17		1 33	2 50	5 80
TIPULARIA DISCOLOR	1 4		1 40									
TOXICODENDRON RADICANS	2 15		1 40	2 42		2 71						
TRILLIUM CUNEATUM	2 2			2 8		2 14						
TRILLIUM ERECTUM	1 19			1 25	1 40	1 14	1 50					1 40
TRILLIUM LUTEUM	1 9			1 33		1 57						
TRILLIUM UNDULATUM	1 36	1 43	2 60	1 42	1 40	1 43	1 25	1 33	1 33	1 33	1 25	2 20
TRILLIUM VASEYI	1 13			1 50	1 20	1 71						
TSUGA CANADENSIS	6 100	5 100	6 100	6 100	7 100	6 100	7 100	6 100	5 100	7 100	6 100	7 100
UVULARIA PERFOLIATA	1 21		1 40	1 67	2 40	1 86						
UVULARIA PUBERULA	1 4		1 40									
VACCINIUM ERYTHROCARPUM	2 9						1 13	2 50		2 100		
VACCINIUM PALLIDUM	2 13	1 14		2 8	2 20		1 13	2 50	1 33	2 67		
VACCINIUM SIMULATUM	2 11	1 14		2 17	2 20	2 14		2 33		2 67		
VACCINIUM STAMINEUM	1 4		1 20					1 17		1 33		
VIBURNUM ACERIFOLIUM	2 28		2 20	2 75	2 60	2 86	2 25	2 17		2 33		
VIOLA BLANDA	2 53	1 14	2 40	2 50	4 40	2 57	3 100	2 50	2 100		2 50	2 60
VIOLA CANADENSIS VAR CANADENSIS	1 9		2 40	1 17		1 29						
VIOLA HASTATA	1 72	1 57	1 100	2 83	2 80	1 86	2 88	2 83	2 100	2 67	1 25	1 40
VIOLA PALMATA VAR PALMATA	1 11			1 42	1 20	1 57						
VIOLA ROTUNDIFOLIA	2 51	2 29	1 20	2 33	2 60	1 14	2 88	2 83	2 100	2 67	1 100	1 20
VIOLA SORORIA	1 9			1 25	1 40	1 14	1 13					
VIOLA STRIATA	2 2			2 8		2 14						
VITIS AESTIVALIS VAR AESTIVALIS	2 23	2 14	4 20	2 42	1 20	3 57	2 25					2 40
VITIS AESTIVALIS VAR BICOLOR	2 4		2 20				1 13					
VITIS CINEREA VAR BAILEYANA	2 11		1 20	2 25	2 40	2 14					3 25	
VITIS ROTUNDIFOLIA	2 6		3 40	2 8		2 14						
VITIS VULPINA	3 19	2 14		1 25	1 20	2 29	4 13	4 50	4 100			1 20
ZIZIA TRIFOLIATA	1 4			1 17		1 29						

Table 5.37. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Acidic Cove and Slope Forests** vegetation class and associated community types and sub-types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

8. Acidic Cove and Slope Forests

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	9.54	79.59	5.41	94.54	3.23	2.89	8.56	5.72
BETULA LENTA	0.64	48.69	3.99	53.32	2.58	1.82	6.46	4.14
HALESIA TETRAPTERA VAR MONTICOLA	58.32	36.84	7.70	102.85	2.85	4.26	6.18	5.22
LIRIODENDRON TULIPIFERA	2.06	29.33	10.59	41.97	4.49	1.62	10.83	6.23
RHODODENDRON MAXIMUM	677.33	789.28	0.00	1466.61	2.37	24.94	5.23	15.08
TSUGA CANADENSIS	190.85	432.80	28.46	652.11	14.54	24.85	27.06	25.95
ALL	1917.62	1858.87	85.28	3861.77	43.72	99.92	100.00	99.96

8.1 Acer rubrum/Rhododendron maximum Forest

SCINAME	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	9.52	225.71	2.86	238.10	3.86	5.37	11.88	8.62
GAYLUSSACIA URSINA	948.10	0.00	0.00	948.10	0.02	10.60	0.06	5.33
QUERCUS MONTANA	0.00	70.00	10.00	80.00	3.64	1.32	8.92	5.12
RHODODENDRON MAXIMUM	801.67	1860.00	0.00	2661.67	6.14	43.20	15.91	29.56
TSUGA CANADENSIS	229.52	510.95	4.29	744.76	4.25	17.47	11.61	14.54
ALL	2465.95	3371.91	52.86	5890.71	34.99	100.00	100.00	100.00

8.2 Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	2.00	106.00	2.00	110.00	2.69	4.41	6.76	5.58
BETULA LENTA	0.00	80.00	8.00	88.00	4.59	3.73	10.48	7.10
ILEX OPACA VAR OPACA	44.00	114.00	0.00	158.00	0.33	8.28	0.79	4.54
LEUCOTHOE FONTANESIANA	310.00	0.00	0.00	310.00	0.01	10.80	0.02	5.41
LIRIODENDRON TULIPIFERA	0.00	84.00	34.00	118.00	12.43	5.27	30.37	17.82
RHODODENDRON MAXIMUM	256.00	422.00	0.00	678.00	1.69	13.08	4.95	9.02
TSUGA CANADENSIS	238.00	370.00	20.00	628.00	7.63	27.62	16.98	22.30
ALL	1168.00	1530.00	88.00	2786.00	40.49	100.01	99.99	99.99

8.3 Tsuga canadensis-Liriodendron/Thelypteris Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	22.22	92.50	5.14	119.86	3.46	4.68	11.39	8.04
BETULA LENTA	1.67	70.21	1.04	72.92	2.36	2.66	8.23	5.44
LIRIODENDRON TULIPIFERA	7.22	51.67	10.76	69.65	4.76	2.95	13.84	8.40
QUERCUS RUBRA	7.50	28.06	6.67	42.22	2.89	1.59	9.74	5.67
TSUGA CANADENSIS	291.46	653.26	21.04	965.76	10.42	40.72	24.94	32.83
ALL	1319.86	1342.50	62.50	2724.86	33.06	99.71	100.00	99.85

8.3.1 Tsuga canadensis-Liriodendron/Mitchella sub-type

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	9.33	56.00	10.33	75.67	4.66	2.61	12.62	7.61
BETULA LENTA	4.00	80.50	2.50	87.00	3.23	2.84	10.32	6.59
GAYLUSSACIA URSINA	526.67	0.00	0.00	526.67	0.01	10.30	0.04	5.17
LIRIODENDRON TULIPIFERA	11.33	34.00	9.83	55.17	5.47	2.41	12.93	7.67
PYRULARIA PUBERA	299.33	2.50	0.00	301.83	0.02	8.46	0.08	4.27
TSUGA CANADENSIS	259.50	625.83	44.50	929.83	17.35	45.67	35.62	40.64
ALL	1673.67	1138.00	86.00	2897.67	39.95	99.30	100.00	99.66

8.3.2 Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	31.43	118.57	1.43	151.43	2.61	6.16	10.52	8.34
BETULA LENTA	0.00	62.86	0.00	62.86	1.75	2.52	6.74	4.63
CORNUS FLORIDA	60.00	161.43	0.00	221.43	0.69	8.93	2.77	5.85
LIRIODENDRON TULIPIFERA	4.29	64.29	11.43	80.00	4.24	3.34	14.50	8.92
QUERCUS RUBRA	4.29	37.14	11.43	52.86	4.51	2.14	15.35	8.74
TSUGA CANADENSIS	314.29	672.86	4.29	991.43	5.47	37.18	17.31	27.25
ALL	1067.14	1488.57	45.71	2601.43	28.13	100.00	99.99	99.99

8.4 Tsuga canadensis-Halesia/Dryopteris intermedia Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	533.54	69.69	0.00	603.23	0.25	28.35	0.58	14.47
HALESIA TETRAPTERA VAR MONTICOLA	118.54	61.04	36.46	216.04	11.35	12.28	22.55	17.41
MAGNOLIA FRASERI	62.19	46.98	5.21	114.38	2.95	5.27	6.33	5.80
RHODODENDRON MAXIMUM	75.52	85.00	0.00	160.52	0.24	7.93	0.35	4.14
TSUGA CANADENSIS	57.92	334.17	37.19	429.27	22.11	25.50	40.98	33.24
ALL	1059.27	744.37	121.67	1925.31	51.91	100.01	100.00	100.01

8.5 Tsuga canadensis-Magnolia fraseri Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	224.17	97.08	0.00	321.25	0.37	10.48	1.10	5.79
ACER RUBRUM VAR RUBRUM	5.00	44.58	9.58	59.17	3.43	1.46	9.49	5.47
FAGUS GRANDIFOLIA	717.08	152.92	1.67	871.67	2.40	13.89	6.07	9.98
HALESIA TETRAPTERA VAR MONTICOLA	96.25	101.67	11.67	209.58	4.85	5.67	11.93	8.80
LIRIODENDRON TULIPIFERA	0.00	1.67	9.17	10.83	3.90	0.37	9.28	4.83
MAGNOLIA FRASERI	108.75	142.50	1.67	252.92	4.06	7.21	10.48	8.84
SMILAX ROTUNDIFOLIA	576.25	0.00	0.00	576.25	0.01	14.49	0.03	7.26
TSUGA CANADENSIS	286.25	469.58	30.83	786.67	15.17	27.13	24.47	25.80
ALL	2296.67	1449.17	73.75	3819.58	45.30	100.01	100.00	100.00

8.5.1 Magnolia fraseri/Acer pensylvanicum sub-type

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	369.17	171.67	0.00	540.83	0.58	18.10	1.89	10.00
ACER RUBRUM VAR RUBRUM	6.67	30.83	10.83	48.33	2.49	1.62	6.60	4.11
BETULA LENTA	0.00	47.50	0.00	47.50	3.15	1.47	7.79	4.64
HALESIA TETRAPTERA VAR MONTICOLA	61.67	50.00	13.33	125.00	3.17	4.07	9.70	6.89
LIRIODENDRON TULIPIFERA	0.00	3.33	18.33	21.67	7.81	0.73	18.57	9.65
MAGNOLIA FRASERI	88.33	184.17	0.00	272.50	5.21	7.55	14.91	11.23
SASSAFRAS ALBIDUM	0.00	80.83	4.17	85.00	5.56	3.27	10.23	6.75
SMILAX ROTUNDIFOLIA	940.83	0.00	0.00	940.83	0.02	24.09	0.05	12.07
TSUGA CANADENSIS	205.83	308.33	20.83	535.00	9.13	20.71	14.68	17.70
ALL	1795.83	1380.83	74.17	3250.83	42.42	100.01	100.00	100.00

8.5.2 Tsuga canadensis-Fagus-Halesia sub-type

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
ACER RUBRUM VAR RUBRUM	3.33	58.33	8.33	70.00	4.38	1.30	12.37	6.84
FAGUS GRANDIFOLIA	1430.00	285.83	3.33	1719.17	4.73	27.17	11.93	19.55
HALESIA TETRAPTERA VAR MONTICOLA	130.83	153.33	10.00	294.17	6.53	7.26	14.17	10.72
ILEX MONTANA	191.67	141.67	0.00	333.33	0.63	8.91	1.51	5.21
MAGNOLIA FRASERI	129.17	100.83	3.33	233.33	2.90	6.86	6.05	6.45
QUERCUS RUBRA	4.17	16.67	4.17	25.00	2.77	0.46	7.83	4.15
TSUGA CANADENSIS	366.67	630.83	40.83	1038.33	21.22	33.55	34.25	33.90
ALL	2797.50	1517.50	73.33	4388.33	48.19	100.01	100.00	100.00

8.6 Tsuga canadensis/Rhododendron maximum Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
ACER RUBRUM VAR RUBRUM	18.75	51.88	9.38	80.00	5.94	1.70	12.01	6.85
QUERCUS RUBRA	0.00	0.00	15.63	15.63	3.09	0.33	7.81	4.07
RHODODENDRON MAXIMUM	1620.31	2560.94	0.00	4181.25	7.44	76.62	14.33	45.47
TILIA AMERICANA VAR HETEROPHYLLA	29.38	38.13	7.50	75.00	4.39	1.07	7.21	4.14
TSUGA CANADENSIS	40.00	177.50	40.63	258.13	18.35	5.41	31.10	18.26
ALL	2159.69	3130.94	100.63	5391.25	54.03	99.96	100.01	99.99

8.7 Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest

	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
SCINAME								
BETULA ALLEGHANIENSIS	52.00	104.00	22.00	178.00	7.49	2.96	13.93	8.45
LIRIODENDRON TULIPIFERA	2.00	31.00	10.00	43.00	7.36	0.98	12.06	6.52
RHODODENDRON MAXIMUM	3475.00	2070.00	0.00	5545.00	5.10	80.51	8.42	44.47
TILIA AMERICANA VAR HETEROPHYLLA	0.00	53.00	12.00	65.00	5.36	1.55	11.46	6.51
TSUGA CANADENSIS	67.00	175.00	62.00	304.00	29.80	6.10	41.43	23.76
ALL	4059.00	2566.00	126.00	6751.00	61.49	99.99	99.99	100.00

Table 5.38. Vertical structure of woody species in the **Acidic Cove and Slope Forests** vegetation class and associated community types and sub-types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

8. Acidic Cove and Slope Forests

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	1		
ACER RUBRUM VAR RUBRUM	1	1	2	2	
BETULA ALLEGHANIENSIS	1	1	1	1	
BETULA LENTA	1	1	2	3	
FAGUS GRANDIFOLIA	1	1	1	1	
HALESIA TETRAPTERA VAR MONTICOLA	1	1	2	2	
LIRIODENDRON TULIPIFERA	1	1	1	3	
MAGNOLIA FRASERI	1	1	1	1	
OXYDENDRUM ARBOREUM	1	1	1	1	
QUERCUS RUBRA	1	1	1	2	
RHODODENDRON MAXIMUM	1	3			
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	1	
TSUGA CANADENSIS	1	4	4	4	1

8.1 Acer rubrum/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
SCINAME					
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	4	4	
BETULA ALLEGHANIENSIS	1	1	1		
BETULA LENTA	1	1	3	3	
GAYLUSSACIA URSINA	1	1			
HAMAMELIS VIRGINIANA	1	1			
KALMIA LATIFOLIA	1	2			
OXYDENDRUM ARBOREUM	1	1	3	2	
PINUS STROBUS	1	1	1	1	
QUERCUS ALBA	1	1	1	2	
QUERCUS COCCINEA VAR COCCINEA	1	1	1	1	
QUERCUS MONTANA	1	1	2	2	
QUERCUS RUBRA	1	1	2	3	
RHODODENDRON MAXIMUM	1	5	1		
RHODODENDRON MINUS	1	1			
SASSAFRAS ALBIDUM	1	1	1		
TSUGA CANADENSIS	1	3	4	1	1

8.2 Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	3	4	
BETULA LENTA	1	1	2	5	1
CARPINUS CAROLINIANA	1	1	1		
CARYA GLABRA	1	1	1	2	
CARYA OVATA	1	1	1	1	
FAGUS GRANDIFOLIA	1	1	2	3	
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1		
LIRIODENDRON TULIPIFERA	1	1	3	6	1
OXYDENDRUM ARBOREUM	1	1	1	1	
PINUS STROBUS	1	1	1	1	1
PRUNUS SEROTINA	1	1	1	1	1
QUERCUS ALBA	1	1	1	1	
QUERCUS RUBRA	1	1	1	1	
QUERCUS VELUTINA	1	1	1	1	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	2	
TSUGA CANADENSIS	1	4	4	4	

8.3 Tsuga canadensis-Liriodendron/Thelypteris Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1		
ACER RUBRUM VAR RUBRUM	1	1	2	4	
BETULA LENTA	1	1	2	4	
CARYA ALBA	1	1	1		
CORNUS FLORIDA	1	1	2		
FAGUS GRANDIFOLIA	1	1			
GAYLUSSACIA URSINA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1	1	
HAMAMELIS VIRGINIANA	1	1	1		
LIRIODENDRON TULIPIFERA	1	1	1	4	
MAGNOLIA ACUMINATA	1	1	1	1	
OXYDENDRUM ARBOREUM	1	1	1	2	
PYRULARIA PUBERA	1	1			
QUERCUS MONTANA	1	1	1	1	
QUERCUS RUBRA	1	1	1	3	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	1	
TSUGA CANADENSIS	1	5	4	3	

8.3.1 Tsuga canadensis-Liriodendron/Mitchella sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	1		
ACER RUBRUM VAR RUBRUM	1	1	1	3	
BETULA LENTA	1	1	3	3	
CARYA ALBA	1	1	1	1	
CARYA GLABRA	1	1	1	1	
CARYA OVATA	1	1	1		
CASTANEA DENTATA	1	1			
GAYLUSSACIA URSINA	2	2			
HALESIA TETRAPTERA VAR					
MONTICOLA	1	1	1		
HAMAMELIS VIRGINIANA	1	1			
LIRIODENDRON TULIPIFERA	1	1	2	5	1
MAGNOLIA ACUMINATA	1	1	1	1	
NYSSA SYLVATICA	1	1	1	1	
OXYDENDRUM ARBOREUM	1	1	1	1	
PYRULARIA PUBERA	1	2			
QUERCUS ALBA	1	1	1	1	
QUERCUS MONTANA	1	1	1	1	
QUERCUS RUBRA	1	1	1	2	
RHODODENDRON MAXIMUM	1	1			
ROBINIA PSEUDOACACIA	1	1	1	1	
TILIA AMERICANA VAR					
HETEROPHYLLA	1	1			
TSUGA CANADENSIS	1	4	4	3	

8.3.2 Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	3	4	
BETULA LENTA	1	1	1	4	
CARYA CORDIFORMIS	1	1	1	1	
CORNUS FLORIDA	1	2	3	1	
FAGUS GRANDIFOLIA	1	1			
HALESIA TETRAPTERA VAR					
MONTICOLA	1	1	1	1	
HAMAMELIS VIRGINIANA	1	1	1		
LIRIODENDRON TULIPIFERA	1	1	1	3	
MAGNOLIA FRASERI	1	1	1	1	
OXYDENDRUM ARBOREUM	1	1	1	2	
QUERCUS MONTANA	1	1	1	1	
QUERCUS RUBRA	1	1	1	4	
QUERCUS VELUTINA	1	1	1	1	
TILIA AMERICANA VAR					
HETEROPHYLLA	1	1	1	2	
TSUGA CANADENSIS	1	5	3	3	

8.4 Tsuga canadensis-Halesia/Dryopteris intermedia Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	2	4	1		
ACER SACCHARUM VAR SACCHARUM	1	1	2	1	
BETULA LENTA	1	1	1	3	
HALESIA TETRAPTERA VAR MONTICOLA	2	2	5	6	
MAGNOLIA FRASERI	1	2	3	3	
RHODODENDRON MAXIMUM	1	1			
TSUGA CANADENSIS	1	3	5	6	1

8.5 Tsuga canadensis-Magnolia fraseri Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	3	1		
ACER RUBRUM VAR RUBRUM	1	1	2	1	
BETULA LENTA	1	1	1	2	
FAGUS GRANDIFOLIA	1	2	1	3	
HALESIA TETRAPTERA VAR MONTICOLA	1	2	3	5	
ILEX MONTANA	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	2	
MAGNOLIA FRASERI	1	2	4	5	
OXYDENDRUM ARBOREUM	1	1	1	1	
QUERCUS RUBRA	1	1	2	3	
RHODODENDRON MAXIMUM	1	2			
ROBINIA PSEUDOACACIA	1	1	1	1	
SASSAFRAS ALBIDUM	1	1	1	3	
SMILAX ROTUNDIFOLIA	1	2			
TSUGA CANADENSIS	1	5	4	4	
VITIS VULPINA	1	1	2	1	

8.5.1 Magnolia fraseri/Acer pensylvanicum sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	4	2		
ACER RUBRUM VAR RUBRUM	1	1	1	1	
ACER SACCHARUM VAR SACCHARUM	1	1			
BETULA LENTA	1	1	1	1	
CALYCANTHUS FLORIDUS VAR GLAUCUS	1				
CASTANEA DENTATA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	2	3	4	
LIRIODENDRON TULIPIFERA	1	1	2	3	
MAGNOLIA FRASERI	1	2	5	6	
OXYDENDRUM ARBOREUM	1	1	2	2	
QUERCUS RUBRA	1	1	1	2	
RHODODENDRON MAXIMUM	1	4			
ROBINIA PSEUDOACACIA	1	1	1	1	
SASSAFRAS ALBIDUM	1	1	2	6	
SMILAX ROTUNDIFOLIA	2	3			
TSUGA CANADENSIS	1	4	4	2	
VITIS VULPINA	1	1	3	2	

8.5.2 Tsuga canadensis-Fagus-Halesia sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2			
ACER RUBRUM VAR RUBRUM	1	1	2	2	
BETULA ALLEGHANIENSIS	1	1	1	1	
BETULA LENTA	1	1	1	2	
FAGUS GRANDIFOLIA	1	3	3	6	
HALESIA TETRAPTERA VAR MONTICOLA	1	1	3	5	
ILEX MONTANA	1	2			
MAGNOLIA ACUMINATA	1	1	1	1	
MAGNOLIA FRASERI	1	2	3	4	
PYRULARIA PUBERA	1	1			
QUERCUS RUBRA	1	1	2	3	
ROBINIA PSEUDOACACIA	1	1	1	1	
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	5	4	5	

8.6 Tsuga canadensis/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	3	2	
ARISTOLOCHIA MACROPHYLLA	1	1	1		
BETULA ALLEGHANIENSIS	1	1	3		
BETULA LENTA	1	1	2	3	
HALESIA TETRAPTERA VAR MONTICOLA	1	1	4	3	
LIRIODENDRON TULIPIFERA	1	1	1	2	
MAGNOLIA ACUMINATA	1	1	1	2	
MAGNOLIA FRASERI	1	1	3	1	
OXYDENDRUM ARBOREUM	1	1	1	1	
QUERCUS RUBRA	1	1	1	2	
RHODODENDRON MAXIMUM	4	8			
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	3	4	4	2

8.7 Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER SACCHARUM VAR SACCHARUM	1	1	1	1	
AESCULUS FLAVA	1	1	1	1	
BETULA ALLEGHANIENSIS	1	1	3	6	
BETULA LENTA	1	1	1	1	
FAGUS GRANDIFOLIA	1	1	1	1	
FRAXINUS AMERICANA	1	1	1	2	1
LIRIODENDRON TULIPIFERA	1	1	1	3	
RHODODENDRON MAXIMUM	2	8	1		
RUBUS ARGUTUS	1	1			
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	2	
TSUGA CANADENSIS	1	2	3	6	2

Table 5.39. Average site information for the **Acidic Cove and Slope Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**Q**=colluvium and alluvium, **4**=slate-metasandstone, **11**=arkosic metasandstone-metaconglomerate-metasiltstone), Landform types (representing micro-scale topographic units) (**C**=coves, **R**=ridges, **RF**=riverflats, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**LS**=lower slopes, **MS**=mid slopes, **T**=toe slopes, **US**=upper slopes).

8. Acidic Cove and Slope Forests

	Group											
	8.	8.1	8.2	8.3	8.3.1	8.3.2	8.4	8.5	8.5.1	8.5.2	8.6	8.7
Site Characteristics:												
Elevation (m)	828	707	602	732	810	676	1042	1034	902	1166	919	792
Slope (o)	23	27	19	20	22	18	26	30	29	30	36	9
Aspect (o)		W-N	SE,NW	E-SW	SW		N-E	S-W,N	SE-S	W-NW	NW-E	W-N
Parent material								11				Q
Soil depth (cm)	61.9	64.2	67.7	56.0	57.3	80.3	71.5	65.8	59.1	72.5	75.7	36.3
Surface Substrate (%):												
Moss/Lichen	5	2	2	11	7	14	3	1	2	1	2	4
Wood	6	4	4	6	10	4	8	9	13	5	5	5
Rock	5	3	2	11	0	18	3	1	1	0	4	7
Organic Matter	86	93	93	81	88	76	86	85	76	93	91	79
Water	1	0	0	1	0	1	0	0	0	0	0	9
Topographic Characteristics:												
Relative slope	65	67	85	79	67	88	58	21	19	23	88	58
LFI	0.27	0.27	0.29	0.29	0.25	0.33	0.25	0.24	0.25	0.24	0.26	0.28
TSI	0.01	-0.08	0.01	0.07	0.03	0.14	0.01	-0.05	-0.06	-0.05	-0.00	0.07
Landform type	SS	SS	SS	C,SS	SS	C	SS	SS	SS	R	SS	RF
Topographic pos	LS,MS	LS	LS	T,LS	LS	T	LS,MS	LS,US		US	LS	T

Q

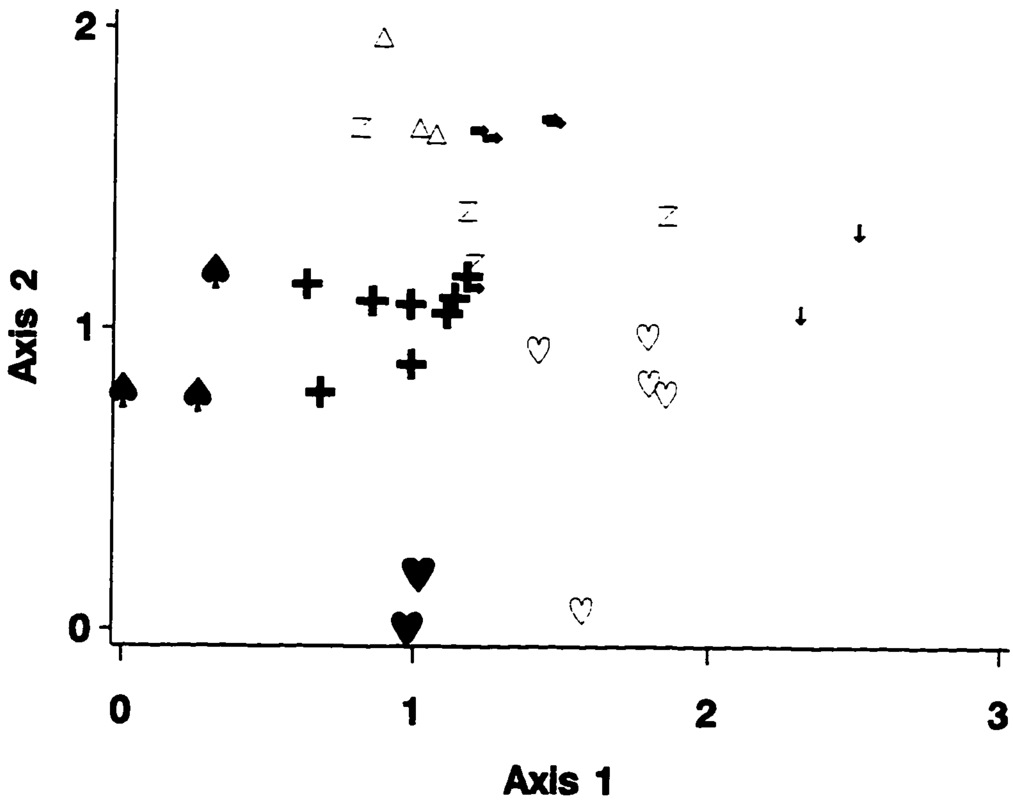
5.5.9 VEGETATION CLASS: 9. **Rich Cove and Slope Forests**

The **Rich Cove and Slope Forests** vegetation class is well known throughout the Southern Appalachian Mountains for its diversity of tree species and herbaceous flora (Whittaker 1956, Schafale and Weakley 1990). In Joyce Kilmer this class dominates coves and lower-slopes in the high- and mid-elevations of the Little Santeetlah and Slickrock valleys. This class typically inhabits more fertile sites than other widely distributed classes (Figures 5.2, 5.3, 5.6, 5.7, 5.8). The **Rich Cove and Slope Forests** represents 19% of the sites sampled (Appendices 3, 6).

At Joyce Kilmer the dominant tree species in this vegetation class include *Acer saccharum* var. *saccharum*, *Aesculus flava*, *Betula alleghaniensis*, *Halesia tetraptera* var. *monticola*, *Liriodendron tulipifera*, *Tilia americana* var. *heterophylla* and *Tsuga canadensis*. This vegetation class typically has high species richness at most spatial scales (Table 5.9).

Individual community types within the **Rich Cove and Slope Forests** class are separated from one another by elevation and subtle differences in soil chemical composition and texture (Figures 5.17, 5.18). The **[Acer saccharum-Halesia/Cladrastis/Solidago curtisii Forest]**, the **Aesculus-Acer saccharum/Solidago curtisii Forest** and the **[Aesculus/Rudbeckia lacinata Forest]** inhabit higher-elevation sites than other types in this vegetation class, with the latter having highest elevation position. These three higher-elevation types have soils with higher Cu, P and Zn values than the lower-elevation types. The **Liriodendron/Cornus florida Forest** inhabits lower-elevation site than any other **Rich Cove and Slope Forests** type. The other lower-elevation types have similar site conditions to one another. The **Tsuga canadensis-Halesia/Laportea Forest** and the **Acer saccharum-Fagus/Viola blanda Forest** have coarser-textured soils (low clay) with typically lower Cu and P and higher Fe and B levels than other lower-elevation types. The **Liriodendron/Cornus florida Forest** and the **[Acer saccharum-Halesia/Cladrastis/ Solidago curtisii Forest]** have finer-textured soils than other types in the **Rich Cove and Slope Forests** class.

Figure 5.17. DCA ordination diagram showing the distribution of the **Rich Cove and Slope Forests** class on the two major compositional gradients.



Community type:

- ♠ 9.1 Liriodendron/Cornus florida Forest
- ✚ 9.2 Acer saccharum – Halesia/Cimicifuga racemosa Forest
- △ 9.3 Tsuga canadensis – Halesia/Laportea Forest
- ➡ 9.4 Acer saccharum – Fagus/Viola blanda Forest
- Z 9.5 Liriodendron – Tilia/Asarum canadense Forest
- ♥ 9.6 [Acer saccharum – Halesia/Cladrastis/Solidago curtisii Forest
- ♡ 9.7 Aesculus – Acer saccharum/Solidago curtisii Forest
- ↓ 9.8 [Aesculus/Rudbeckia lacinata Forest]

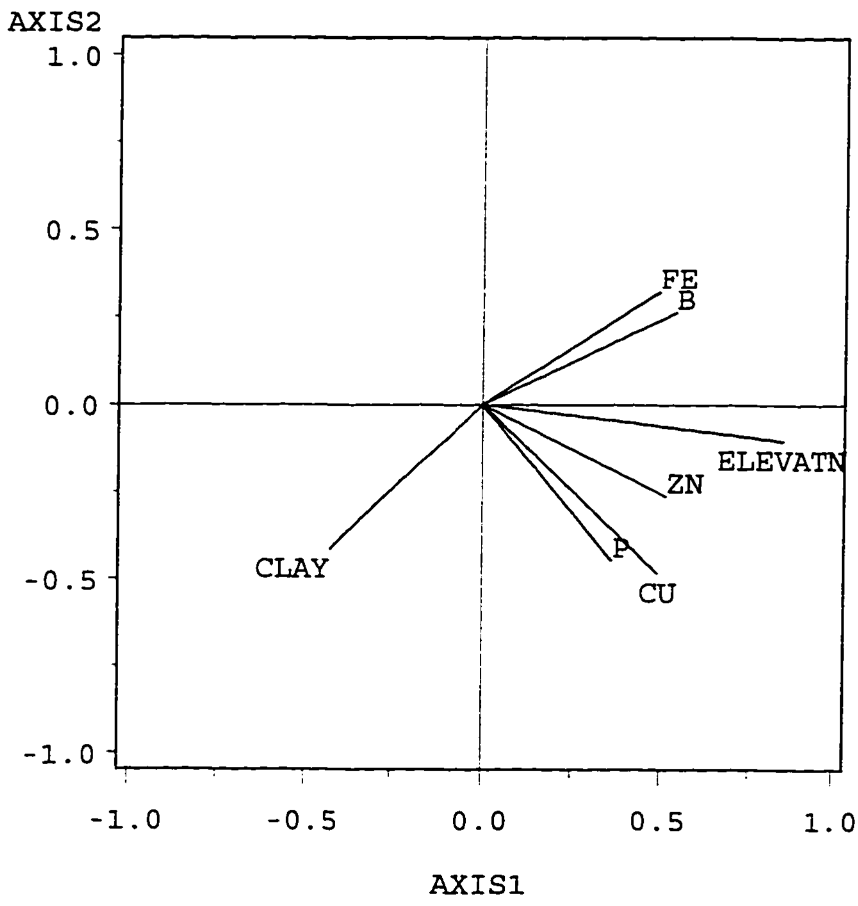


Figure 5.18. Vector diagram for DCA ordination of the **Rich Cove and Slope Forests** class showing association between species composition and major environmental gradients.

COMMUNITY TYPE: Liriodendron/Cornus florida Forest (9.1)

Synonymy

Rich Cove Forest (Schafale & Weakley 1990), Cove hardwoods Forest (Whittaker 1956), Second Growth Yellow Poplar Cover Type (Thomas 1966), Yellow Poplar Type (Golden 1974, 1981), Yellow Poplar Forest (Callaway *et al.* 1987), Oak, Mixed Mesic Forest p.p. (McLeod 1988), Cove Forest (Patterson 1994), [*Liriodendron-Carya glabra* Forest] (Chapter 3), *Liriodendron/Halesia* Forest p.p. (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Aesculus flava*, *Ageratina altissima* var. *roanensis*, *Amphicarpaea bracteata*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Betula lenta*, *Botrychium virginianum*, *Cardamine diphylla*, *Carex appalachica*, *Carya glabra*, *Cornus florida*, *Dennstaedtia punctilobula*, *Euonymus americana*, *Fraxinus americana*, *Galium circaezans* var. *circaezans*, *Galium triflorum*, *Halesia tetraptera* var. *monticola*, *Houstonia purpurea* var. *purpurea*, *Ilex opaca* var. *opaca*, *Liriodendron tulipifera*, *Monarda clinopodia*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Polystichum acrostichoides*, *Prenanthes* species, *Robinia pseudo-acacia*, *Sanicula canadensis* var. *canadensis*, *Smilax rotundifolia*, *Solidago curtisii*, *Stellaria pubera*, *Thelypteris novaeboracensis*, *Tilia americana* var. *heterophylla*, *Tsuga canadensis*, *Viola blanda*, *Viola palmata* var. *palmata*.

Listed species

Carex manhartii, *Stachys clingmanii*.

Physiognomy

Tall, mostly 40-50 cm diameter *Liriodendron tulipifera* dominate the canopy (34 m mean height) in association with smaller-diameter *Acer saccharum*, *A. rubrum* and *Halesia tetraptera* (Tables 5.40, 5.41, 5.42). *Acer saccharum* dominates the subcanopy. The understory is open with a scattered shrub layer, typically dominated by *Halesia* and *Cornus florida*. *Ilex opaca* and *Tsuga canadensis* are less abundant in this stratum. *Ageratina altissima* var. *roanensis*, *Amphicarpaea bracteata*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Polystichum acrostichoides* and *Viola blanda* dominate the forest floor. The abundance of these species varies between sites. Throughout all sites *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Botrychium virginianum*, *Cardamine diphylla*, *Carex appalachica*, *Dennstaedtia punctilobula*, *Euonymus americana*, *Galium circaezans* var. *circaezans*, *Galium triflorum*, *Houstonia purpurea* var. *purpurea*, *Monarda clinopodia*, *Prenanthes* species, *Sanicula canadensis* var. *canadensis*, *Smilax rotundifolia*, *Solidago curtisii*, *Stellaria pubera*, *Thelypteris novaeboracensis* and *Viola palmata* var. *palmata* have low, but consistent cover.

Habitat and Distribution

This type is restricted to low-elevation (645 m average), shallow-sloping (10° average, 8 to 12° range) toeslopes and coves in Slickrock valley, specifically Nichols Cove (both sites 573 m; Figure 1.5) and the broad cove at the base of Hangover Creek (789 m elevation; Table 5.43). All three sites are underlain by colluvium and alluvium.

The soils are coarser-textured than other **<u>Rich Cove</u> and <u>Slope Forests</u>** types, but also have a high clay content. This type has more fertile soils than average vegetation class values with higher pH and percent base saturation levels (Tables 5.7, 5.8).

Distinguishing Features

This is the only **<u>Rich Cove</u> and <u>Slope Forests</u>** type which appears to have established on areas previously cultivated rather than disturbed by logging alone.

Succession and Disturbance

Piles of stones provide evidence for the past cultivation of sites inhabited by the **Liriodendron/Cornus florida Forest**.

The high abundance of *Halesia* saplings and dominance of small-diameter *Acer saccharum* in this type (Table 5.41) suggests that these two species will ultimately become dominant. There are no *Liriodendron* saplings; *Liriodendron* is a shade intolerant species that requires large canopy openings for establishment (Lorimer 1980, Runkle & Yetter 1987). Such conditions may be periodically created as the present canopy ages and senescent trees create canopy gaps. The present dominance of this species is likely a consequence of the past clearing of these sites.

COMMUNITY TYPE: Acer saccharum-Halesia/Cimicifuga racemosa Forest (9.2)

Synonymy

Rich Cove Forest (Schafale & Weakley 1990), Cove hardwoods Forests (Whittaker 1956), Sugar Maple Type p.p. (Golden 1974), Lower cove hardwoods p.p. (Lorimer 1980), Cove Hardwoods p.p. (McLeod 1988).

Constant species

Acer pensylvanicum, *Acer saccharum*, *Aesculus flava*, *Amelanchier arborea*, *Anemone quinquefolia* var. *quinquefolia*, *Aster divaricatus*, *Athyrium asplenioides*, *Betula lenta*, *Caulophyllum thalictroides*, *Cimicifuga racemosa*, *Collinsonia canadensis*, *Fagus grandifolia*, *Fraxinus americana*, *Galium triflorum*, *Halesia tetraptera* var. *monticola*, *Laportea canadensis*, *Liriodendron tulipifera*, *Magnolia acuminata*, *Melanthium parviflorum*, *Osmorhiza claytonii*, *Polystichum acrostichoides*, *Polygonatum biflorum* var. *biflorum*, *Prenanthes* species, *Prosartes lanuginosum*, *Solidago curtisii*, *Stellaria pubera*, *Thelypteris novaeboracensis*, *Tiarella cordifolia* var. *cordifolia*, *Tilia americana* var. *heterophylla*, *Tsuga canadensis*, *Viola hastata*, *Viola rotundifolia*.

Listed species

Carex manhartii, *Panax quinquefolius*, *Stachys clingmanii*.

Physiognomy

Large *Acer saccharum* (stems mostly 42 to 64 cm) and *Halesia* (mostly 45 to 67 cm) dominate the canopy of this type, with more scattered *Betula lenta* and *Tilia americana* var. *heterophylla* (mostly 41 to 63 cm) (Tables 5.40, 5.41, 5.42). The open understory is dominated by *Acer saccharum* with scattered *Acer pensylvanicum* and *Fagus* present in the shrub stratum. *Cimicifuga racemosa* is the most prominent herbaceous species with *Aster divaricatus*, *Polystichum acrostichoides* and *Solidago curtisii* also having high cover. Low-cover species present in the majority of sites include; *Anemone quinquefolia* var. *quinquefolia*, *Athyrium asplenioides*, *Caulophyllum thalictroides*, *Collinsonia canadensis*, *Galium triflorum*, *Laportea canadensis*, *Melanthium parviflorum*, *Osmorhiza claytonii*, *Polygonatum biflorum*, *Prenanthes* species, *Prosartes lanuginosum*, *Stellaria pubera*, *Thelypteris novaeboracensis*, *Tiarella cordifolia* var. *cordifolia*, *Viola hastata* and *Viola rotundifolia*.

This community type divides into two sub-types which separate by elevation, slope position and disturbance history.

Community sub-types:

Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type (9.2.1)
Synonymy: Rich Cove Forest (Schafale & Weakley 1990), Cove hardwoods Forests (Whittaker 1956), Sugar Maple Type p.p. (Golden 1974), Lower cove hardwoods, Upper cove hardwoods (Lorimer 1980), Cove Hardwoods p.p. (McLeod 1988).

The canopy (34 m height) is dominated by *Halesia tetraptera*, *Tilia* and *Acer saccharum* with scattered, large-diameter, emergent *Liriodendron tulipifera* (107 to 141 cm in size) (Tables 5.40, 5.41, 5.42). Dominant canopy species vary between sites. Large-diameter *Tsuga canadensis* (stems 45 to 64 cm, largest 103), as well as *Tilia* and *Liriodendron* dominate the site adjacent to a tributary of the main creek in Poplar Cove. In contrast, *Liriodendron* is emergent over *Fagus* and *Halesia* and an understory of *Acer* *saccharum* in the stand situated in the main cove portion of Poplar Cove. *Tilia*, *Betula lenta* and *Acer saccharum* are most abundant in the canopy of a steeper, lower-slope stand up-slope of the main cove.

Acer pensylvanicum and *A. saccharum* are the major shrub species (Tables 5.40, 5.41, 5.42). *Cimicifuga racemosa* and *Caulophyllum thalictroides* are the dominant ground species, with *Adiantum pedatum* var. *pedatum*, *Aristolochia macrophylla*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Athyrium asplenioides*, *Botrychium virginianum*, *Carex austrocaroliniana*, *Collinsonia canadensis*, *Dryopteris marginalis*, *Euonymus americana*, *Galium circaezans* var. *circaezans*, *Galium triflorum*, *Iris cristatum*, *Melanthium parviflorum*, *Mitchella repens*, *Osmorhiza claytonii*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Phegopteris hexagonoptera*, *Polystichum acrostichoides*, *Polygonatum biflorum*, *Prosartes lanuginosum*, *Sanicula odorata*, *Solidago curtisii*, *Stellaria pubera*, *Thelypteris novaeboracensis*, *Trillium erectum*, *Viola canadensis* var. *canadensis* and *V. hastata* having low, but consistent cover throughout this sub-type.

***Halesia-Acer saccharum-Tilia/Viola blanda* sub-type** (9.2.2)

Synonymy: Rich Cove Forest (Schafale & Weakley 1990), *Acer saccharum-Halesia monticola* variant of Cove hardwoods Forest (Whittaker 1956), Sugar Maple Type (Golden 1974), Cove Hardwoods p.p. (McLeod 1988).

Large-sized *Halesia* and *Acer saccharum* dominate the canopy (31 m mean height) in association with *Tilia* (Tables 5.40, 5.41, 5.42). *Aesculus flava* has more scattered distribution in this stratum. *Acer saccharum*, *A. pensylvanicum* and scattered *Fagus* and *Aesculus* dominate the strata beneath. *Viola blanda* is the most prominent herbaceous species with *Aster divaricatus*, *Athyrium asplenioides*, *Caulophyllum thalictroides*, *Cimicifuga racemosa*, *Polystichum acrostichoides*, *Solidago curtisii* and *Stellaria pubera* also abundant. *Ageratina altissima* var. *roanensis*, *Anemone quinquefolia* var. *quinquefolia*, *Cardamine diphylla*, *Galium latifolium*, *Hydrangea arborescens*, *Laportea canadensis*, *Maianthemum racemosum*, *Melanthium parviflorum*, *Osmorhiza claytonii*, *Prenanthes* species, *Prosartes lanuginosum*, *Tiarella cordifolia* var. *cordifolia*, *Trillium erectum*, *Viola hastata* and *V. rotundifolia* scattered with low-cover across most sites.

Habitat and Distribution

The **Acer saccharum-Halesia/Cimicifuga racemosa Forest** inhabits northerly-facing lower-slopes across Joyce Kilmer. The two sub-types are separated by elevation, slope position and geographic location. Restricted to Little Santeetlah, the ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type*** is situated on the main cove-floor and adjacent lower-slopes of Poplar Cove (764 - 836 m elevation range, 796 m average; Table 5.43). Sites are north-facing and shallow- to moderately-sloped (15° average, 6 to 29° range). The ***Acer saccharum-Tilia-Halesia/Viola blanda sub-type*** inhabits mid-elevation (1022 m average, 891 - 1121 m range), northwest- to northeast-facing mid- to lower-slopes (12 to 35° range, 27° average) in Little Santeetlah, Slickrock and Deep Creek (Table 5.43).

This community type has moderately coarse-textured, fertile soils. The ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type*** has deep soils with second highest percent base saturation and pH levels of any community type or sub-type in the study (Tables 5.7, 5.8, 5.43). Two of the three stands in this sub-type are underlain by colluvium and alluvium. The ***Acer saccharum-Tilia-Halesia/Viola blanda sub-type*** has less fertile soils with higher Cu and S levels than the former sub-type. The latter sub-type has highest Al and organic matter levels of any type or sub-type in the **Rich Cove and Slope Forest** class. Sites in the ***Acer saccharum-Tilia-Halesia/Viola blanda sub-type*** are scattered across a range of geologic types.

Distinguishing Features

The **Acer saccharum-Halesia/Cimicifuga racemosa Forest** has higher than average species richness for the vegetation class at all scales. The ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type*** has highest richness at all scales for the **Rich Cove and Slope Forest** class except the second smallest scale. Such diversity reflects both dense small-scale packing of herbaceous species and larger-scale variation in their distribution (Table 5.9).

This sub-type includes stands that were part of an intense study on stand dynamics and disturbance history by Lorimer (1980). The *Liriodendron/Fagus-Halesia/Acer* *saccharum* stand described above (plot 526) represents the Lower cove hardwoods described by Lorimer (1976, 1980), whereas the *Tilia-Betula lenta-Acer saccharum* stand (plot 527) has closest resemblance to Lorimer's Upper cove hardwoods. The *Tsuga-Tilia-Liriodendron* stand (plot 524) does not fit well with Lorimer's descriptions.

Panax trifolius, a rare spring ephemeral (Amoroso & Weakley 1995) is present in the ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type***. This species is widely distributed throughout plot 526 and environs during spring each year (*pers. obs.*) but died down before stands in this sub-type were sampled.

Succession and Disturbance

The ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type*** contains old-growth forest. Two 67 cm diameter *Tsuga* in the *Tsuga-Tilia-Liriodendron* stand aged 147 and 157 years, while a 141 cm *Liriodendron* was over 200 years in age. A 60 cm Fagus in the *Liriodendron/Fagus-Halesia/Acer saccharum* stand was at least 160 years in age. The Little Santeetlah plots in the ***Acer saccharum-Tilia-Halesia/Viola blanda sub-type*** are old-growth, whereas the remaining stands (42%) outside this watershed have been logged.

The presence of chestnut logs are present in the majority of stands in this community type. Seventy one percent of plots in the ***Acer saccharum-Tilia-Halesia/Viola blanda sub-type*** had one or two chestnut logs present, suggesting that this species was only a minor component of the canopy. Chestnut logs were present in both ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type*** stands with deciduous canopies. Research by Lorimer (1976, 1980) indicates that chestnut blight caused substantial changes to the composition and structure of this sub-type. Lorimer suggests that chestnut made up approximately 20% of the trees ≥15 cm dbh in the lower-slope *Tilia-Betula lenta- Acer saccharum* stand prior to chestnut blight. The abundance of *B. lenta* in the canopy probably is a reflection of chestnut loss (Woods & Shanks 1959, Lorimer 1980, Johnson & Ware 1982). Lower chestnut log abundance in the main cove suggests that this species was less abundant in areas dominated by *Liriodendron/Fagus-Halesia/Acer saccharum* where Lorimer (1980) estimated chestnut represented 10% of trees ≥15 cm dbh.

Lack of evidence suggests that fire has been absent or only a minor feature of the ***Acer saccharum-Tilia-Halesia/Viola blanda sub-type***. Lorimer (1976) discounts fire for forests in the vicinity of the ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type*** due to lack of evidence. However, my observations of charcoal 2.5 cm below the soil surface in the *Liriodendron/Fagus-Halesia/Acer saccharum* stand suggests that fire may have been a disturbance factor in these forests.

High numbers of *Acer saccharum*, *Halesia* and *Tilia* saplings indicate the continuing dominance of these three species in the canopy of the ***Acer saccharum-Tilia-Halesia/Viola blanda sub-type*** (Table 5.41). In the ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type*** abundant *A. saccharum*, *Halesia*, *Tilia* and *Tsuga* saplings assures the continuing canopy dominance of these species (Table 5.41). However, *Liriodendron* has limited regeneration. This species needs high-light conditions for establishment (Lorimer 1980) and tends to establish in large-sized gaps (Runkle & Yetter 1987) where it can grow rapidly (Lorimer 1976). Lorimer suggests that *Liriodendron* presence reflects the degree and frequency of disturbance events in the Poplar Cove area. Higher than average disturbance events have taken place on a 30-year interval since approximately 1730 (Lorimer 1980). Events such as treefalls create large gaps in the intact canopy, providing high-light conditions suitable for *Liriodendron* establishment. For example, Lorimer (1980) recorded three tree falls which created a combined open area of 2200 m^2. Tornado damage in nearby Deep Creek (*pers. obs.*, D. Holder *pers. comm.*) also suggests that gaps caused by wind (see Runkle 1981) could create suitable conditions for *Liriodendron* establishment.

COMMUNITY TYPE: Tsuga canadensis-Halesia/Laportea Forest (9.3)

Synonymy

Canada Hemlock Forest p.p. (Schafale & Weakley 1990), Hemlock-Mixed Mesophytic Forests p.p. (Braun 1950), Hemlock Forest-Herb type (Oosting & Bourdeau 1955), Hemlock-Buckeye Type (Golden 1974), Hemlock-Silverbell Type p.p. (Golden 1974), Hemlock/herb Forest (Lorimer 1980).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Actaea pachypoda*, *Adiantum pedatum* var. *pedatum*, *Anemonella thalictroides*, *Aristolochea macrophylla*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Betula alleghaniensis*, *Cardamine diphylla*, *Carex plantaginea*, *Deparia acrostichoides*, *Dryopteris intermedia*, *Euonymus americana*, *Euonymus obovatus*, *Fagus grandifolia*, *Fraxinus americana*, *Galium triflorum*, *Halesia tetraptera* var. *monticola*, *Ilex montana*, *Laportea canadensis*, *Liriodendron tulipifera*, *Magnolia acuminata*, *Magnolia fraseri*, *Mitchella repens*, *Osmorhiza claytonii*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Polygonatum pubescens*, *Polystichum acrostichoides*, *Prosartes lanuginosum*, *Rhododendron maximum*, *Rubus canadensis*, *Solidago curtisii*, *Smilax glauca* var. *glauca*, *Stellaria pubera*, *Tiarella cordifolia* var. *cordifolia*, *Tilia americana* var. *heterophylla*, *Trillium erectum*, *Tsuga canadensis*, *Viola blanda*, *Viola canadensis* var. *canadensis*.

Listed species

Panax quinquefolius.

Physiognomy

Tsuga canadensis (stems mostly 44 to 88 cm; largest 112, plot 683) dominates the tall canopy (36 to 50 m height range) of this type in conjunction with smaller diameter *Halesia tetraptera* (Tables 5.40, 5.41, 5.42). *Tilia* and *Acer saccharum* have more limited presence in this stratum. A 173 cm diameter emergent *Liriodendron tulipifera* is present in one plot (plot 682). The understory is open with scattered small-tree-sized *Tsuga* and *A. saccharum* and 2 to 5 m tall *A. pensylvanicum* and *T. canadensis* shrubs. The forest floor is moist and mossy (16 % moss surface substrate; Table 5.43). *Dryopteris intermedia*, *Laportea canadensis*, *Solidago curtisii*, *Stellaria pubera*, and *Tiarella cordifolia* var.

cordifolia are the most prominent vascular species with *Cimicifuga americana*, *Mitchella repens*, *Viola blanda* and *Carex plantaginea* also abundant. Low-cover species present in most sites include; *Actaea pachypoda*, *Adiantum pedatum* var. *pedatum*, *Anemonella thalictroides*, *Aristolochea macrophylla*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Cardamine diphylla*, *Deparia acrostichoides*, *Euonymus americana*, *Euonymus obovatus*, *Galium triflorum*, *Osmorhiza claytonii*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Polygonatum pubescens*, *Polystichum acrostichoides*, *Prosartes lanuginosum*, *Rubus canadensis*, *Smilax glauca* var. *glauca*, *Trillium erectum* and *Viola canadensis* var. *canadensis*.

Habitat and Distribution

This community type inhabits low-elevation (776-812 m, 791 m average), northeast-facing lower-slopes and toeslopes on the south side of the Little Santeetlah Creek in the area immediately bordering the alternate Naked Ground Trail. Site slope varies (12 to 32° range, 25° average), reflecting differences in the slope positions inhabited by this type.

The soils are deep and coarse-textured with a higher sand component than other types in the **Rich Cove and Slope Forests** class. The **Tsuga canadensis-Halesia/ Laportea Forest** has higher than average class percent base saturation and pH levels but lowest Ca, cation exchange capacity and soil density values for all types in this class (Tables 5.7, 5.8). All sites are underlain by arkosic metasandstone-metaconglomerate (parent material type 13; Table 5.43).

Distinguishing Features

The **Tsuga canadensis-Halesia/Laportea Forest** is the only **Rich Cove and Slope Forests** community type in the present study with a canopy of *Tsuga canadensis*. This type is also by far the most species-rich of any type dominated by *Tsuga* in this study (Table 5.9). The dominance of large-diameter trees account for the fact that this type has second highest basal area measurements of any type in the study. This type is surpassed only by the **Tsuga**

canadensis-Betula alleghaniensis/Rhododendron maximum Forest which inhabits the broad riverflats nearby.

Succession and Disturbance

The **Tsuga canadensis-Halesia/Laportea Forest** is old-growth forest. There is no evidence of past fire or chestnut presence. Large-diameter decaying *Tsuga* logs on the forest floor point to the long-standing presence of this species in the canopy. Abundant *Tsuga*, *Acer saccharum*, *Halesia* and *Tilia* saplings numbers suggest that the present canopy will continue to maintain itself (Table 5.41).

COMMUNITY TYPE: Acer saccharum-Fagus/Viola blanda Forest (9.4)

Synonymy

Rich Cove Forest (Schafale & Weakley 1990), *Acer saccharum-Halesia monticola* variant of Cove hardwoods Forest (Whittaker 1956), Sugar Maple Type (Golden 1974), Cove Hardwoods p.p. (McLeod 1988), *Tilia-Betula lenta* Forest p.p. (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Aesculus flava*, *Ageratina altissima* var. *roanensis*, *Anemone quinquefolia* var. *quinquefolia*, *Arisaema triphylla* var. *triphylla*, *Aster divaricatus*, *Betula alleghaniensis*, *Cardamine diphylla*, *Caulophyllum thalictroides*, *Collinsonia canadensis*, *Dioscorea quaternata*, *Dryopteris intermedia*, *Fagus grandifolia*, *Halesia tetraptera* var. *monticola*, *Huperzia lucidula*, *Ilex montana*, *Laportea canadensis*, *Magnolia acuminata*, *Medeola virginiana*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Prosartes lanuginosum*, *Quercus rubra*, *Rubus canadensis*, *Solidago curtisii*, *Stellaria pubera*, *Thalictrum clavatum*, *Thelypteris novaeboracensis*, *Tiarella cordifolia* var.

cordifolia, *Tilia americana* var. *heterophylla*, *Trillium erectum*, *Tsuga canadensis*, *Viola blanda*, *Viola hastata*, *Viola rotundifolia*.

Listed species

Carex manhartii, *Panax quinquefolius*, *Stachys clingmanii*.

Physiognomy

Large-diameter *Acer saccharum* dominate the canopy (31 m height) in conjunction with *Halesia tetraptera*, *Fagus* and *Betula alleghaniensis* (Tables 5.40, 5.41, 5.42). *Liriodendron* has variable cover. *Tsuga canadensis* and *Fagus grandifolia* are the major understory species with *A. saccharum* also present. The ground is somewhat rocky with moss-covered boulders on or immediately below the ground surface (20 % rock surface substrate; Table 5.43). *Viola blanda* is the major ground species with abundant *Aster divaricatus*, *Collinsonia canadensis*, *Dryopteris intermedia*, *Solidago curtisii*, *Thelypteris noveboracensis* and *Tiarella cordifolia* var. *cordifolia*. Low-cover species present across most sites include; *Ageratina altissima* var. *roanensis*, *Anemone quinquefolia* var. *quinquefolia*, *Arisaema triphylla* var. *triphylla*, *Cardamine diphylla*, *Caulophyllum thalictroides*, *Dioscorea quaternata*, *Huperzia lucidula*, *Laportea canadensis*, *Medeola virginiana*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Prenanthes* species, *Prosartes lanuginosum*, *Rubus canadensis*, *Stellaria pubera*, *Thalictrum clavatum*, *Trillium erectum*, *Viola hastata* and *V. rotundifolia*.

Habitat and Distribution

The **Acer saccharum-Fagus/Viola blanda Forest** inhabits gently sloping (14° average, 10 to 19° range), mid-elevation (1106 m mean, range of 958 to 1188 m), east- to south-facing rocky coves and toeslopes in the Little Santeetlah watershed (Table 5.43).

The soils have high silt content but are less fertile than any other **Rich Cove and Slope Forests** type, with lowest base saturation and pH levels in this vegetation class (Tables 5.7, 5.8). Forty percent of the sites are underlain by colluvium and alluvium, with another 40% situated on arkosic metasandstone-metaconglomerate (parent material type 13; Table 5.43).

Distinguishing Features

This type has higher than average species richness at the two largest scales (Table 5.9) and lowest species richness at the smallest scale. This reflects the diverse set of comparatively large-sized herbaceous species present.

Succession and Disturbance

Presence of a chestnut stump in each of two sites suggests that this species had a minor role in some sites of this type. No sites have been logged or have evidence of past burning. High *Acer saccharum*, *Betula alleghaniensis*, *Fagus* and *Halesia* sapling numbers point to the continuing dominance of the present canopy composition (Table 5.41).

COMMUNITY TYPE: Liriodendron-Tilia/Asarum canadense Forest (9.5)

Synonymy

Rich Cove Forest (Schafale & Weakley 1990), Cove hardwoods Forest (Whittaker 1956), Basswood Type (Golden 1974), Cove Hardwoods (McLeod 1988), *Tilia-Betula lenta* Forest p.p. (Chapter 4).

Constant species

Acer pensylvanicum, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Aesculus flava*, *Ageratina altissima* var. *roanensis*, *Arisaema triphylla* var. *triphylla*, *Aristolochia macrophylla*, *Asarum canadense*, *Aster divaricatus*, *Betula alleghaniensis*, *Betula lenta*, *Cardamine diphylla*, *Carya cordiformis*, *Cimicifuga racemosa*, *Cryptotaenia canadensis*, *Dryopteris intermedia*, *Fraxinus americana*, *Halesia tetraptera* var. *monticola*, *Hamamelis virginiana*, *Hydrophyllum canadense*, *Impatiens capensis*, *Laportea canadensis*, *Liriodendron tulipifera, Maianthemum racemosum, Osmorhiza claytonii, Parthenocissus quinquefolia* var. *quinquefolia, Polygonatum biflorum* var. *biflorum, Polystichum acrostichoides, Prosartes lanuginosum, Quercus rubra, Solidago curtisii, Stellaria pubera, Tiarella cordifolia* var. *cordifolia, Tilia americana* var. *heterophylla, Trillium erectum, Tsuga canadensis, Viola blanda, Viola canadensis* var. *canadensis*

Listed species

Carex manhartii, Chelone lyonii, Panax quinquefolius.

Physiognomy

The canopy (27 m height) of this community type is dominated by large-diameter *Liriodendron* (mostly 41 to 66 cm; largest 107, plot 678) and *Tilia* (50 to 67 cm) (Tables 5.40, 5.41, 5.42). *Betula alleghaniensis* and *Acer saccharum* are subdominant in this stratum. One higher-elevation site in a narrow, sheltered draw is dominated by *Aesculus* and *Acer saccharum*. *Hamamelis* and *Acer saccharum* are the major understory species with *Aesculus flava* and the liana *Aristolochia macrophylla* also present. *Vitis cinera* var. *baileyana* occurs in some sites. Moss-covered boulders are prominent on the forest floor (Table 5.43), with *Asarum canadense, Aster divaricatus, Cimicifuga racemosa, Dryopteris intermedia, Impatiens capensis, Laportea canadensis, Maianthemum racemosum, Parthenocissus quinquefolia* var. *quinquefolia, Solidago curtisii, Tiarella cordifolia* var. *cordifolia* and *Viola blanda* dominating. *Carex plantaginea* has high-cover in some sites, whereas *Chelone lyonii* is dominant at the higher-elevation site. *Ageratina altissima* var. *roanensis, Arisaema triphylla* var. *triphylla, Cardamine diphylla, Cryptotaenia canadensis, Hydrophyllum canadense, Osmorhiza claytonii, Polygonatum biflorum, Polystichum acrostichoides, Prosartes lanuginosum, Stellaria pubera, Trillium erectum* and *Viola canadensis* var. *canadensis* are present with low-cover across most sites.

Habitat and Distribution

This community type inhabits low-elevation (812 to 911 m range, 843 m average) coves (12° average slope, 5 to 18° range) in Little Santeetlah, Slickrock and Deep Creek (Table 5.43). Sites are typically dominated by moss-covered boulders (40% rock, 30% bryophyte surface substrate). The surface of one site is covered by 2 m diameter boulders. Sites have west- through north to east-facing aspects with no single dominant orientation.

The **Liriodendron-Tilia/Asarum canadense Forest** has shallow, fertile and coarser-textured soils than average vegetation class values. This class has highest Ca, Fe, Mg and Zn levels of any type in the **Rich Cove and Slope Forests** class (Tables 5.7, 5.8, 5.43).

Distinguishing Features

This community type has low species richness at the smallest scale and lowest richness at the 0.1m^2 and 1m^2 scales (Table 5.9), reflecting the predominately bouldery substrate and somewhat sparse distribution of herbaceous species.

Succession and Disturbance

There is no evidence of fire in any sites in this type. One less rocky stand had a chestnut stump present. Sixty percent of stands have evidence of logging.

The small numbers of *Liriodendron* saplings suggest that the presence canopy dominance of this species may decline in the future unless canopy gaps provide sufficient light for this shade-intolerant species to regenerate (Table 5.41). Abundant *Acer saccharum* and *Tilia* saplings indicate that these two species will continue to dominate the canopy of the **Liriodendron-Tilia/Asarum canadense Forest**.

COMMUNITY TYPE: [Acer saccharum-Halesia/Cladrastis/Solidago curtisii Forest] (9.6)

Synonymy

Rich Cove Forests (Schafale & Weakley 1990), *Acer saccharum-Halesia monticola* variant of Cove hardwoods Forest (Whittaker 1956), Sugar Maple Type (Golden 1974).

Listed species

Dryopteris goldiana, *Panax quinquefolius*.

Physiognomy

Acer saccharum (stems mostly 40 to 53 cm) dominates the canopy (36 and 37 m height) in association with smaller-diameter *Halesia* (Tables 5.40, 5.41, 5.42). Large-diameter *Liriodendron* stems (47 to 91 cm) are present in the cove site. The understory is open with a distinct shrub layer of *Acer saccharum*, *Aesculus flava* and *Lindera benzoin* with *Asimina triloba* and *Cladrastis kentukea* also present. The forest floor is densely covered by a range of herbaceous species. *Solidago curtisii* is the most prominent species with *Cimicifuga racemosa*, *Impatiens pallida*, *Laportea canadensis* and *Monarda clinopodia* also abundant. *Ageratina altissima* var. *roanensis*, *Amphicarpaea bracteata*, *Anemonella thalictroides*, *Asarum canadense*, *Aster divaricatus*, *Botrychium virginianum*, *Caulophyllum thalictroides*, *Collinsonia canadensis*, *Cystopteris protrusa*, *Dryopteris intermedia*, *Dryopteris marginalis*, *Galium circaezans* var. *circaezans*, *G. triflorum*, *Hepatica acutiloba*, *Hydrophyllum canadense*, *Maianthemum racemosum*, *Osmorhiza claytonii*, *Panax quinquefolius*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Polygonatum biflorum* var. *biflorum*, *Polygonatum pubescens*, *Polystichum acrostichoides*, *Prosartes lanuginosum*, *Sanguinaria canadensis*, *Smilax rotundifolia*, *Stellaria pubera*, *Tiarella cordifolia* var. *cordifolia*, *Uvularia perfoliata*, *U. grandiflora*, *Viola canadensis* var. *canadensis*, *V. palmata* var. *palmata* have low cover in both sites.

Habitat and Distribution

This community type is restricted to the moist, north-facing cove and associated lower-slopes at the head of Big Fat Gap in Slickrock valley (Figure 1.5; elevation of 890 and 942 m, slopes of 24 and 32°; Table 5.43).

The **[Acer saccharum-Halesia/Cladrastis/Solidago curtisii Forest]** has highest cation exchange capacity and S levels of any type in the **Rich Cove and Slope Forests** class (Tables 5.7, 5.8). This type has the highest P levels of any group in the study. Both sites in this type are underlain by arkosic metasandstone-slate (parent material type 10; Table 5.43).

Distinguishing Features

This community type has highest species richness levels at the two smallest scales of all forest community types in the study (Table 5.9). This is indicative of the broad set of small-sized herbaceous species present.

Cladrastis kentukea has highest abundance in the **[Acer saccharum-Halesia/ Cladrastis/Solidago curtisii Forest]**. This species is a rich-soil species. The high Ca, cation exchange capacity and P levels of the soils in this type may account for the abundance of *Cladrastis*, as well as *Asimina triloba*, *Diplazium pycnocarpon*, *Dryopteris goldiana* and *Uvularia grandiflora*.

Succession and Disturbance

There is no evidence of past chestnut presence in either plot. One stand shows evidence of logging and the other fire. High *Halesia* and *Tilia* sapling numbers and fewer *Acer saccharum* saplings point to a decline in dominance of the latter species with *Halesia* and *Tilia* becoming the major canopy species of this community type (Table 5.41).

COMMUNITY TYPE: Aesculus-Acer saccharum/Solidago curtisii Forest (9.7)

Synonymy

Rich Cove Forest (Schafale & Weakley 1990), Buckeye-Basswood segregate p.p. (Cain 1943), Cove hardwoods Forests (Whittaker 1956), Buckeye Type p.p. (Golden 1974), Sugar Maple Type p.p. (Golden 1974), Basswood-Buckeye Forest p.p. (Callaway *et al.* 1987).

Constant species

Acer saccharum var. *saccharum*, *Aesculus flava*, *Ageratina altissima* var. *roanensis*, *Aster divaricatus*, *Betula alleghaniensis*, *Caulophyllum thalictroides*, *Cimicifuga racemosa*, *Cryptotaenia canadensis*, *Dryopteris intermedia*, *Fraxinus americana*, *Halesia tetraptera* var. *monticola*, *Hydrophyllum canadense*, *Impatiens pallida*, *Laportea canadensis*, *Osmorhiza claytonii*, *Polygonatum biflorum* var. *biflorum*, *Polystichum acrostichoides*, *Prosartes lanuginosum*, *Solidago curtisii*, *Stellaria pubera*, *Tiarella cordifolia* var. *cordifolia*, *Tilia americana* var. *heterophylla*, *Trillium erectum*, *Viola blanda*, *Viola canadensis* var. *canadensis*.

Listed species

Carex manhartii, *Dryopteris goldiana*, *Stachys clingmanii*.

Physiognomy

Large-diameter *Aesculus flava* (mostly 52 to 64 cm) and *Acer saccharum* (44 to 69 cm) dominate the canopy (31m mean height) with *Tilia americana* var. *heterophylla* (41-58 cm) also present (Tables 5.40, 5.41, 5.42). *Halesia* is scattered throughout. The lower strata are open with *Acer saccharum* and *Halesia* dominant. These two species are joined by *Aesculus* in the shrub stratum. The lush forest floor is dominated by *Solidago curtisii* and *Stellaria pubera* with *Aster divaricatus*, *Caulophyllum thalictroides*, *Cimicifuga racemosa*, *Dryopteris intermedia*, *Impatiens pallida*, *Laportea canadensis*, and *Viola* *canadensis* var. *canadensis* also abundant. Dominant species vary between sites with one site dominated by *Impatiens pallida* and another by *Stachys clingmanii*. *Solidago flexicaulis* has high cover in some sites. *Ageratina altissima* var. *roanensis*, *Cryptotaenia canadensis*, *Hydrophyllum canadense*, *Osmorhiza claytonii*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Prosartes lanuginosum*, *Tiarella cordifolia* var. *cordifolia*, *Trillium erectum* and *Viola blanda* have low abundance throughout most sites.

Habitat and Distribution

The **Aesculus-Acer saccharum/Solidago curtisii Forest** occurs at high-elevations (915 to 1339 m, 1109 m average) in Little Santeetlah and upper Slickrock (Table 5.43), where it inhabits moist, concave, moderately steep (27° slope average, 21 to 35° range), north- and east-facing lower-slopes and coves.

The soils are sandy with similar fertility to average **Rich Cove and Slope Forests** vegetation class values (Tables 5.7, 5.8).

Distinguishing Features

This community type has lowest diversity at the three largest spatial scales in comparison to other **Rich Cove and Slope Forests** types (Table 5.9). This reflects the lush cover of the herbaceous stratum and dominance by a limited number of high-cover species (e.g., *Caulophyllum*, *Laportea*, *Solidago curtisii*) .

Succession and Disturbance

All of the Slickrock stands contain evidence of logging. There is no evidence of chestnut or fire observed in any of the sites.

The high abundance of *Aesculus flava* saplings assures its future dominance in the canopy of this community type. The presence of *Acer saccharum*, *Halesia* and *Tilia* saplings also suggests the persistence of these species in the canopy (Table 5.41).

COMMUNITY TYPE: [Aesculus/Rudbeckia lacinata Forest] (9.8)

Synonymy

Rich Cove Forest (Schafale & Weakley 1990), Buckeye-Basswood segregate p.p. (Cain 1943), *Aesculus octandra-Betula alleghaniensis* variant of Cove Hardwood Forests (Whittaker 1956), *Aesculus octandra-Tilia heterophylla* variant of Cove hardwoods Forests (Whittaker 1956), Buckeye Type (Golden 1974), Basswood-Buckeye Forest (Callaway *et al.* 1987), Northern Hardwood Forests (White *et al.* 1993).

Listed species

Allium burdickii, *Carex manhartii*

Physiognomy

Tall, large-diameter *Aesculus flava* (62 to 88 cm) dominate the canopy (28 and 34 m height) in both sites in association with *Acer saccharum* and *Fagus grandiflora* (Tables 5.40, 5.41, 5.42). *Betula alleghaniensis* and *Tilia* have more scattered distribution. The understory is open with scattered, small-tree and shrub-sized *Aesculus*, *Acer saccharum*, *Acer spicatum* and *Fagus* present. The ground is rocky with a lush, 1 m tall herbaceous layer dominated by *Rudbeckia lacinata* (sites with cover of 5 and 7) and *Ageratina altissima* var. *roanensis*. *Aster chlorolepis*, *Caulophyllum thalictroides*, *Cimicifuga racemosa*, *Euonymus obovatus*, *Dryopteris intermedia*, *Laportea canadensis*, *Monarda didyma*, *Polystichum acrostichoides*, *Solidago curtisii* and *Tiarella cordifolia* var. *cordifolia* have low-cover in both sites.

Habitat and Distribution

This community type inhabits the major high-elevation east- and southeast-facing cove (1406, 1420 m elevation) and associated concave seepage slopes (25 and 32° slopes) at the head of the Little Santeetlah valley (Table 5.43). The surface substrate is rocky, with 1 to 2 m diameter boulders typically near or on the surface (average soil depth of 33 cm;

Table 5.43). There is evidence of continual down-slope seepage from the steep slopes above.

The soils have lowest clay content of any **Rich Cove and Slope Forests** type and have similar fertility to the vegetation class averages (Tables 5.7, 5.8). Both sites are underlain by metagraywacke (parent material type 12; Table 5.43).

Distinguishing Features

This community type has low diversity at all scales (Table 5.9), pointing to the prominence of a few high-cover herbaceous species. The **[Aesculus/Rudbeckia lacinata Forest]** has the highest elevational distribution of any **Rich Cove and Slope Forests** type (Table 5.43).

Succession and Disturbance

This community type is old-growth forest that shows no evidence of past disturbance by fire or chestnut blight. Abundant *Acer saccharum*, *Aesculus*, *Fagus* and *Tilia* saplings suggest that the present canopy composition will be maintained in the future (Table 5.41).

Discussion

The **Rich Cove and Slope Forests** vegetation class is widespread throughout the Little Santeetlah watershed, whereas it is typically restricted to the mid- and upper-reaches of the Slickrock valley. In lower Slickrock conditions are generally too xeric except on sheltered alluvial flats that are inhabited by the **Liriodendron/Cornus florida Forest**. This vegetation class inhabits similar environmental conditions and slope positions (fertile coves and concave lower-slopes) to previous descriptions (e.g., Whittaker 1956, Schafale & Weakley 1990). Recent studies in Shining Rock Wilderness, the Black Mountains and Linville Gorge Wilderness (McLeod 1988, Newell *et al. in press*, Chapters 3 & 4) indicate that the **Rich Cove and Slope Forests** are distributed across a broader range of topographic positions in some landscapes. However, in Joyce Kilmer this vegetation class conforms to the more typical range of distribution. Several factors might account for the limited range of topographic positions in this landscape. The **Montane Oak Forests** are well-developed on mid- and lower-elevation, mid-slope positions in Little Santeetlah, whereas similar high-elevations sites are dominated by the **Fagus-Betula alleghaniensis/Dryopteris intermedia Forest**. The cooler, northern orientation of the Slickrock valley may restrict **Rich Cove and Slope Forests** distribution on coves and lower-slopes in the mid- and upper-portions of this valley. The **Acidic Cove and Slope Forests** community types are well-developed on mid- and upper-slope positions in this valley. Past disturbance by logging may also have altered the distribution of these two vegetation classes in the Slickrock valley.

Although **Rich Cove and Slope Forests** have been documented by many authors (e.g., Braun 1950, Whittaker 1956, McLeod 1988, Schafale & Weakley 1990), most studies have given very general descriptions of species composition, structure and site characteristics without quantifying the variation within this class (but see Golden 1974, Chapter 4). The detailed quantitative information provided in the present study helps clarify and focus attention on this unappreciated variation.

Community types within the **Rich Cove and Slope Forests** class separate by elevation, subtle differences in soil chemistry (Figures 5.17, 5.18), watershed and surface substrate (Table 5.43). The **Liriodendron/Cornus florida Forest** is restricted to previously cultivated, broad, low-elevation alluvial flats in the mid-section of Slickrock. By contrast, the ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type*** and the **Tsuga canadensis-Halesia/Laportea Forest** are the two low-elevation **Rich Cove and Slope Forests** groups in Little Santeetlah. The former sub-type is restricted to the broad, shallow-sloping Poplar Cove area, whereas the latter type inhabits the lower-slopes and toeslopes along the south-side of the main river valley. Two community types inhabit rocky coves that are underlain by thick deposits of colluvium and alluvium. The low-elevation **Liriodendron -Tilia/Asarum canadense Forest** occurs in Slickrock, Santeetlah and Deep Creek. The **Acer saccharum-Fagus/Viola blanda Forest**, the second rock-cove type, is restricted to sheltered, higher-elevation draws in Little Santeetlah. The **Liriodendron-Tilia/Asarum**

canadense Forest has rockier and more fertile soils, with higher percent base saturation, Ca, Mn and pH levels than the latter type (Tables 5.7, 5.43). Higher soil fertility is perhaps the result of periodic flooding. In contrast, the ***Halesia-Acer saccharum-Tilia/Viola blanda sub-type*** inhabits mid-elevation coves and concave lower-slopes in both major valleys that have limited colluvial deposits. This sub-type has a similar elevational distribution to the **[Acer saccharum-Halesia/Cladrastis/Solidago curtisii Forest]** which is restricted to the cove at the head of Big Fat Creek in the Slickrock valley. There are two high-elevation **Rich Cove and Slope Forests** types. The **Aesculus-Acer saccharum/ Solidago curtisii Forest** inhabits both watersheds whereas the **[Aesculus/Rudbeckia lacinata Forest]** is restricted to higher-elevation sites in Little Santeetlah. The high-elevation position of the latter type can be seen in the presence of *Fagus* and *Betula alleghaniensis* and high-elevation herbs such as *Rudbeckia lacinata*. *Halesia* is also absent from the latter type. The **[Aesculus/Rudbeckia lacinata Forest]** has a rockier surface substrate than the **Aesculus-Acer saccharum/Solidago curtisii Forest** and is more obviously subject to infiltration of water and nutrients from slopes above.

The range of community types in Joyce Kilmer corresponds most closely to descriptions of rich cove forests in the Great Smoky Mountains, which is probably indicative of the close geographic proximity and the geologic and climatic similarities of these two areas. The work of Whittaker (1956) and Golden (1974) enable comparisons between **Rich Cove and Slope Forests** types in both areas. Whittaker (1956) documented the abundance of *Aesculus flava*, *Tilia* and *Betula alleghaniensis* in high-elevation coves that correspond to canopy species in the high-elevation **[Aesculus/Rudbeckia lacinata Forest]** in this study. This type has affinities with Golden's Buckeye type and includes a similar set of dominant species (e.g., *Cimicifuga racemosa*, *Euonymus obovata*, *Laportea canadensis*, *Solidago curtisii*, *Tiarella cordifolia* var. *cordifolia*, *Dryopteris intermedia* and *Caulophyllum thalictroides*). However, the Joyce Kilmer type has a narrower elevation distribution, restricted to the high-elevation-end of Golden's Buckeye type distribution (1130 to 1400 m). This might explain the dominance of *Rudbeckia lacinata* and *Monarda didyma* in the Joyce Kilmer type, which Whittaker (1956) associated with high-elevation cove forests. The presence of such species suggests that the **[Aesculus/Rudbeckia lacinata Forest]** is a higher-elevation or cooler variant of Golden's type.

All other **Rich Cove and Slope Forests** community types described by Golden (1974) are present in Joyce Kilmer. The Sugar Maple type (Golden 1974) has closest compositional similarity with the **Acer saccharum-Fagus/Viola blanda Forest** and the **Liriodendron-Tilia/Asarum canadense Forest** and inhabits similar habitats (lower-slopes and coves). Golden's type is however, distributed across a broader elevational range (942 to 1442 m) than the Joyce Kilmer type. Golden (1974) suggests that his type inhabits coves with limited colluvial deposits and this corresponds with the site characteristics of the two Joyce Kilmer rocky-cove types. In contrast, Golden's Basswood type dominates coves in the central Smokies with thick colluvium (Golden 1974). The dominance of *Acer saccharum*, *Aesculus*, *Betula alleghaniensis* and *Tsuga* gives Golden's type some resemblance to the two rocky-cove types in Joyce Kilmer, however, *Tsuga* has limited presence in the latter types, whereas *Liriodendron* is abundant in the **Liriodendron-Tilia/Asarum canadense Forest**.

The composition of **Rich Cove and Slope Forests** types in Joyce Kilmer also have some affinities with forests found in other landscapes throughout the Southern Appalachian region. McLeod (1988) described the dominance of *Acer saccharum*, *Aesculus*, *Betula alleghaniensis*, *Fagus* and *Tilia* in cove forests of the Black Mountains. These species are also dominant at Joyce Kilmer, although *Betula* is restricted to a limited number of community types. *Liriodendron* and *Tsuga* are also major canopy species at Joyce Kilmer. The **Rich Cove and Slope Forests** present in the present study, the Black Mountains and the Smoky Mountains contrast to representatives of this class at Shining Rock Wilderness which are dominated by *Quercus rubra*. This species is a consistent, but minor component in types at Joyce Kilmer.

The presence of a **Rich Cove and Slope Forests** type dominated by the evergreen *Tsuga canadensis* contrasts with most descriptions of this vegetation class throughout the Southern Appalachians. *Tsuga* is typically associated with the **Acidic Cove and Slope Forests** vegetation class (Schafale & Weakley 1990). Species-rich *Tsuga* forests, such as the **Tsuga canadensis-Halesia/Laportea Forest** present in Joyce Kilmer, appear to be restricted to the western portion of the Southern Appalachian Mountains. Similar community types have been reported previously only by Oosting & Bourdeau (1955) and Lorimer (1976,1980) in the Little Santeetlah valley and by Golden (1974, 1981) in the central Smokies. Golden (1981) attributes the dominance of *Tsuga* in mid-elevation coves (900 to 1250 m in elevation) in the central Smokies to the cooler, moister conditions in this portion of the park. Such a hypothesis perhaps may explain the presence of the species-rich **Tsuga canadensis-Halesia/Laportea Forest** at Joyce Kilmer. This community type has closest florisitic similarities with Golden's (1974) Hemlock-Buckeye type, which in the understory is also dominated by *Laportea canadensis*, *Tiarella cordifolia*, *Dryopteris* and *Cimicifuga*. His type inhabits rocky coves and lower-slopes between 1119 and 1125 m, which is substantially higher in elevation than the Joyce Kilmer type. Elevational differences may explain the absence of *Aesculus* in the type at Joyce Kilmer. Cold-air drainage associated with the valley-floor and adjacent lower-slopes of the Little Santeetlah valley might explain the lower-elevation position of the Joyce Kilmer type. There is no higher-elevation equivalent of the **Tsuga canadensis-Halesia/Laportea Forest** at Joyce Kilmer, although the **Tsuga canadensis-Halesia/Dryopteris intermedia Forest**, in the **Acidic Cove and Slope Forests** vegetation class, inhabits similar elevations to Golden's type, but is situated on higher-slope positions.

Table 5.40. Average cover class and constancy of species present in the **Rich Cove and Slope Forests** vegetation class. Values are given for the vegetation class as a whole as well as within each community type and sub-type. Each group is represented by its abbreviation code. For full group names see Table 5. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species. The prevalent species (see text) in each specific group are underlined. Homoteneity is the mean constancy of the prevalent species.

Group:	9.	9.1	9.2	9.2.1	9.2.2	9.3	9.4	9.5	9.6	9.7	9.8
Number of plots:	34	3	10	3	7	3	5	4	2	5	2
Homoteneity:	0.686	0.812	0.708	0.840	0.714	0.876	0.745	0.754	0.905	0.720	0.767
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species											
ACER PENSYLVANICUM	3 85	3 100	4 100	3 100	4 100	5 100	3 100	3 75	2 100	2 60	
ACER RUBRUM	4 59	6 100	5 50	5 67	5 43	2 100	5 80	2 100		1 20	
ACER SACCHARUM VAR SACCHARUM	6 100	6 100	6 100	5 100	6 100	6 100	6 100	6 100	8 100	7 100	6 100
ACER SPICATUM	3 9						2 20				3 100
ACTAEA PACHYPODA	2 29					1 100	2 40	2 50		2 40	2 50
ADIANTUM PEDATUM VAR PEDATUM	2 32	1 33	2 50	2 100	3 29	1 100			2 50	2 20	
AESCULUS FLAVA	4 91	2 100	4 100	2 100	5 100	2 33	3 80	5 100	5 100	6 100	8 100
AGERATINA ALTISSIMA VAR ROANENSIS	2 76	3 100	2 60		2 86		2 80	2 100	2 100	2 100	5 100
AGROSTIS PERENNANS	1 6	1 33									1 50
ALLIUM BURDICKII*	2 3										2 50
ALLIUM TRICOCCUM	2 3									2 20	
AMELANCHIER ARBOREA	2 47		1 80	1 100	2 71	2 67	2 60	3 50			2 50
AMPHICARPAEA BRACTEATA	2 29	3 100	2 30	2 67	2 14			1 25	2 100	3 20	
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	2 41	1 33	2 80	2 67	2 86		2 80			1 20	
ANEMONELLA THALICTROIDES	2 35	2 67	2 40	2 33	2 43	1 100		1 25	2 100		
ANGELICA TRIQUINATA	2 9						2 20			2 20	2 50
APLECTRUM HYEMALE	1 3		1 10		1 14						
ARALIA RACEMOSA VAR RACEMOSA	2 18		2 50	3 67	2 43				1 50		
ARALIA SPINOSA	2 3							2 25			
ARISTOLOCHIA MACROPHYLLA	2 62	2 67	2 70	2 100	3 57	2 100	3 40	3 100	1 50	2 40	
ARISAEMA TRIPHYLLUM SSP QUINATUM	2 12		1 10		1 14		2 40				2 50
ARISAEMA TRIPHYLLUM VAR TRIPHYLLUM	1 79	1 100	1 70	1 100	1 57	1 100	1 100	2 100	1 50	1 40	2 100
ASARUM CANADENSE	2 24		2 10	2 33				3 75	1 100	2 40	

Group:	9.	9.1	9.2	9.2.1	9.2.2	9.3	9.4	9.5	9.6	9.7	9.8
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
ASIMINA TRILOBA	3 9	2 33							4 100		
ASPLENIUM PLATYNEURON VAR PLATYNEURON	1 6	1 67									
ASPLENIUM RHIZOPHYLLUM	1 3		1 10	1 33							
ASTER CHLOROLEPIS	2 9									2 20	3 100
ASTER CORDIFOLIUS	2 3		2 10		2 14						
ASTER DIVARICATUS	3 91	2 100	3 100	2 100	4 100	2 100	4 100	4 100	2 100	3 80	
ASTER LATERIFLORUS VAR LATERIFLORUS	1 3	1 33									
ASTER PRENANTHOIDES	2 3										2 50
ASTER UNDULATUS	1 3							1 25			
ASTILBE BITERNATA	2 12		2 20	2 67		1 33		2 25			
ATHYRIUM ASPLENIOIDES	2 68	2 67	2 100	2 100	3 100	2 67	2 60		1 50	2 60	2 100
BETULA ALLEGHANIENSIS	4 56		3 40	2 67	4 29	2 67	6 80	6 75		4 80	4 100
BETULA LENTA	4 65	4 100	4 90	4 100	4 86	4 100	5 40	2 75		4 40	
BIGNONIA CAPREOLATA	1 3	1 33									
BOTRYCHIUM BITERNATUM	1 6	1 33									1 50
BOTRYCHIUM VIRGINIANUM	1 53	1 100	1 70	1 100	1 57	1 33	1 20	2 50	2 100	1 20	1 50
BRACHYELYTRUM ERECTUM	2 12	1 33	2 10		2 14		2 20		1 50		
CALYCANTHUS FLORIDUS VAR GLAUCUS	2 12	2 33	1 10		1 14	2 67					
CARDAMINE DIPHYLLA	1 65	1 100	1 90	1 67	1 100		2 80	1 75		1 60	
CAREX AESTIVALIS	1 18		1 40	1 33	1 43		1 40				
CAREX APPALACHICA	1 21	1 100	1 20		1 29					1 20	1 50
CAREX AUSTROCAROLINIANA	2 18	4 67	2 30	2 100		1 33					
CAREX BLANDA	2 6	2 67									
CAREX DIGITALIS	2 12	2 33	1 10		1 14	2 67					
CAREX FLEXUOSA	2 6	1 33						2 25			
CAREX LEPTONERVIA	1 6		1 10		1 14		1 20				
CAREX LAXIFLORA VAR LAXIFLORA	1 9						1 20	1 25			2 50
CAREX MANHARTII*	1 41	2 67	1 60	1 67	1 57		2 60	1 25		1 20	2 50
CAREX PENSYLVANICA	2 9	2 33					2 40				
CAREX PLANTAGINEA	3 24		2 20	2 67		3 100		5 50		1 20	
CAREX PLATYPHYLLA	2 12		1 10		1 14		1 20			4 40	
CAREX SWANII	1 6	1 67									
CAREX VIRESCENS	1 3	1 33									
CARPINUS CAROLINIANA	4 6		4 20	4 67							
CARYA ALBA	1 18	1 33	1 30	1 67	1 14		1 20	1 25			
CARYA CORDIFORMIS	2 38		2 40	5 33	1 43	1 67	1 20	2 75	2 100	1 20	
CARYA GLABRA	2 26	1 100	2 10	2 33		2 67			2 100	6 20	
CARYA OVATA	4 6		4 20	1 33	6 14						
CASTANEA DENTATA	2 12		2 40	2 33	1 43						

Group:	9.	9.1	9.2	9.2.1	9.2.2	9.3	9.4	9.5	9.6	9.7	9.8
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
CAULOPHYLLUM THALICTROIDES	2 71		3 90	3 100	3 86	1 33	2 80	3 25	2 100	3 100	3 100
CHELONE GLABRA	2 12		2 10	2 33			1 40				3 50
CHELONE LYONII*	5 3							5 25			
CIMICIFUGA AMERICANA	4 15		1 10		1 14	4 100					
CIMICIFUGA RACEMOSA	4 79	1 33	4 100	5 100	4 100		2 60	3 100	5 100	4 100	4 100
CIRCAEA ALPINA VAR ALPINA	2 12		2 10		2 14		1 20	1 25		2 20	
CIRCAEA CANADENSIS	1 12	1 67	1 20	1 33	1 14						
CLADRASTIS KENTUKEA	3 9		2 10		2 14				4 100		
CLETHRA ACUMINATA	2 6		2 10		2 14	2 33					
CLINTONIA UMBELLULATA	2 24		1 30	1 33	1 29	1 33	2 60	2 25			
COLLINSONIA CANADENSIS	3 53		2 80	1 100	3 71		3 80	2 50	2 100	5 40	
CONOPHOLIS AMERICANA	1 18		1 40	1 33	1 43		1 20			1 20	
CORNUS ALTERNIFOLIA	2 35		2 60	2 67	2 57	3 67	2 20	2 25		1 20	1 50
CORNUS FLORIDA	3 26	5 100	4 30	4 67	5 14	1 33			2 100		
CRYPTOTAENIA CANADENSIS	2 21							1 75		2 80	
CUSCUTA SP. #1	1 18		1 10		1 14			2 25	1 50	1 40	2 50
CYMOPHYLLUS FRASERI	2 3										2 50
CYPRIPEDIUM ACAULE	1 3		1 10		1 14						
CYSTOPTERIS PROTRUSA	1 24		1 10	1 33					2 100	1 60	1 100
DENNSTAEDTIA PUNCTILOBULA	1 9	1 100									
DEPARIA ACROSTICHOIDES	2 38	1 33	2 30		2 43	2 100		3 25	2 50	2 60	6 50
DESMODIUM NUDIFLORUM	1 9	1 33	2 20	1 33	2 14						
DIOSCOREA QUATERNATA	2 35		2 60	1 33	2 71	1 33	2 80	2 25			
DIPHYLLEIA CYMOSA	2 12		3 20		3 29		2 20	1 25			
DIPLAZIUM PYCNOCARPON	1 3								1 50		
DRYOPTERIS GOLDIANA*	2 9								1 50	3 40	
DRYOPTERIS INTERMEDIA	3 74	2 33	3 40		3 57	6 100	3 100	4 100	2 100	4 80	3 100
DRYOPTERIS MARGINALIS	2 47		2 70	2 100	3 57	2 67	2 60	4 25	2 100	2 20	
ELYMUS HYSTRIX	2 3										2 50
EPIFAGUS VIRGINIANA	1 3					1 33					
EUONYMUS AMERICANA	2 32	2 100	2 30	2 100		2 100		2 50			
EUONYMUS OBOVATA	2 41		2 20		2 29	1 100	3 60	3 50		2 40	3 100
EUPATORIUM PURPUREUM VAR PURPUREUM	1 26	2 67	2 40	1 33	2 43		1 40				1 50
FAGUS GRANDIFOLIA	4 53		3 80	4 100	3 71	3 100	5 80			2 20	7 100
FESTUCA SUBVERTICILLATA	2 18						2 20			1 60	2 100
FRAXINUS AMERICANA	2 85	3 100	2 100	2 100	2 100	2 100	2 60	2 75	2 100	2 100	
GALEARIS SPECTABILIS	1 15	1 33	1 30	1 33	2 29			2 25			
GALIUM APARINE	2 18	2 67	1 10		1 14		1 20	2 25		2 20	
GALIUM CIRCAEZANS VAR CIRCAEZANS	2 26	2 100	2 30	2 100					2 100	2 20	
GALIUM LANCEOLATUM	1 9	1 33	1 10		1 14		1 20				

Group:	9.	9.1	9.2	9.2.1	9.2.2	9.3	9.4	9.5	9.6	9.7	9.8
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
GALIUM LATIFOLIUM	1 32		1 60		1 86	1 33	2 60		1 50		
GALIUM TRIFLORUM	2 74	2 100	2 80	1 100	2 71	2 100	2 60	2 50	2 100	1 60	1 50
GERANIUM MACULATUM	3 6		3 10		3 14		2 20				
GEUM CANADENSE	2 12						1 20		1 50	2 20	2 50
GOODYERA PUBESCENS	1 32	1 33	1 50	1 67	2 43	2 67	2 40	1 25			
HALESIA TETRAPTERA VAR MONTICOLA	5 91	5 100	6 100	6 100	6 100	6 100	5 100	4 100	7 100	6 80	
HAMAMELIS VIRGINIANA	4 32		2 10	2 33		3 67	5 60	5 100			2 50
HELIANTHUS STRUMOSUS	1 9	1 33	1 20	1 33	1 14						
HEPATICA ACUTILOBA	3 21		4 30	5 67	2 14	2 33			2 100	2 20	
HEUCHERA VILLOSA VAR VILLOSA	2 21		2 30	2 67	1 14			2 50		1 40	
HOUSTONIA CAERULEA	1 12		2 10		2 14		1 20			1 20	1 50
HOUSTONIA PURPUREA VAR PURPUREA	1 18	1 100	1 10		1 14		2 20		1 50		
HOUSTONIA SERPYLLIFOLIA	2 6						2 20				1 50
HUPERZIA LUCIDULA	2 24		2 20		2 29	2 67	2 80				
HYDRANGEA ARBORESCENS	2 53		2 70	2 33	2 86	1 67	1 60	2 50	1 50	2 40	3 50
HYDROPHYLLUM CANADENSE	2 56		2 30	2 33	2 29	1 67	1 20	2 100	2 100	2 100	2 100
ILEX MONTANA	2 35		2 30		2 43	4 100	2 80			1 20	2 50
ILEX OPACA VAR OPACA	2 26	3 100	2 20	2 33	2 14	3 67		2 50			
IMPATIENS CAPENSIS	2 26	1 33	1 10		1 14		1 20	3 75		2 20	2 100
IMPATIENS PALLIDA	2 26		1 20	1 33	1 14			1 25	3 100	4 80	
IRIS CRISTATA	2 18		2 50	2 100	2 29	1 33					
ISOTRIA VERTICILLATA	1 3						1 20				
JUGLANS NIGRA	3 6	3 67									
LAPORTEA CANADENSIS	3 94	2 67	2 90	2 67	2 100	5 100	2 100	3 100	4 100	4 100	3 100
LEUCOTHOE FONTANESIANA	3 6	2 33						3 25			
LILIUM MICHAUXII	1 9		1 10		1 14		1 20				2 50
LILIUM SUPERBUM	2 12		2 20	1 33	2 14			2 50			
LINDERA BENZOIN	2 32	2 67	2 30	3 67	1 14	3 33		2 50	3 100	3 20	
LIRIODENDRON TULIPIFERA	5 71	7 100	4 80	4 100	4 71	3 100	5 60	6 100	4 100	1 20	
LUZULA ACUMINATA	2 9						2 40				2 50
LUZULA MULTIFLORA VAR CONGESTA	2 6		2 10		2 14						1 50
LYSIMACHIA QUADRIFOLIA	1 6		1 20	1 33	1 14						
MAGNOLIA ACUMINATA	3 59	2 33	2 90	2 100	2 86	2 100	4 100	6 25		2 20	
MAGNOLIA FRASERI	2 35	1 33	2 50	2 33	3 57	1 100	1 60				
MAIANTHEMUM CANADENSE	3 9						3 60				
MAIANTHEMUM RACEMOSUM	2 62	1 33	2 70	2 67	2 71	2 67	1 60	3 75	1 100	1 40	1 50
MEDEOLA VIRGINIANA	1 47	1 33	1 60	2 67	1 57	1 67	2 80	2 50			1 50
MELANTHIUM PARVIFLORUM	2 44		2 90	2 100	2 86		2 60	2 25	2 50	1 20	
MITCHELLA REPENS	2 44	2 67	1 50	1 100	1 29	4 100	2 60	2 25			2 50
MITELLA DIPHYLLA	2 3		2 10	2 33							

Group:	9.	9.1	9.2	9.2.1	9.2.2	9.3	9.4	9.5	9.6	9.7	9.8
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
MONARDA CLINOPODIA	2 29	2 100	2 20		2 29		2 20		3 100	4 20	2 50
MONARDA DIDYMA	2 26						2 40	2 50		2 60	3 100
NYSSA SYLVATICA	2 3	2 33									
ORCHIDACEAE SPECIES #1	1 3		1 10		1 14						
OSMORHIZA CLAYTONII	2 88	1 67	2 90	2 100	2 86	2 100	1 60	2 100	2 100	2 100	2 100
OXALIS MONTANA	2 24		2 10	2 33		3 67	2 40	2 50		2 20	
OXALIS STRICTA	2 6	2 67									
OXYDENDRUM ARBOREUM	3 6	3 67									
PANAX QUINQUEFOLIUS*	1 38		1 70	2 67	1 71	1 33	1 40	1 25	2 100		
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	2 56	3 100	2 50	2 100	2 29	2 100	2 20	4 100	2 100	1 20	
PHACELIA BIPINNATIFIDA	1 3		1 10		1 14						
PHEGOPTERIS HEXAGONOPTERA	2 15	2 33	2 30	2 100					1 50		
PHRYMA LEPTOSTACHYA	1 3		1 10		1 14						
PINUS STROBUS	1 6	1 33	1 10		1 14						
PLATANTHERA CLAVELLATA	1 3		1 10	1 33							
POA AUTUMNALIS	1 3									1 20	
POA COMPRESSA	1 26	1 33	1 20	1 33	1 14			1 25		2 60	2 100
POA CUSPIDATA	2 18		1 30		1 43		2 40				2 50
PODOPHYLLUM PELTATUM	2 24		2 40	1 33	3 43		2 20	1 25		2 40	
POLYGONATUM BIFLORUM VAR BIFLORUM	2 74	2 67	2 80	2 100	2 71	2 67	2 80	2 75	2 100	2 80	
POLYGONATUM PUBESCENS	2 26		3 20		3 29	1 100	2 20	1 25	2 100		
POLYGONUM VIRGINIANUM	1 12	1 67	1 10		1 14					1 20	
POLYPODIUM APPALACHIANUM	2 21		2 10		2 14	2 33	2 40	2 50			1 50
POLYPODIUM VIRGINIANUM	2 6		1 10	1 33		2 33					
POLYSTICHUM ACROSTICHOIDES	2 100	3 100	3 100	2 100	3 100	2 100	2 100	2 100	2 100	2 100	3 100
PRENANTHES SP. #1	2 62	2 100	2 90	2 67	2 100		2 80	2 50		1 60	
PROSARTES LANUGINOSA	2 85	1 33	2 100	2 100	2 100	2 100	2 80	2 75	1 100	1 80	2 100
PRUNUS PENSYLVANICA	2 26	2 33	1 10		1 14		2 60		2 50	3 60	
PRUNUS SEROTINA	2 50	4 33	2 60	6 33	2 71	1 33	2 40	2 50	1 100	4 40	6 50
PYRULARIA PUBERA	3 24		3 30	5 33	3 29	3 67	3 40	4 25			
QUERCUS COCCINEA VAR COCCINEA	1 3		1 10	1 33							
QUERCUS RUBRA	2 74	2 67	3 70	2 67	3 71	2 67	4 100	2 75	3 100	1 60	1 50
QUERCUS VELUTINA	1 3	1 33									
QUERCUS X HAWKINSIAE	4 3							4 25			
RANUNCULUS HISPIDUS	1 21	1 67	2 30	2 67	2 14			1 25			1 50
RANUNCULUS RECURVATUS	2 6		2 10		2 14				1 50		
RHODODENDRON MAXIMUM	2 26	2 33	1 10		1 14	2 100	3 40	3 50			
RIBES CYNOSBATI	2 18		2 20		2 29			2 25		2 60	
ROBINIA PSEUDOACACIA	2 26	2 100	2 20		2 29		1 20	6 25	4 50	1 20	

Group:	9.	9.1	9.2	9.2.1	9.2.2	9.3	9.4	9.5	9.6	9.7	9.8
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
RUBUS ARGUTUS	2 15	2 67	2 10		2 14			2 50			
RUBUS CANADENSIS	2 62	2 33	2 60	1 67	2 57	1 100	2 100	2 50		2 60	2 50
RUBUS ODORATUS VAR ODORATUS	1 3		1 10		1 14						
RUDBECKIA LACINIATA	4 15		5 10		5 14					2 40	6 100
SAMBUCUS CANADENSIS VAR CANADENSIS	2 3						2 20				
SAMBUCUS RACEMOSA VAR PUBENS	1 3									1 20	
SANGUINARIA CANADENSIS	1 32		1 60	2 67	1 57	1 67		2 25	1 100		
SANICULA CANADENSIS VAR CANADENSIS	2 24	2 100	1 30		1 43	1 33				1 20	
SANICULA ODORATA	2 18		2 40	2 100	2 14				2 50		2 50
SANICULA SMALLII	1 9		2 20		2 29			1 25			
SANICULA TRIFOLIATA	2 6								2 50	2 20	
SASSAFRAS ALBIDUM	2 9	1 33	3 20	5 33	1 14						
SAXIFRAGA MICHAUXII	1 3										1 50
SAXIFRAGA MICRANTHIDIFOLIA	2 12		2 10		2 14		2 20	2 25			2 50
SCUTELLARIA ELLIPTICA VAR ELLIPTICA	1 3	1 33									
SENECIO AUREUS	3 6						1 20				4 50
SILENE VIRGINICA VAR VIRGINICA	1 12	1 33	1 10		1 14		1 20				1 50
SMILAX GLAUCA VAR GLAUCA	2 15	2 67				1 100					
SMILAX HERBACEA	1 24		1 30		1 43		1 60			1 20	1 50
SMILAX ROTUNDIFOLIA	2 53	2 100	2 40	1 33	2 43	1 67	2 60	1 50	1 100	2 20	1 50
SOLIDAGO CURTISII	3 100	1 100	3 100	1 100	3 100	3 100	4 100	3 100	6 100	5 100	4 100
SOLIDAGO FLEXICAULIS	2 9							2 25		3 40	
STACHYS CLINGMANII*	2 15	2 67	2 10		2 14		2 20			5 20	
STELLARIA PUBERA	3 100	2 100	2 100	2 100	2 100	3 100	2 100	2 100	2 100	5 100	2 100
STREPTOPUS ROSEUS VAR ROSEUS	1 6						1 40				
THALICTRUM CLAVATUM	2 21		2 20	1 33	2 14		2 80	2 25			
THALICTRUM CORIACEUM	2 6		2 20		2 29						
THALICTRUM DIOICUM	2 18	2 33	2 40	2 33	2 43					2 20	
THALICTRUM REVOLUTUM	2 9							2 25			2 100
THASPIUM BARBINODE	2 12		3 20		3 29		2 20				1 50
THELYPTERIS NOVEBORACENSIS	2 65	2 100	2 80	2 100	2 71	2 67	3 80	2 25	1 50	2 40	1 50
TIARELLA CORDIFOLIA VAR CORDIFOLIA	3 88	2 67	2 90	1 67	2 100	5 100	3 100	3 75	2 100	2 80	3 100
TILIA AMERICANA VAR HETEROPHYLLA	5 97	2 100	6 100	6 100	6 100	5 100	4 80	6 100	3 100	5 100	3 100
TIPULARIA DISCOLOR	1 3					1 33					
TOXICODENDRON RADICANS	1 3								1 50		

Group:	9.	9.1	9.2	9.2.1	9.2.2	9.3	9.4	9.5	9.6	9.7	9.8
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
TRAUTVETTERIA CAROLINIENSIS VAR CAROLINIENSIS	1 3						1 20				
TRILLIUM CUNEATUM	1 3		1 10	1 33							
TRILLIUM ERECTUM	1 76		2 90	1 100	2 86	1 100	2 80	2 75		1 100	1 100
TRILLIUM GRANDIFLORUM	2 21		2 30	2 33	2 29		2 60	2 25			
TRILLIUM LUTEUM	1 18	1 33	1 40	1 67	2 29			1 25			
TRILLIUM UNDULATUM	1 15		1 50	1 33	1 57						
TRILLIUM VASEYI	1 15		1 30	1 67	2 14		1 40				
TSUGA CANADENSIS	5 82	3 100	4 90	6 100	4 86	7 100	6 100	5 100		2 60	2 50
UVULARIA GRANDIFLORA	2 6								2 100		
UVULARIA PERFOLIATA	2 35		2 70	2 67	2 71			1 25	2 100	2 40	
UVULARIA PUBERULA	1 3	1 33									
VACCINIUM CORYMBOSUM	2 3		2 10		2 14						
VACCINIUM ERYTHROCARPUM	1 12		2 10		2 14		1 40				1 50
VACCINIUM SIMULATUM	2 9						2 40				1 50
VIBURNUM ACERIFOLIUM	2 29		2 60	2 67	1 57	2 67	2 40				
VIBURNUM LANTANOIDES	2 6						2 40				
VIOLA BLANDA	3 79	3 100	4 70	2 67	4 71	4 100	5 100	4 75	1 50	1 80	1 50
VIOLA CANADENSIS VAR CANADENSIS	2 76	2 67	2 70	2 100	2 57	2 100	2 20	2 100	3 100	3 100	2 100
VIOLA HASTATA	2 47	1 33	2 100	1 100	2 100		2 80			1 20	
VIOLA PALMATA VAR PALMATA	2 18	2 100	4 10		4 14				1 100		
VIOLA PUBESCENS VAR LEIOCARPON	2 6	2 33					2 20				
VIOLA PUBESCENS VAR PUBESCENS	2 15		2 40		2 57		1 20				
VIOLA ROTUNDIFOLIA	2 38		2 80	2 67	2 86	1 33	2 80				
VIOLA SORORIA	2 38	3 33	2 40		2 57		2 40	2 50		1 60	2 50
VIOLA STRIATA	1 6	1 67									
VITIS AESTIVALIS VAR AESTIVALIS	2 9					2 67				3 20	
VITIS AESTIVALIS VAR BICOLOR	2 3	2 33									
VITIS CINEREA VAR BAILEYANA	2 12		1 10		1 14			4 50	1 50		
VITIS VULPINA	3 6	2 33							3 50		

Table 5.41. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Rich Cove and Slope Forests** vegetation class and associated community types and sub-types. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

9. Rich Cove and Slope Forests

SCINAME	SAPDEN	TREDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER SACCHARUM VAR SACCHARUM	132.57	172.87	12.06	317.50	4.97	14.18	11.81	13.00
AESCULUS FLAVA	80.54	52.40	9.51	142.45	3.79	8.91	9.11	9.01
FAGUS GRANDIFOLIA	222.99	94.31	4.02	321.32	1.56	12.69	3.27	7.98
HALESIA TETRAPTERA VAR MONTICOLA	156.94	66.59	7.23	230.76	3.50	12.03	8.36	10.20
LIRIODENDRON TULIPIFERA	5.88	21.64	20.49	48.01	10.14	2.31	19.64	10.97
TILIA AMERICANA VAR HETEROPHYLLA	91.42	63.16	14.56	169.14	5.22	7.35	12.12	9.74
TSUGA CANADENSIS	28.68	117.70	10.69	157.06	5.41	7.10	9.73	8.41
ALL	1341.47	852.18	102.41	2296.06	46.16	99.47	99.93	99.70

9.1 Liriodendron/Cornus florida Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	3.33	160.00	10.00	173.33	7.67	9.88	18.28	14.08
ACER SACCHARUM VAR SACCHARUM	43.33	213.33	0.00	256.67	0.71	12.28	1.47	6.88
HALESIA TETRAPTERA VAR MONTICOLA	360.00	30.00	0.00	390.00	0.20	24.77	0.42	12.60
LIRIODENDRON TULIPIFERA	0.00	156.67	93.33	250.00	29.76	13.65	65.88	39.76
ALL	756.67	903.33	103.33	1763.33	43.77	100.01	99.99	99.99

9.2 Acer saccharum-Halesia/Cimicifuga racemosa Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	189.00	29.00	0.00	218.00	0.24	11.06	0.63	5.85
ACER SACCHARUM VAR SACCHARUM	176.00	281.00	9.00	466.00	5.04	19.96	11.06	15.51
FAGUS GRANDIFOLIA	304.00	94.00	7.00	405.00	2.36	13.22	4.17	8.70
HALESIA TETRAPTERA VAR MONTICOLA	173.00	83.00	11.00	267.00	5.77	13.07	13.72	13.40
LIRIODENDRON TULIPIFERA	11.00	4.00	10.00	25.00	9.51	0.98	15.10	8.04
QUERCUS RUBRA	0.00	1.00	8.54	9.54	6.48	0.37	13.54	6.96
TILIA AMERICANA VAR HETEROPHYLLA	136.00	62.00	13.00	211.00	5.09	9.34	12.07	10.70
TSUGA CANADENSIS	25.00	66.00	14.00	105.00	4.56	5.82	7.37	6.60
ALL	1460.00	764.00	97.54	2321.54	49.33	99.43	99.91	99.67

9.2.1 Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER SACCHARUM VAR SACCHARUM	176.67	173.33	6.67	356.67	3.32	14.26	6.82	10.54
CARPINUS CAROLINIANA	210.00	56.67	0.00	266.67	0.12	8.97	0.18	4.57
FAGUS GRANDIFOLIA	133.33	93.33	13.33	240.00	3.38	9.51	5.71	7.61
HALESIA TETRAPTERA VAR MONTICOLA	150.00	53.33	6.67	210.00	3.64	9.35	8.20	8.77
LIRIODENDRON TULIPIFERA	3.33	0.00	16.67	20.00	19.43	0.77	28.02	14.39
PYRULARIA PUBERA	183.33	0.00	0.00	183.33	0.02	8.57	0.06	4.31
TILIA AMERICANA VAR HETEROPHYLLA	213.33	76.67	13.33	303.33	5.92	14.92	10.38	12.66
TSUGA CANADENSIS	40.00	140.00	36.67	216.67	12.54	12.52	17.45	14.99
ALL	1386.67	713.33	120.00	2220.00	56.95	99.22	99.99	99.61

9.2.2 Halesia-Acer saccharum-Tilia/Viola blanda sub-type

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	235.71	38.57	0.00	274.29	0.33	14.05	0.88	7.47
ACER SACCHARUM VAR SACCHARUM	175.71	327.14	10.00	512.86	5.78	22.40	12.88	17.64
AESCULUS FLAVA	70.00	34.29	10.00	114.29	2.32	4.93	5.99	5.46
FAGUS GRANDIFOLIA	377.14	94.29	4.29	475.71	1.93	14.82	3.51	9.16
HALESIA TETRAPTERA VAR MONTICOLA	182.86	95.71	12.86	291.43	6.69	14.66	16.09	15.38
LIRIODENDRON TULIPIFERA	14.29	5.71	7.14	27.14	5.26	1.06	9.57	5.32
QUERCUS RUBRA	0.00	1.43	7.91	9.34	8.42	0.33	16.56	8.45
TILIA AMERICANA VAR HETEROPHYLLA	102.86	55.71	12.86	171.43	4.73	6.94	12.79	9.86
ALL	1491.43	785.71	87.91	2365.06	46.07	99.52	99.87	99.70

9.3 Tsuga canadensis-Halesia/Laportea Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER PENSYLVANICUM	113.33	96.67	0.00	210.00	0.25	11.68	0.45	6.06
ACER SACCHARUM VAR SACCHARUM	73.33	50.00	3.33	126.67	1.56	6.21	2.53	4.37
BETULA LENTA	16.67	26.67	16.67	60.00	4.48	2.96	7.87	5.42
HALESIA TETRAPTERA VAR MONTICOLA	56.67	116.67	0.00	173.33	3.20	8.98	5.68	7.33
LIRIODENDRON TULIPIFERA	13.33	10.00	6.67	30.00	9.36	1.45	13.25	7.35
TILIA AMERICANA VAR HETEROPHYLLA	60.00	33.33	13.33	106.67	5.17	5.26	8.47	6.87
TSUGA CANADENSIS	46.67	453.33	53.33	553.33	30.68	26.58	51.84	39.21
ALL	800.00	1140.00	103.33	2043.33	60.37	99.71	99.99	99.84

9.4 Acer saccharum-Fagus/Viola blanda Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER SACCHARUM VAR SACCHARUM	207.00	73.33	14.50	294.83	4.79	9.26	9.57	9.41
BETULA ALLEGHANIENSIS	114.00	84.00	8.00	206.00	2.64	4.61	5.69	5.15
FAGUS GRANDIFOLIA	546.33	265.33	7.33	819.00	2.89	30.73	5.57	18.15
HALESIA TETRAPTERA VAR MONTICOLA	132.17	69.00	6.67	207.83	2.97	8.03	5.74	6.88
LIRIODENDRON TULIPIFERA	4.00	5.17	16.17	25.33	10.53	0.84	19.37	10.11
MAGNOLIA ACUMINATA	8.50	6.67	12.00	27.17	3.25	1.01	7.11	4.06
QUERCUS RUBRA	36.00	7.17	8.65	51.82	5.65	1.20	11.22	6.21
TILIA AMERICANA VAR HETEROPHYLLA	78.50	73.17	17.83	169.50	5.04	4.54	11.20	7.87
TSUGA CANADENSIS	93.00	322.50	6.00	421.50	6.22	15.11	12.47	13.79
ALL	2030.17	1112.33	113.82	3256.32	49.25	100.00	100.00	100.00

9.5 Liriodendron-Tilia/Asarum canadense Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER SACCHARUM VAR SACCHARUM	267.50	169.17	5.00	441.67	2.41	13.58	4.93	9.26
AESCULUS FLAVA	95.83	56.67	25.00	177.50	7.30	9.29	13.56	11.42
ARISTOLOCHIA MACROPHYLLA	278.33	63.33	0.00	341.67	0.15	10.72	0.32	5.52
BETULA ALLEGHANIENSIS	34.17	116.67	0.00	150.83	2.95	5.71	6.72	6.22
HAMAMELIS VIRGINIANA	179.17	100.00	0.00	279.17	0.18	8.83	0.41	4.62
LIRIODENDRON TULIPIFERA	7.50	42.50	39.17	89.17	14.24	4.10	31.12	17.61
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	347.50	10.83	0.00	358.33	0.02	9.91	0.05	4.98
RHODODENDRON MAXIMUM	224.17	152.50	0.00	376.67	0.29	9.63	0.74	5.18
TILIA AMERICANA VAR HETEROPHYLLA	78.33	136.67	23.33	238.33	9.12	5.86	21.47	13.67
TSUGA CANADENSIS	5.00	39.17	8.33	52.50	3.08	2.60	7.69	5.15
ALL	1894.17	1225.83	110.83	3230.83	45.31	99.30	99.76	99.53

9.6 [Acer saccharum-Halesia/Cladrastis/Solidago curtisii Forest]

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER SACCHARUM VAR SACCHARUM	45.00	60.83	41.25	147.08	12.64	6.55	29.72	18.14
AESCULUS FLAVA	176.25	97.50	10.00	283.75	3.57	12.39	9.34	10.86
HALESIA TETRAPTERA VAR MONTICOLA	423.75	85.00	12.50	521.25	5.59	19.12	12.93	16.02
LINDERA BENZOIN	592.50	0.00	0.00	592.50	0.07	26.68	0.17	13.42
LIRIODENDRON TULIPIFERA	0.00	0.00	29.58	29.58	11.26	1.48	28.94	15.21
TILIA AMERICANA VAR HETEROPHYLLA	296.25	95.00	6.25	397.50	3.83	16.57	9.16	12.86
ALL	1805.00	392.08	109.58	2306.67	40.61	95.64	99.74	97.68

9.7 Aesculus-Acer saccharum/Solidago curtisii Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER SACCHARUM VAR SACCHARUM	22.50	178.50	21.00	222.00	8.57	18.65	24.05	21.35
AESCULUS FLAVA	216.50	144.00	14.00	374.50	8.78	31.97	20.11	26.04
BETULA ALLEGHANIENSIS	0.00	18.00	10.50	28.50	2.16	2.61	5.70	4.15
FAGUS GRANDIFOLIA	136.00	20.00	2.00	158.00	0.81	8.32	1.36	4.84
HALESIA TETRAPTERA VAR MONTICOLA	115.50	72.50	15.50	203.50	4.88	17.75	14.58	16.16
TILIA AMERICANA VAR HETEROPHYLLA	34.00	47.00	24.00	105.00	7.33	9.77	18.16	13.96
ALL	590.50	513.00	105.00	1208.50	38.49	99.99	100.00	99.99

9.8 [Aesculus/Rudbeckia lacinata Forest]

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER SACCHARUM VAR SACCHARUM	45.00	110.00	15.00	170.00	5.08	10.02	15.87	12.94
AESCULUS FLAVA	140.00	145.00	20.00	305.00	11.85	18.38	37.31	27.84
BETULA ALLEGHANIENSIS	10.00	30.00	20.00	60.00	7.66	3.22	23.43	13.32
FAGUS GRANDIFOLIA	545.00	300.00	5.00	850.00	4.52	45.78	16.17	30.98
TILIA AMERICANA VAR HETEROPHYLLA	45.00	25.00	5.00	75.00	1.29	4.54	4.25	4.39
ALL	1025.00	695.00	65.00	1785.00	31.26	100.03	99.99	100.00

Table 5.42. Vertical structure of woody species in the **Rich Cove and Slope Forests** vegetation class and associated community types and sub-types. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

9. Rich Cove and Slope Forest

SCINAME	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2	1		
ACER RUBRUM VAR RUBRUM	1	1	1	1	
ACER SACCHARUM VAR SACCHARUM	1	3	4	5	
AESCULUS FLAVA	1	2	1	2	
BETULA ALLEGHANIENSIS	1	1	1	2	
BETULA LENTA	1	1	1	1	
FAGUS GRANDIFOLIA	1	1	1		
HALESIA TETRAPTERA VAR MONTICOLA	1	2	2	3	
HAMAMELIS VIRGINIANA	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	2	1
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	3	
TSUGA CANADENSIS	1	2	2	2	

9.1 Liriodendron/Cornus florida Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	2	3	5	
ACER SACCHARUM VAR SACCHARUM	1	1	5	3	
AESCULUS FLAVA	1	1			
BETULA LENTA	1	1	1	2	2
CORNUS FLORIDA	1	3	1		
HALESIA TETRAPTERA VAR MONTICOLA	1	3	2	2	
JUGLANS NIGRA	1	1	1	1	1
LINDERA BENZOIN	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	4	5
OXYDENDRUM ARBOREUM	1	1	1		
PRUNUS SEROTINA	1	1	1	1	
SMILAX ROTUNDIFOLIA	1	1			
TSUGA CANADENSIS	1	2	1		

9.2 Acer saccharum-Halesia/Cimicifuga racemosa Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
SCINAME					
ACER PENSYLVANICUM	1	2			
ACER RUBRUM VAR RUBRUM	1	1	1	2	
ACER SACCHARUM VAR SACCHARUM	1	4	4	5	
AESCULUS FLAVA	1	2	1	2	
BETULA LENTA	1	1	1	2	
FAGUS GRANDIFOLIA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	1	2	5	
LIRIODENDRON TULIPIFERA	1	1	1	2	1
QUERCUS RUBRA	1	1	1	1	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	4	
TSUGA CANADENSIS	1	2	1	2	

9.2.1 Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER RUBRUM VAR RUBRUM	1	1	1	2	
ACER SACCHARUM VAR SACCHARUM	1	3	2	4	
AESCULUS FLAVA	1	1			
BETULA LENTA	1	1	1	3	
CARPINUS CAROLINIANA	1	2			
CARYA GLABRA	1	1	1	1	
CORNUS FLORIDA	1	2	1		
FAGUS GRANDIFOLIA	1	1	1	1	2
FRAXINUS AMERICANA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1	4	2
LINDERA BENZOIN	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	4	2
PRUNUS SEROTINA	1	1	1	2	
PYRULARIA PUBERA	1	1			
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	6	1
TSUGA CANADENSIS	1	2	1	3	

9.2.2 Halesia-Acer saccharum-Tilia/Viola blanda sub-type

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	3	1		
ACER RUBRUM VAR RUBRUM	1	1	1	1	
ACER SACCHARUM VAR SACCHARUM	1	4	4	6	
AESCULUS FLAVA	1	2	1	2	
BETULA ALLEGHANIENSIS	1	1	1	1	
BETULA LENTA	1	1	1	2	
CARYA OVATA	1	1	1	1	
FAGUS GRANDIFOLIA	1	1			
HALESIA TETRAPTERA VAR MONTICOLA	1	1	2	5	
LIRIODENDRON TULIPIFERA	1	1	1	1	1
MAGNOLIA FRASERI	1	1	1	1	
QUERCUS RUBRA	1	1	1	1	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	2	
TSUGA CANADENSIS	1	1	2	1	

9.3 Tsuga canadensis-Halesia/Laportea Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	4	2		
ACER RUBRUM VAR RUBRUM	1	1			
ACER SACCHARUM VAR SACCHARUM	1	2	3	2	1
AMELANCHIER ARBOREA	1	1			
BETULA ALLEGHANIENSIS	1	1			
BETULA LENTA	1	1	1	2	2
CALYCANTHUS FLORIDUS VAR GLAUCUS	1	1			
CLETHRA ACUMINATA	1	1			
CORNUS ALTERNIFOLIA	1	2			
FAGUS GRANDIFOLIA	1	2			
FRAXINUS AMERICANA	1	2			
HALESIA TETRAPTERA VAR MONTICOLA	1	2	4	5	3
HAMAMELIS VIRGINIANA	1	1			
ILEX MONTANA	2	3			
ILEX OPACA VAR OPACA	1	1			
LINDERA BENZOIN	1	1			
LIRIODENDRON TULIPIFERA	1	1	1	1	2
MAGNOLIA ACUMINATA	1	1			
MAGNOLIA FRASERI	1	1			
PYRULARIA PUBERA	1	1			
QUERCUS RUBRA	1	1			
RHODODENDRON MAXIMUM	1	1			
TILIA AMERICANA VAR HETEROPHYLLA	1	2	1	2	3
TSUGA CANADENSIS	1	4	4	8	7

9.4 Acer saccharum-Fagus/Viola blanda Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1	1		
ACER RUBRUM VAR RUBRUM	1	1	2	3	
ACER SACCHARUM VAR SACCHARUM	1	2	5	4	
AESCULUS FLAVA	1	1	1	1	
ARISTOLOCHIA MACROPHYLLA	1	1	1		
BETULA ALLEGHANIENSIS	1	1	2	3	
BETULA LENTA	1	1	1	1	
FAGUS GRANDIFOLIA	1	3	3	2	
HALESIA TETRAPTERA VAR MONTICOLA	1	2	2	3	
HAMAMELIS VIRGINIANA	1	2	1		
LIRIODENDRON TULIPIFERA	1	1	2	3	
MAGNOLIA ACUMINATA	1	1	1	3	
QUERCUS RUBRA	1	1	1	2	1
RHODODENDRON MAXIMUM	1	1			
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	3	
TSUGA CANADENSIS	1	6	3	1	

9.5 Liriodendron-Tilia/Asarum canadense Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2			
ACER SACCHARUM VAR SACCHARUM	1	3	4	4	
AESCULUS FLAVA	1	3	3	2	
ARISTOLOCHIA MACROPHYLLA	1	2	1		
BETULA ALLEGHANIENSIS	1	1	3	6	
HALESIA TETRAPTERA VAR MONTICOLA	1	2	1	1	
HAMAMELIS VIRGINIANA	1	3	1		
LIRIODENDRON TULIPIFERA	1	1	2	6	
MAGNOLIA ACUMINATA	1	1	1	1	
RHODODENDRON MAXIMUM	1	1			
ROBINIA PSEUDOACACIA	1	1	1	1	
TILIA AMERICANA VAR HETEROPHYLLA	1	1	3	5	
TSUGA CANADENSIS	1	2	3	2	
VITIS CINEREA VAR BAILEYANA	1	1	1	1	

9.6 [Acer saccharum-Halesia/Cladrastis/Solidago curtisii Forest]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER SACCHARUM VAR					
SACCHARUM	1	1	1	7	5
AESCULUS FLAVA	1	3	1	3	
ASIMINA TRILOBA	1	4			
HALESIA TETRAPTERA VAR					
MONTICOLA	1	3	1	4	3
LINDERA BENZOIN	1	3			
LIRIODENDRON TULIPIFERA	1	1	2	4	1
ROBINIA PSEUDOACACIA	1	1	1	1	
TILIA AMERICANA VAR					
HETEROPHYLLA	1	1	1		

9.7 Aesculus-Acer saccharum/Solidago curtisii Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	1			
ACER SACCHARUM VAR					
SACCHARUM	1	3	3	6	1
AESCULUS FLAVA	1	3	3	4	1
BETULA ALLEGHANIENSIS	1	1	1	2	
BETULA LENTA	1	1	1	1	
CARYA GLABRA	1	1	1	1	1
FRAXINUS AMERICANA	1	1			
HALESIA TETRAPTERA VAR					
MONTICOLA	1	2	1	3	1
PRUNUS PENSYLVANICA	1	1	1	1	
PRUNUS SEROTINA	1	1	1	1	
TILIA AMERICANA VAR					
HETEROPHYLLA	1	1	2	4	

9.8 [Aesculus/Rudbeckia lacinata Forest]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER SACCHARUM VAR					
SACCHARUM	1	3	6	4	
ACER SPICATUM	1	1			
AESCULUS FLAVA	1	3	6	8	
BETULA ALLEGHANIENSIS	1	1	3	3	
FAGUS GRANDIFOLIA	1	5	2	5	
ILEX MONTANA	1	1			
PRUNUS SEROTINA	1	1	1	3	

Table 5.43. Average site information for the **Rich Cove and Slope Forests** vegetation class. Groups represented by their abbreviation code. For full names see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**Q**=colluvium and alluvium, **11**=arkosic metasandstone-metaconglomerate-metasiltstone, **12**=metagraywacke, **13**=arkosic metasandstone-metaconglomerate), Landform types (representing micro-scale topographic units) (**C**=coves, **SS**=sideslopes) and Topographic position (representing macro-scale topographic units) (**LS**=lower slopes, **MS**=mid-slopes, **T**=toeslopes, **US**=upper-slopes).

9. Rich Cove and Slope Forests

	Group										
	9.	9.1	9.2	9.2.1	9.2.2	9.3	9.4	9.5	9.6	9.7	9.8
Site Characteristics:											
Elevation (m)	969	645	954	796	1022	791	1106	843	916	1109	1413
Slope (o)	21	10	23	16	27	25	14	12	28	27	29
Aspect (o)	W-E		NW-NE	N	NW-NE	NE	E-S	W-E	N	N,E	
Parent Material		Q		Q		13	13,Q		10	10,11	12
Soil depth (cm)	52.8	48.2	65.6	70.8	63.3	72.2	47.2	37.1	43.1	47.1	32.9
Surface Substrate (%):											
Moss/Lichen	10	2	8	13	7	16	11	30	3	3	16
Wood	5	6	7	9	6	7	5	3	3	4	3
Rock	12	13	5	5	4	0	20	40	4	5	25
Organic Matter	78	73	85	81	87	81	72	50	91	90	68
Water	2	0	1	2	1	0	6	9	0	1	1
Topographic Characteristics:											
Relative slope	78	85	68	76	64	74	87	93	92	72	72
LFI	0.28	0.20	0.27	0.23	0.29	0.24	0.28	0.32	0.29	0.30	0.29
TSI	0.06	0.03	0.07	0.04	0.09	-0.02	0.01	0.18	0.06	0.07	-0.03
Landform type	SS	C	SS	C	SS	SS	C,SS	C	C,SS	C,SS	SS
Topgraphic pos.	MS,US	T	US	T,LS	US	LS	MS	T,MS	US	MS,US	US

5.5.10 VEGETATION CLASS: 10. Alluvial Forests

Alluvial Forests have limited distributed in the Southern Appalachian Mountains, restricted to stream edges and river floodplains (Schafale and Weakley 1990, Chapters 3 & 4). In Joyce Kilmer this vegetation class is mostly confined to a few broad, flat river margins and permanent islands scattered along the lower-half of Slickrock Creek.

COMMUNITY TYPE: [Liriodendron-Platanus/Amphicarpaea Alluvial Forest] (10.1)

Synonymy

Montane Alluvial Forest p.p. (Schafale & Weakley 1990), Rich Cove Forest (Schafale & Weakley 1990), Oak, Mixed Mesic Forest p.p. (McLeod 1988).

Listed species

Carex lucorum var. *austrolucorum*, *Panax quinquefolius*, *Stachys clingmanii*.

Physiognomy

Tall (35 m height) *Liriodendron tulipifera*, *Platanus occidentalis* and *Betula lenta* dominate the canopy of this stand (Tables 5.44, 5.45, 5.46). *Aesculus*, *Carya alba* and *Fagus* are also present. The understory is open with *Tsuga canadensis* and *Halesia tetraptera* dominant. The high large-scale species richness levels (Table 5.9) are a reflection of the broad set of species scattered across the forest floor. *Amphicarpaea bracteata* and *Cimicifuga racemosa* are most abundant in this stratum.

Habitat and Distribution

This stand is situated on a low-elevation (485 m), west-facing toeslope (12° slope) at the confluence of two small creeks at the head the cove below Yellowhammer Gap (Table 5.47; Appendix 6). Periodic flooding may account for the high soil fertility (Tables

5.7, 5.8). This type has highest base saturation, Ca and pH levels of any type or sub-type in the study.

Distinguishing Features

This stand has highest species richness of the two **Alluvial Forests** types at all spatial scales (Table 5.9). A well-developed ground-floor strata, most likely the result of lower flooding frequency and intensity in the **[Liriodendron-Platanus/Amphicarpaea Forest]**, probably accounts for differences in richness levels between these two types.

Succession and Disturbance

Lack of saplings of all species that presently dominate this stand suggests the canopy composition will change greatly (Table 5.45). The abundance of *Carya alba*, *Halesia* and *Tsuga* saplings indicates that these species may dominate the future canopy.

COMMUNITY TYPE: Platanus-Betula alleghaniensis Alluvial Forest (10.2)

Synonymy

Montane Alluvial Forest (Schafale & Weakley 1990), Floodplain Woodlands (Pittillo & Smathers 1979), Alluvial Forests (McLeod 1988), [*Platanus/Asimina/Microstegium* Alluvial Forest] p.p. (Chapter 3).

Constant species

Aristolochia macrophylla, *Aster divaricatus*, *Athyrium asplenioides*, *Betula alleghaniensis*, *Betula lenta*, *Fraxinus americana*, *Hamamelis virginiana*, *Hydrangea arborescens*, *Leucothoe fontanesiana*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Luzula multiflora*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Pinus strobus*, *Platanus occidentalis*, *Polystichum acrostichoides*, *Prunella vulgaris*, *Rhododendron maximum*, *Rubus canadensis*, *Rudbeckia lacinata*, *Tilia americana* var. *heterophylla*, *Tsuga canadensis*, *Viola blanda*.

Physiognomy

Large-diameter *Platanus occidentalis* (40 to 49 cm) and *Betula alleghaniensis* dominate the canopy (23 m height) in conjunction with *B. lenta* and *Liriodendron tulipifera* and scattered *Fraxinus americana* and *Liquidambar styraciflua* (Tables 5.44, 5.45, 5.46). The high total basal area (50.97 m^2) reflects the density and size of the trees present in this community type. *Platanus* and *B. alleghaniensis* also dominate the subcanopy. *Tsuga* is the major shrub layer species with *Hamamelis* and *Pinus strobus* also present. *Cornus florida* and *Alnus serrulata* have more variable cover in this stratum. The ground is rocky with patchy vascular cover with comparatively low small-scale species richness (Table 12). *Leucothoe fontanesiana* dominates this stratum in one stand. *Aster divaricatus*, *Athyrium asplenioides*, *Hydrangea arborescens*, *Luzula multiflora*, *Parthenocissus quinquefolia* var. *quinquefolia*, *Polystichum acrostichoides*, *Prunella vulgaris*, *Rubus canadensis*, *Rudbeckia lacinata* and *Viola blanda* have consistent, but low abundance across the three sites.

Habitat and Distribution

The **Platanus-Betula alleghaniensis Alluvial Forest** inhabits small permanent islands and broad river margins in the flatter portions (1° average slope) of mid- and lower-Slickrock Creek (418 to 503 m elevation, 468 m mean) (Table 5.47, Appendix 6). The soils are much sandier and more fertile on average than those of other vegetation classes, but lower than those in the **[Liriodendron-Platanus/Amphicarpaea Alluvial Forest]**. The former type has much lower Al and N values than recorded in other vegetation classes (Tables 5.7, 5.8). All three sites are mapped as having metasandstone-metaconglomerate bedrock (parent material type 3; Figure 1.5), but their inhabitance of river flats and islands suggests that the underlying substrate maybe alluvial in origin.

Distinguishing Features

This community type has high basal area measurements that are comparable to levels in the ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type***, which contains scattered large-diameter (107-141 cm diameter) *Liriodendron* (Tables 5.41, 5.45). However, in this **Alluvial Forest** type high densities of medium-sized trees account for high basal area values rather than the presence of especially large-sized individuals.

Succession and Disturbance

This community type is subject to infrequent flooding and this is reflected by the restricted distribution of herbaceous species and dominance of a gravel-rock ground stratum. The periodicity and intensity of flooding will determine the longevity and sustainability of the **Platanus-Betula alleghaniensis Alluvial Forest**. High flooding or more frequent flooding could preclude tree seedling establishment. Canopy-sized *Betula alleghaniensis*, *Liriodendron* and *Platanus* trees are typically aged between 40 and 50 years. The young, even age of this canopy suggests that the present community type established 50 or so years ago after a particularly high flood or a dramatic change in the flooding regime. High sapling numbers indicate that a woody species-based community type can be self-sustaining under the present flooding regime (Table 5.45). Limited *Platanus* saplings and high *Tsuga* and *Betula alleghaniensis* numbers suggest that the composition of the canopy may alter in the future. Less frequent flooding than the present regime would enable soil profile development, permitting the development of a spatially more extensive and well-developed herbaceous layer.

Discussion

The **Alluvial Forests** vegetation class is restricted to river flats and islands in the lower half of the Slickrock valley. The less meandering path of the Little Santeetlah Creek probably flushes sediment quickly downstream inhibiting alluvial build-up and the formation of islands. This watershed is also smaller than the Slickrock valley and has a steeper vertical descent per unit distance than the Slickrock valley. There are extensive broad toeslopes and river flats in the Little Santeetlah Creek watershed, but these typically have well-developed soils and a much lower flood frequency. These areas are inhabited by the **Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest**.

Data summarized in this study adds additional information to the seldom described **Alluvial Forests** vegetation class. The **Platanus-Betula alleghaniensis Alluvial Forest** has similar canopy composition to the Floodplain Woodlands documented by Pittillo & Smathers (1979) who describe the dominance of *Platanus*, *Liriodendron* and *Halesia*. However, *Halesia* is absent in the Joyce Kilmer type. The understory composition is also different and less developed in this type, which probably results from a higher flood frequency and predominately boulder substrate. Differences in the composition of adjacent forests, which are probably the source for invading species, may also account for compositional differences between these two **Alluvial Forests**. At Linville Gorge Wilderness an **Alluvial Forest** dominated by *Platanus*, *Liquidambar* and *Liriodendron*, (the **[Platanus/Asimina/Microstegium Forest]**; Chapter 3) inhabits a similar elevation (409 m) to the **Platanus-Betula alleghaniensis Alluvial Forest**. However, the Linville type has a lower flooding regime and a well-developed herbaceous layer dominated by *Ageratina altissima* and introduced *Microstegium*. The presence of *Betula alleghaniensis* and lower abundance of *Liquidambar* in the Joyce Kilmer type also contrasts to the Linville Gorge type, which Schafale & Weakley (1990) suggest reflects a more montane environment. It is possible that the proximity of Linville Gorge to the piedmont and greater distance from higher-elevation vegetation allows a greater piedmont/low mountain (Schafale & Weakley 1990) selection of species to dominate.

The **[Liriodendron-Platanus/Amphicarpaea Alluvial Forest]** does not closely resemble previous descriptions. This type inhabits a toeslope of a small, low-elevation creek. The small-size of this creek and presence of a well-developed understory in the **[Liriodendron-Platanus/Amphicarpaea Alluvial Forest]** suggests that this community has a low-frequency, low-intensity flooding regime. The existence of *Liriodendron* and *Platanus* in the canopy, presence of a well-developed herbaceous layer and low frequency flooding regime gives this type loose affiliation with the **[Platanus/Asimina/**

Microstegium Forest] at Linville Gorge Wilderness (Chapter 3).

Table 5.44. Average cover class and constancy of species present in the **Alluvial Forests** vegetation class. The vegetation class is represented by its abbreviation code. For full name see Table 5.1. 'Cov' is the mean cover class for a species for the sites it is present in, 'Con' is the constancy of a species and '*' indicates a regionally or nationally listed species.

Group:	10.	10.1	10.2
Number of plots:	4	1	3
Homoteniety:	0.686		0.774
	Cov/Con	Cov/Con	Cov/Con
Species			
ACER PENSYLVANICUM	3 75	4 100	2 67
ACER RUBRUM VAR RUBRUM	5 75	4 100	6 67
ACER SACCHARUM VAR SACCHARUM	2 25		2 33
ADIANTUM PEDATUM VAR PEDATUM	1 25	1 100	
AESCULUS FLAVA	5 50	5 100	5 33
AGERATINA ALTISSIMA VAR ROANENSIS	2 75	2 100	2 67
AGRIMONIA GRYPOSEPALA	1 25	1 100	
ALNUS SERRULATA	4 50		4 67
AMELANCHIER ARBOREA	1 50		1 67
AMPHICARPAEA BRACTEATA	6 25	6 100	
ARISTOLOCHIA MACROPHYLLA	2 100	1 100	2 100
ARISAEMA TRIPHYLLUM VAR TRIPHYLLUM	2 50	2 100	1 33
ARNOGLOSSUM ATRIPLICIFOLIUM	2 25		2 33
ASTER DIVARICATUS	2 100	2 100	2 100
ASTER LATERIFLORUS VAR LATERIFLORUS	2 25		2 33
ASTER PUNICEUS	1 25		1 33
ASTER RETROFLEXUS	2 50		2 67
ASTER UNDULATUS	2 25	2 100	
ATHYRIUM ASPLENIOIDES	2 75		2 100
BETULA ALLEGHANIENSIS	7 75		7 100
BETULA LENTA	6 100	7 100	6 100
BIGNONIA CAPREOLATA	2 50	2 100	2 33
BOTRYCHIUM VIRGINIANUM	2 25	2 100	
BRACHYELYTRUM ERECTUM	1 25	1 100	
CAMPANULA DIVARICATA	2 25		2 33
CARDAMINE DIPHYLLA	1 75	2 100	1 67
CAREX APPALACHICA	1 25	1 100	
CAREX AUSTROCAROLINIANA	2 25	2 100	
CAREX BLANDA	2 25	2 100	
CAREX DIGITALIS	2 50	1 100	2 33
CAREX LUCORUM VAR AUSTROLUCORUM*	1 25	1 100	
CAREX PLANTAGINEA	1 50		1 67
CAREX SWANII	1 25	1 100	
CAREX TORTA	2 50		2 67
CARPINUS CAROLINIANA	2 25		2 33
CARYA ALBA	3 75	6 100	1 67
CARYA OVATA	1 25	1 100	
CAULOPHYLLUM THALICTROIDES	1 25	1 100	
CHELONE GLABRA	1 50		1 67
CHIMAPHILA MACULATA VAR MACULATA	1 50	1 100	1 33
CIMICIFUGA RACEMOSA	5 25	5 100	
CIRCAEA CANADENSIS	2 25	2 100	
CLETHRA ACUMINATA	2 25		2 33
COLLINSONIA CANADENSIS	2 25		2 33

Group:	10.	10.1	10.2
	Cov/Con	Cov/Con	Cov/Con
CORNUS FLORIDA	3 75	1 100	4 67
DESMODIUM GLUTINOSUM	1 25	1 100	
DESMODIUM NUDIFLORUM	2 25	2 100	
DICHANTHELIUM BOSCII	1 50	1 100	1 33
DICHANTHELIUM COMMUTATUM	1 25		1 33
DICHANTHELIUM DICHOTOMUM VAR DICHOTOMUM	1 25		1 33
DIOSCOREA QUATERNATA	1 25	1 100	
DRYOPTERIS MARGINALIS	2 50	1 100	2 33
ERECHTITES HIERACIIFOLIA VAR HIERACIIFOLIA	2 25		2 33
ERIGERON PULCHELLUS VAR PULCHELLUS	1 25		1 33
EUONYMUS AMERICANA	2 75	2 100	2 67
EUPATORIUM PURPUREUM VAR PURPUREUM	2 75	1 100	2 67
FAGUS GRANDIFOLIA	5 25	5 100	
FRAXINUS AMERICANA	5 100	4 100	5 100
GALEARIS SPECTABILIS	1 25	1 100	
GALIUM APARINE	2 25	2 100	
GALIUM CIRCAEZANS VAR CIRCAEZANS	2 25	2 100	
GALIUM TRIFLORUM	1 25		1 33
GAYLUSSACIA URSINA	2 25		2 33
GOODYERA PUBESCENS	1 25	1 100	
HALESIA TETRAPTERA VAR MONTICOLA	4 50	5 100	2 33
HAMAMELIS VIRGINIANA	4 100	3 100	4 100
HEPATICA ACUTILOBA	1 25	1 100	
HEUCHERA VILLOSA VAR VILLOSA	2 25	2 100	
HIERACIUM PANICULATUM	1 25		1 33
HOUSTONIA PURPUREA VAR PURPUREA	1 25	1 100	
HOUSTONIA SERPYLLIFOLIA	2 50		2 67
HUPERZIA LUCIDULA	1 25		1 33
HYDRANGEA ARBORESCENS	2 75		2 100
IRIS CRISTATA	2 25	2 100	
KALMIA LATIFOLIA	3 50		3 67
LAPORTEA CANADENSIS	2 50	1 100	2 33
LEUCOTHOE FONTANESIANA	3 100	3 100	3 100
LIQUIDAMBAR STYRACIFLUA	5 75		5 100
LIRIODENDRON TULIPIFERA	6 100	6 100	6 100
LUZULA MULTIFLORA VAR CONGESTA	1 75		1 100
LYSIMACHIA QUADRIFOLIA	1 50	1 100	1 33
MAGNOLIA FRASERI	1 25		1 33
MAIANTHEMUM RACEMOSUM	1 75	2 100	1 67
MEDEOLA VIRGINIANA	1 25	1 100	
MICROSTEGIUM VIMINEUM	1 50		1 67
MITCHELLA REPENS	2 25	2 100	
MONARDA DIDYMA	2 50	2 100	1 33
OSMORHIZA CLAYTONII	2 25	2 100	
OXALIS GRANDIS	1 25		1 33
OXALIS STRICTA	2 25		2 33
OXYDENDRUM ARBOREUM	3 50		3 67
PANAX QUINQUEFOLIUS*	1 25	1 100	
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	2 100	2 100	2 100
PHEGOPTERIS HEXAGONOPTERA	2 25	2 100	
PHRYMA LEPTOSTACHYA	1 25	1 100	
PINUS STROBUS	3 100	1 100	3 100
PINUS VIRGINIANA	4 25		4 33
PLATANUS OCCIDENTALIS	7 100	6 100	7 100

Group:	10.	10.1	10.2
	Cov/Con	Cov/Con	Cov/Con
POA COMPRESSA	1 25	1 100	
POA CUSPIDATA	1 50		1 67
POLYGONATUM BIFLORUM VAR BIFLORUM	2 25	2 100	
POLYGONUM VIRGINIANUM	2 50		2 67
POLYSTICHUM ACROSTICHOIDES	3 100	4 100	2 100
PRENANTHES SP. #1	2 50	1 100	2 33
PROSARTES LANUGINOSA	1 25	1 100	
PRUNELLA VULGARIS	1 75		1 100
PYRULARIA PUBERA	2 25	2 100	
QUERCUS ALBA	2 25		2 33
QUERCUS RUBRA	2 75	1 100	2 67
RANUNCULUS HISPIDUS	2 25	2 100	
RHODODENDRON MAXIMUM	2 100	2 100	2 100
RHODODENDRON MINUS	2 25		2 33
RUBUS ARGUTUS	2 25	2 100	
RUBUS CANADENSIS	2 75		2 100
RUBUS FLAGELLARIS	2 50		2 67
RUDBECKIA LACINIATA	2 75		2 100
SANICULA TRIFOLIATA	2 25	2 100	
SASSAFRAS ALBIDUM	1 25		1 33
SCUTELLARIA ELLIPTICA VAR ELLIPTICA	1 25	1 100	
SMILAX GLAUCA VAR GLAUCA	2 75	1 100	2 67
SMILAX ROTUNDIFOLIA	2 25	2 100	
SOLIDAGO CAESIA	2 25		2 33
SOLIDAGO CURTISII	1 25	1 100	
SOLIDAGO RUGOSA	2 25		2 33
STACHYS CLINGMANII*	1 50	1 100	1 33
STELLARIA PUBERA	1 75	1 100	2 67
THALICTRUM CLAVATUM	2 50	2 100	1 33
THELYPTERIS NOVEBORACENSIS	2 50		2 67
TIARELLA CORDIFOLIA VAR CORDIFOLIA	1 25		1 33
TILIA AMERICANA VAR HETEROPHYLLA	3 75		3 100
TRADESCANTIA SUBASPERA	1 25		1 33
TRILLIUM ERECTUM	1 25	1 100	
TRILLIUM UNDULATUM	1 50	1 100	1 33
TSUGA CANADENSIS	5 100	6 100	5 100
UVULARIA PERFOLIATA	2 25	2 100	
VIOLA BLANDA	2 100	2 100	2 100
VIOLA HASTATA	1 25	1 100	
VIOLA PALMATA VAR PALMATA	1 25		1 33
VIOLA SORORIA	2 75	2 100	2 67
VIOLA STRIATA	3 25	3 100	
VITIS AESTIVALIS VAR BICOLOR	1 75	2 100	1 67
VITIS ROTUNDIFOLIA	2 25		2 33

Table 5.45. Density and basal area per hectare for woody stems ≥1.4 m in height with Importance Values of >4.00 for the **Alluvial Forests** vegetation class. 'ALL' = the sum of all woody species present in this group, 'SAPLDEN' = average sapling density (stems <2.5 cm), 'TREEDEN' = average tree density (stems 2.5 to 39.9 cm), 'BIGDEN' = average density for trees ≥40 cm), 'TOTDEN' = total stem density per species, 'TOTBA' = total basal area per species, 'REL DEN' = relative density per species (all size classes), 'REL B.A' = relative basal area per species, 'TIV' = average Importance Value per species.

10. Alluvial Forests

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	4.17	171.21	11.36	186.74	3.57	5.23	6.43	5.83
BETULA ALLEGHANIENSIS	106.25	367.61	0.00	473.86	2.97	11.30	6.81	9.05
BETULA LENTA	0.00	239.58	0.00	239.58	4.38	6.48	10.26	8.37
LIRIODENDRON TULIPIFERA	6.25	70.64	15.53	92.42	7.09	3.09	15.22	9.15
PLATANUS OCCIDENTALIS	8.33	292.42	22.92	323.67	18.69	10.15	38.54	24.34
TSUGA CANADENSIS	321.40	208.33	0.00	529.74	0.70	15.48	1.78	8.63
ALL	1214.77	2106.44	61.17	3382.39	46.03	100.01	99.99	100.00

10.1 [Liriodendron-Platanus/Amphicarpaea Alluvial Forest]

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	16.67	133.33	0.00	150.00	0.45	7.26	1.43	4.35
BETULA LENTA	0.00	133.33	0.00	133.33	6.03	6.45	19.31	12.88
CARYA ALBA	33.33	66.67	0.00	100.00	2.98	4.84	9.54	7.19
FAGUS GRANDIFOLIA	16.67	50.00	0.00	66.67	1.93	3.23	6.19	4.71
HALESIA TETRAPTERA VAR MONTICOLA	433.33	66.67	0.00	500.00	0.17	24.19	0.56	12.38
LIRIODENDRON TULIPIFERA	0.00	50.00	16.67	66.67	6.78	3.23	21.70	12.46
PLATANUS OCCIDENTALIS	0.00	50.00	16.67	66.67	8.08	3.23	25.87	14.55
TSUGA CANADENSIS	250.00	116.67	0.00	366.67	1.18	17.74	3.77	10.76
ALL	1100.00	933.34	33.33	2066.67	31.23	100.03	99.98	100.00

10.2 Platanus-Betula alleghaniensis Alluvial Forest

SCINAME	SAPLDEN	TREEDEN	BIGDEN	TOTDEN	TOTBA	REL DEN	REL B.A	TIV
ACER RUBRUM VAR RUBRUM	0.00	183.84	15.15	198.99	4.61	4.55	8.09	6.32
ALNUS SERRULATA	97.22	119.44	0.00	216.67	0.58	7.87	1.45	4.66
BETULA ALLEGHANIENSIS	141.67	490.15	0.00	631.82	3.97	15.06	9.08	12.07
BETULA LENTA	0.00	275.00	0.00	275.00	3.83	6.49	7.25	6.87
LIRIODENDRON TULIPIFERA	8.33	77.53	15.15	101.01	7.19	3.04	13.05	8.05
PLATANUS OCCIDENTALIS	11.11	373.23	25.00	409.34	22.23	12.45	42.76	27.60
TSUGA CANADENSIS	345.20	238.89	0.00	584.09	0.54	14.72	1.12	7.92
ALL	1253.03	2497.48	70.46	3820.96	50.97	100.01	99.99	100.00

Table 5.46. Vertical structure of woody species in the **Alluvial Forests** vegetation class. The height class of each stratum is measured in meters (m). Mean cover across all plots, is represented by a cover class. Only species with a cover class of ≥1 in a stratum are shown.

10. Alluvial Forests

SCINAME	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	2	2	
AESCULUS FLAVA	1	1	1	1	
ALNUS SERRULATA	1	2	2		
BETULA ALLEGHANIENSIS	1	1	3	5	
BETULA LENTA	1	1	2	6	
CARYA ALBA	1	1	1	1	
CORNUS FLORIDA	1	2	1		
FAGUS GRANDIFOLIA	1	1	1	1	
FRAXINUS AMERICANA	1	2	2	3	
HALESIA TETRAPTERA VAR MONTICOLA	1	1	1		
HAMAMELIS VIRGINIANA	1	2	1		
KALMIA LATIFOLIA	1	1			
LIQUIDAMBAR STYRACIFLUA	1	1	1	3	
LIRIODENDRON TULIPIFERA	1	1	2	5	
OXYDENDRUM ARBOREUM	1	1			
PINUS STROBUS	1	2			
PINUS VIRGINIANA	1	1	1	1	
PLATANUS OCCIDENTALIS	1	1	3	7	
RHODODENDRON MAXIMUM	1	1			
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	1	
TSUGA CANADENSIS	1	4	2		

10.1 [Liriodendron-Platanus/Amphicarpaea Alluvial Forest]

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER PENSYLVANICUM	1	2			
ACER RUBRUM VAR RUBRUM	1	2	2		
AESCULUS FLAVA	1	2	3	3	
ARISTOLOCHIA MACROPHYLLA	1	1			
BETULA LENTA	1	1	1	7	
CARYA ALBA	1	2	1	4	
FAGUS GRANDIFOLIA	1	1	1	3	
FRAXINUS AMERICANA	1	1	1	2	
HALESIA TETRAPTERA VAR MONTICOLA	1	4	3	1	
HAMAMELIS VIRGINIANA	1	2			
LIRIODENDRON TULIPIFERA	1	1	1	6	
PLATANUS OCCIDENTALIS	1	1	1	6	
SMILAX GLAUCA VAR GLAUCA	1	1	1	1	
TSUGA CANADENSIS	1	3	5		
VITIS AESTIVALIS VAR BICOLOR	1	1	1		

10.2 Platanus-Betula alleghaniensis Alluvial Forest

	<0.5m	6-0.5m	15-6m	35-15m	>35m
ACER RUBRUM VAR RUBRUM	1	1	2	3	
AESCULUS FLAVA	1	1	1	1	
ALNUS SERRULATA	1	2	2		
BETULA ALLEGHANIENSIS	1	1	4	6	
BETULA LENTA	1	1	3	6	
CARPINUS CAROLINIANA	1	1	1		
CLETHRA ACUMINATA	1	1			
CORNUS FLORIDA	1	2	1		
FRAXINUS AMERICANA	1	2	2	3	
HAMAMELIS VIRGINIANA	1	2	1		
KALMIA LATIFOLIA	1	1			
LIQUIDAMBAR STYRACIFLUA	1	1	2	3	
LIRIODENDRON TULIPIFERA	1	1	2	5	
OXYDENDRUM ARBOREUM	1	1	1		
PINUS STROBUS	1	2			
PINUS VIRGINIANA	1	1	1	1	
PLATANUS OCCIDENTALIS	1	1	3	7	
RHODODENDRON MAXIMUM	1	1			
RUBUS CANADENSIS	1	1			
TILIA AMERICANA VAR HETEROPHYLLA	1	1	1	1	
TSUGA CANADENSIS	1	4	1		

Table 5.47. Average site information for the **Alluvial Forests** vegetation class. The vegetation class is represented by its abbreviation code. For full community type name see Table 5.1. Dominant slope, slope aspect and underlying parent material are given where appropriate. The following abbreviations are used; Parent material types (**Q**=colluvium and alluvium, **3**= metasandstone-metaconglomerate), Landform types (representing micro-scale topographic units) (**C**=coves, **RF**=riverflats) and Topographic position (representing macro-scale topographic units) (**T**=toeslopes).

10. Alluvial Forests

	Group		
	10.	10.1	10.2
Site Characteristics:			
Elevation (m)	473	485	468
Slope (o)	4	12	1
Aspect (o)		W	
Parent material	3	Q	3
Soil depth (cm)	23.2	55.6	8.9
Surface Substrate (%):			
Moss/Lichen	2	2	1
Wood	3	2	4
Rock	22	5	27
Organic Matter	30	87	11
Water	7	1	9
Topographic Characteristics:			
Relative slope (%)	99	95	99
LFI	0.39	0.35	0.40
TSI	0.19	0.05	0.24
Landform type	RF	C	RF
Topgraphic position	T	T	T

5.6 Discussion

5.6.1 Comparisons with other Southern Appalachian landscapes

The five major vegetation classes in Joyce Kilmer are common throughout most of the Southern Appalachians (e.g., see Whittaker 1956, McLeod 1988, Schafale & Weakley 1990). The range of vegetation classes and community types in the present study closely follows those described by Whittaker (1956) and Golden (1974) in the Great Smoky Mountains. Others researchers that have examined the vegetation of the Smoky Mountain region, lack detailed community descriptions making comparisons with this present study difficult. Comparisons were made with Golden's (1974) dissertation rather than his published article (1981) because of more detailed community documentation in the former. Apart from the **Non-Alluvial Wetlands**, the same set of vegetation classes is present in both Joyce Kilmer and the central Smoky Mountains. These two regions are geographically close to one another, with corresponding climatic similarities. Underlying geology is also similar.

Subtle differences in climate, land position and history account for differences in the distribution of vegetation classes in the Smoky Mountains and Joyce Kilmer. In contrast to the Joyce Kilmer landscape, the central and western portion of Smoky Mountain region is dominated by the **Spruce-Fir Forests** at high-elevations (Whittaker 1956, Golden 1974). However, this class is only well-developed at elevations above those present in Joyce Kilmer. Both the **Grasslands** and **Shrub Balds** vegetation classes have very limited distribution in Joyce Kilmer, which reflects differences in land area and disturbance history. In contrast to the situation in the western Smoky Mountains, the distribution of xeric *Quercus* and *Pinus*-dominated community types in the **Xeric Evergreen Forests** is limited in distribution to the dryer and warmer lower-elevation section of Slickrock. Differences in orientation and proximity to high-rainfall, high-elevation areas probably accounts for this. The high-rainfall, higher-elevation conditions are most likely responsible for the near absence of this class in Little Santeetlah and the upper-half of Slickrock. Areas dominated by this class in the Smokies are west-facing and further from high-rainfall areas than similar elevations in Joyce Kilmer. The *Quercus alba* community type described by Whittaker (1956) and Baranski (1975) as inhabiting southwest-facing ridges is also absent from Joyce Kilmer. The conditions in the Little Santeetlah valley may be too moist for this community type, corresponding to a hypothesis put forward to explain the absence of this type in the central Smoky Mountains and Shining Rock Wilderness (see Golden 1981, Chapter 4). In contrast, the dryer, but northerly-facing Slickrock valley typically lacks suitable southwest-facing ridgelines. Sites with southwest orientation are only present in the lower-most end of the valley where conditions are probably too xeric, as indicated by the dominance of the **Xeric Evergreen Forests** vegetation class.

The little-described, species-rich and herbaceous-dominated *Tsuga* forests present in Joyce Kilmer appear to be restricted to this landscape and the Smoky Mountains (see Oosting & Bourdeau 1955, Whittaker 1956, Golden 1974, Lorimer 1976). These forests inhabit cool, north-facing coves and slopes in both regions. There are no obvious explanations for the confinement of these community types to the southwest section of the Southern Appalachian region. Some stands now dominated by *Tsuga* may have formerly been inhabited by *Castanea dentata* (Woods & Shanks 1959; see discussion below). However, many herbaceous-dominated *Tsuga* stands have little evidence to suggest past presence of chestnut. *Tsuga* canopy trees are generally at least 150 years of age in these sites. Similarly, the presence of large-diameter decaying *Tsuga* logs on the forest floor points to the long-standing presence of this species in the canopy of these types. In the central Smoky Mountains, Golden (1981) attributes the dominance of *Tsuga* in mid-elevation coves to the cooler, moister conditions in this area. Such a hypothesis could explain the presence of the herbaceous-dominated *Tsuga* community types in Joyce Kilmer. These types are present throughout the higher-rainfall Little Santeetlah watershed, but are restricted to the cooler, moister, high-elevation end of Slickrock. This, however, does not explain the absence of these types from other high-rainfall, mid-elevation landscapes in the Southern Appalachian Mountains. Descriptions by DuMond (1970) and Oosting & Billings (1951) suggest that herbaceous-dominated *Tsuga* forests were once also present in the high-rainfall southern Escarpment region. Site plant records suggests that these stands were probably inhabited by less mesic herbaceous species than the most diverse stands described in Joyce Kilmer and the Smoky Mountains. Herbaceous *Tsuga* forests may have been eliminated from the Southern Escarpment areas by logging, as was the case for the stands described by Oosting & Billings (1951). It is possible that logging changed the site conditions of these stands, with the herbaceous understory of the pre-logged stands replaced by ericaceous shrubs in second-growth stands.

The species richness patterns quantified in this study show a general correlation between species richness and soil fertility. Richness is typically higher in vegetation classes that inhabit sites with moderate to high soil fertility (the **Rich Cove and Slope Forests**, the **Montane Oak Forests**, the **Alluvial Forests**) and low in vegetation classes inhabiting poor conditions (the **Xeric Evergreen Forests**, the **Acidic Cove and Slope Forests**; Table 5.9). Positive correlations between species richness and soil fertility have been documented in other Southern Appalachian landscapes (e.g., McLeod 1988, Chapters 3 & 4). However, in contrast to most accounts of species richness patterns in the Southern Appalachians, my results show that the **Montane Oak Forests** have higher richness than the **Rich Cove and Slope Forests** at the two largest scales. It appears that the density of herbaceous cover may limit overall species richness on the most fertile sites (see Graves 1995). In fertile sites inhabited by the latter vegetation class, communities typically have lush herbaceous canopy of a limited number of species. In contrast, on less fertile sites inhabited by the **Montane Oak Forests**, herbaceous species provide only sparse, scattered ground floor cover, with a diverse array of low-cover species widely scattered across this stratum.

5.6.2 Vegetation - environment relationships

Soil nutrients, soil texture, topographic position, landform shape and elevation are the major factors controlling the distribution of vegetation across the Joyce Kilmer landscape. The **High-Elevation Mixed Hardwood Forests** class dominates high-elevation areas and typically has more organic and less fertile soils than other classes. The **Rich Cove and Slope Forests**, **Acidic Cove and Slope Forests**, **Montane Oak Forests** and **Xeric Evergreen Forests** dominate the mid- and low-elevation elevations of this Wilderness. The latter class inhabits dryer (low TMI, high solar radiation) low-elevations areas in the lower Slickrock valley and typically has finer-textured soils (high Clay) than the former three classes (Figures 5.2, 5.3, 5.6, 5.8). Both the **Rich Cove and Slope Forests** and the **Acidic Cove and Slope Forests** inhabit moister (high TMI, low solar radiation), higher-elevation sites than the other two classes, but are separated from one another by slope position and soil fertility. There is a progression along the complex soil nutrient and slope position gradient from the **Rich Cove and Slope Forests** on fertile (high Ca, Mg, Mn, cation exchange capacity), sheltered (high LFI), concave lower-slopes and coves, to the **Montane Oak Forests** on less fertile open-slopes with the **Acidic Cove and Slope Forests** and **Xeric Evergreen Forests** situated on the least fertile sites.

Strong correlations between vegetation composition and elevation, topographic position and soil nutrients broadly follow the pattern suggested by Whittaker (1956) and others (e.g., Golden 1981, Callaway *et al.* 1987, Busing *et al.* 1993) for the Smoky Mountains and elsewhere in the Southern Appalachians (e.g., DeLapp 1978, McLeod 1988, Chapter 4). In contrast to Linville Gorge Wilderness (Chapter 3), the first study in this series on Southern Appalachian Wilderness areas, the vegetation patterns at Joyce Kilmer are not closely associated with underlying geologic patterns. Although a multiple analysis of variance indicates that there are statistically significant differences in soil chemistry and texture between the sixteen major parent material types (Tables 5.2, 5.3, 5.6), geologic differences are not closely correlated with major compositional gradients. This probably reflects the high numbers of parent material types present. Aggregating parent material types by rock composition did not clarify geologic patterns. The importance of soil texture for the distribution of vegetation corresponds with patterns described in a limited number of Southern Appalachian studies (e.g., Mowbray & Oosting 1968, Golden 1981, Chapter 3), but contrasts with the Shining Rock study (Chapter 4). The significance of texture probably relates to the variation in the composition of underlying bedrock, corresponding to patterns described at Linville Gorge (Chapter 3). The present study also highlights the importance of site shape on the distribution of vegetation, supporting results of other recent Southern Appalachian studies (e.g., Patterson 1994, Chapters 3 & 4). The recent identification of site shape as an important influence of vegetation composition is a reflection of developments in methods for quantifying topography rather than the limited importance of site shape in other landscapes across the Southern Appalachians.

The separation of Joyce Kilmer stands into two distinct elevation subsets follows patterns observed in the Black Mountains and at Shining Rock (McLeod 1988, Chapter 4). In Chapter 3, I proposed that vegetation inhabiting the dissected mid- and lower-slope regions within the Southern Appalachians is distributed across a broader range of topographic and soil extremes than vegetation at higher-elevation sites. I suggested that topographic characteristics and soil nutrients have greater influence on vegetation distribution in mid- and low-elevation sites, whereas elevation has primary influence on vegetation patterns at high-elevations where differences in topography and other environmental conditions are more subtle. Vegetation patterns in the Black Mountains and Shining Rock (McLeod 1988, Chapter 4) are consistent with this hypothesis. The patterns at Joyce Kilmer are less clear. The separation point between high-elevation and mid-low-elevation stands is lower in Joyce Kilmer than the previous two studies (approximately 1200 m at Joyce Kilmer; 1500 m in the Black Mountains (McLeod 1988); 1590 m at Shining Rock (Chapter 4)). The elevational position of specific vegetation groups typically decreases with increasing latitude (see Peet 1978), contrasting to the patterns observed at Joyce Kilmer. The summit of Joyce Kilmer (1600 m) is much lower than elevations reached at the other two landscapes (>1800 m). The central ridge of Joyce Kilmer is exposed to extreme weather conditions that perhaps provides cooler and moister site conditions that are typically found at higher-elevations. The narrow elevational range of high-elevation vegetation in this landscape suggests that site conditions quickly become more favorable in the valleys either side of the central ridge.

High-elevation types at Joyce Kilmer are distributed along gradients of temperature (represented by site orientation) and topographic shape (section curvature) (Figures 5.4, 5.5, Table 5.27), corresponding to the fine-scale site differences present within a restricted elevation range. Lack of association with elevation, described by McLeod (1988) and at Shining Rock (Chapter 4) most likely relates to the narrow elevational range of high-elevation community types. Narrow elevation range probably accounts for the limited diversity of high-elevation community types present in Joyce Kilmer. However, separation of high-elevation community types by topographic characteristics observed in the present study corresponds to the pattern observed at Shining Rock (Chapter 4).

In the Black Mountains and Shining Rock studies, stands below 1500 m were primarily influenced by soil nutrient and topographic gradients (McLeod 1988, Chapter 4). Elevation was of secondary importance in the former study and of even more limited significance in the latter. Similarly, in Joyce Kilmer mid- and low-elevation vegetation has strongest correlations with nutrients and topographic position.

5.6.3 Watershed differences in community type distribution

In Joyce Kilmer the dominance and distribution of the four major mid- and low-elevation vegetation classes differs between the two watersheds. The dominance of the **Montane Oak Forests** and the **Rich Cove and Slope Forests** in the Little Santeetlah watershed corresponds to other Southern Appalachian landscapes (e.g., Whittaker 1956, McLeod 1988, Chapter 4). However, in Slickrock the **Montane Oak Forests** are limited to the dryer, lower-elevation half of the Slickrock valley and the **Rich Cove and Slope Forests** are confined to a few lower-slopes and coves in the mid- and upper-portions of this valley. In contrast to Little Santeetlah, the **Acidic Cove and Slope Forests** class dominates the upper-portion of the Slickrock watershed. In Little Santeetlah, this class is restricted to lower-slopes and coves and sheltered low-elevation ridgelines. The **Xeric Evergreen Forests** dominate the low-rainfall, low-elevation, mid- to upper-slopes and ridgelines and are almost totally restricted to the low-rainfall areas of Joyce Kilmer in lower Slickrock.

Contrasting watershed orientation may account for such marked differences in vegetation class distribution. Disturbance history may also be a contributing factor, with the impact of chestnut death and periodic low-intensity fire of forests in Little Santeetlah contrasting to impacts associated with broad-scale logging and subsequent intense fire in Slickrock. However, it is difficult to pin-point to what extent disturbance has altered broad-scale vegetation class distribution patterns in this cool, north-facing valley which would probably have naturally had higher abundance of **Acidic Cove and Slope Forests** than the Little Santeetlah valley.

A series of analyses were performed to quantify compositional differences between the two major watersheds and to determine whether the same set of environmental factors are associated with vegetation patterns in each watershed. For each watershed, stands were plotted on standardized soil fertility, elevation and topographic moisture gradients (identified as the primary gradients influencing vegetation distribution in Joyce Kilmer) to compare the distribution of broad-based vegetation classes in each watershed. For this analysis Horse Cove and Little Santeetlah stands were grouped together because of the similar aspect of the two valleys, and Deep Creek stands were grouped with Slickrock stands for similar reasons.

Gradient diagrams have been used to summarize landscape-level vegetation-environment relationships along elevation and topographic-moisture gradients (e.g., Whittaker 1956, McLeod 1988, Allen *et al.* 1991, Parker 1991, Newell *et al. in press*). Newell *et al.* (*in press*) used gradient diagrams to quantify the distribution of vegetation with respect to elevation and topographic moisture under different soil fertility regimes. They found that across a number of landscapes Mn provided a more consistent measure of soil fertility than pH for comparing vegetation distribution across nutrient levels. Mn has been shown to be highly positively correlated with pH and soil moisture status (McLeod 1988, Chapters 3 & 4) and to display particularly strong correlations with vascular plant species richness (e.g., Chapters 3 & 4).

The 182 stands were classified into two fertility classes using log-transformed Mn (ppm) values (mean of 3.624, SD of 1.21, range of 0.693 to 6.021). The infertile class included stands with Mn values below the mean while those at and above the mean were assigned to the fertile class. For each respective fertility regime in each watershed, stands were plotted on the gradient diagram using consistent elevation and topographic-moisture (quantified using TMI) axes (Figures 21,22,23,24). Stands were identified on the diagram by their respective vegetation class. TMI values, which range from 0 to 60 were reversed to enable direct comparisons with previous graphical models of Southern Appalachian vegetation (e.g., Whittaker 1956, McLeod 1988, Newell *et al. in press*) where higher index values correspond to increasingly xeric conditions. Variation in the lower-elevational distribution of stands in each watershed reflects differences in the elevational range of the respective watershed.

The distribution of stands on the topographic gradient in each fertility regime differs between watersheds. Little Santeetlah stands are distributed across a range of topographic positions under both fertility regimes (Figures 5.19, 5.20). By contrast, in Slickrock stands on fertile soils tend to be positioned on the moister mid- to lower-slope and cove end of the topographic moisture gradient (mid- to low-TMI values), whereas infertile stands typically have dryer mid- and upper-slope topographic positions (Figures 5.21, 5.22). Greater differentiation by topographic position and soil fertility in Slickrock perhaps reflect the longer rainfall and temperature gradients in this watershed.

In Little Santeetlah, the **High-Elevation Mixed Hardwood Forests** class dominates a range of topographic positions in both fertile and infertile regimes (Figures 5.19, 5.20). By contrast, in Slickrock this vegetation class is restricted in topographic position and is limited to infertile conditions (Figures 5.21, 5.22). Some stands within the **Rich Cove and Slope Forests** class also inhabit fertile, high-elevation sites in Little Santeetlah.

There are visible differences in the distribution of the mid- and low-elevation vegetation classes in the two watersheds under the infertile regime. The **Acidic Cove and Slope Forests** class inhabits infertile mid- and lower-slopes in both watersheds (Figures 5.19, 5.21). However, whereas the **Montane Oak Forests** dominate the mid- and upper-slopes of Little Santeetlah, similar topographic positions in Slickrock are inhabited by the **Xeric Evergreen Forests**. In Little Santeetlah, the latter class is restricted to low-elevation ridgelines. The **Montane Oak Forests** are present on low-elevation upper-slopes in Slickrock.

On fertile soils in Little Santeetlah, vegetation classes separate by topographic position and elevation. The **Rich Cove and Slope Forests** mostly inhabit mid- and low-elevation lower-slopes and coves (Figure 5.20). Mid- and upper-slopes across a similar elevational range are dominated by the **Montane Oak Forests**. By contrast, some fertile lower-elevation, mid- and lower-slopes are inhabited by the **Acidic Cove and Slope Forests**. In Slickrock both the **Rich Cove and Slope Forests** and the **Alluvial Forests** have distinct distributions. The former class inhabits similar site positions to those in the former watershed and the **Alluvial Forests** are situated on low-elevation coves (Figure 5.22). The pattern is generally less distinct on fertile soils in Slickrock with more overlap between vegetation classes. Site differences between the remaining vegetation classes are somewhat blurred with the **Acidic Cove and Slope Forests** and the **Montane Oak Forests** inhabiting a broad range of topographic positions and elevations. The **Acidic Cove and Slope Forests** occur across a much broader elevational range in Slickrock than Little Santeetlah.

Differences in the clarity of vegetation class distribution in these watersheds with respect to the elevation, fertility and topographic position probably relates to differences in the disturbance history. Vegetation class patterns are less distinct in the heavily logged and fired Slickrock watershed. While I acknowledge that these two watersheds have opposing aspects, different moisture regimes and elevational ranges, I do not consider these sufficient to account for differences in the clarity of vegetation class patterns. Similar results have been found for differences in the distribution of individual species from old-growth forests of Linville Gorge Wilderness and the second-growth forests of Shining Rock Wilderness (C. Newell *unpub. data*). Aspect-related differences would more likely correspond with differences in the dominance of specific vegetation classes present rather than the consistency of distribution. This, for example, explains greater dominance of the **Xeric Evergreen Forests** in dryer, lower-elevation areas of Slickrock.

A series of ordinations was performed to compare the relationship of mid- and low-elevation vegetation classes to specific environmental factors in each respective watershed. Preliminary ordinations with the **High-Elevation Mixed Hardwood Forests** class included identified elevation and soil nutrients as the most significant variables in both watersheds. This class and the high-elevation **[Aesculus/Rudbeckia lacinata Forest]** in the **Rich Cove and Slope Forests** class were excluded from the following analyses. Environmental factors controlling vegetation are similar to those identified for the entire Joyce Kilmer landscape.

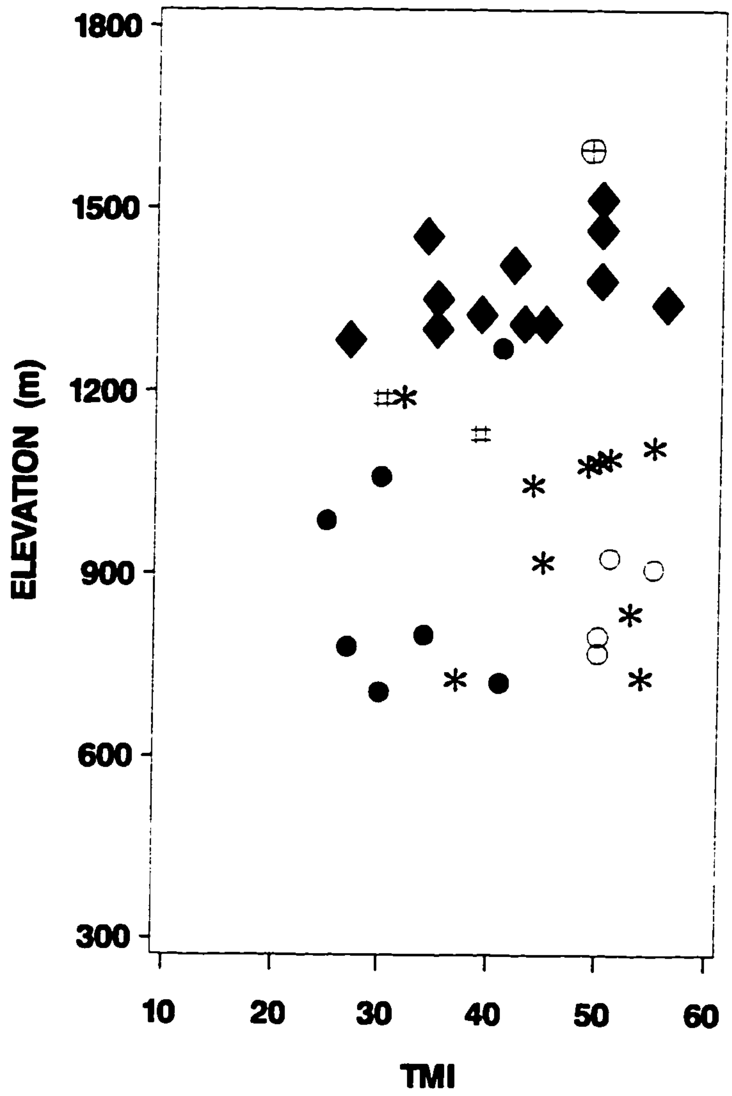


Figure 5.19. Gradient diagram showing the distribution of vegetation classes on infertile sites in the Little Santeetlah watershed. Stands are classified by their respective vegetation class and are plotted by elevation and topographic moisture (TMI). Increasing TMI values correspond to increasingly xeric conditions. Vegetation classes are represented by the following symbols: • = **Acidic Cove and Slope Forests**, ⊕ = **Grasslands**, ♦ = **High-Elevation Mixed Hardwood Forests**, * = **Montane Oak Forests**, # = **Rich Cove and Slope Forests**, O = **Xeric Evergreen Forests**.

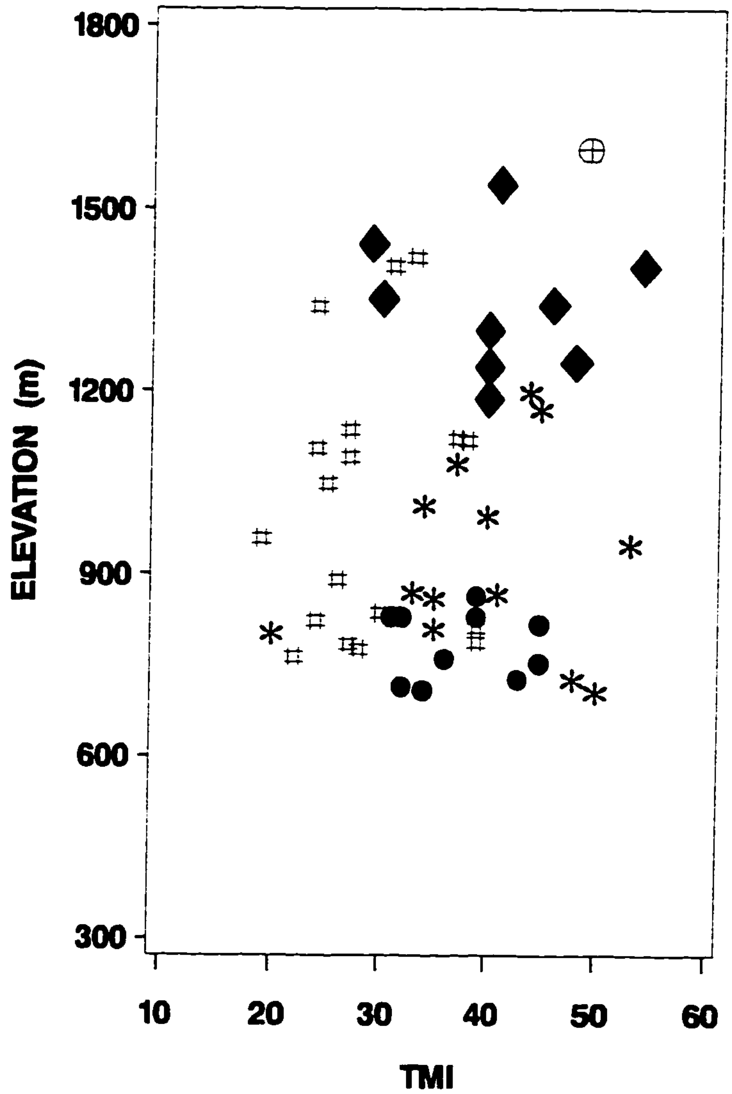


Figure 5.20. Gradient diagram showing the distribution of vegetation classes on fertile sites in the Little Santeetlah watershed. Stands are classified by their respective vegetation class and are plotted by elevation and topographic moisture (TMI). Increasing TMI values correspond to increasingly xeric conditions. Vegetation classes are represented by the following symbols: • = **Acidic Cove and Slope Forests**, ⊕ = **Grasslands**, ♦ = **High-Elevation Mixed Hardwood Forests**, * = **Montane Oak Forests**, # = **Rich Cove and Slope Forests**.

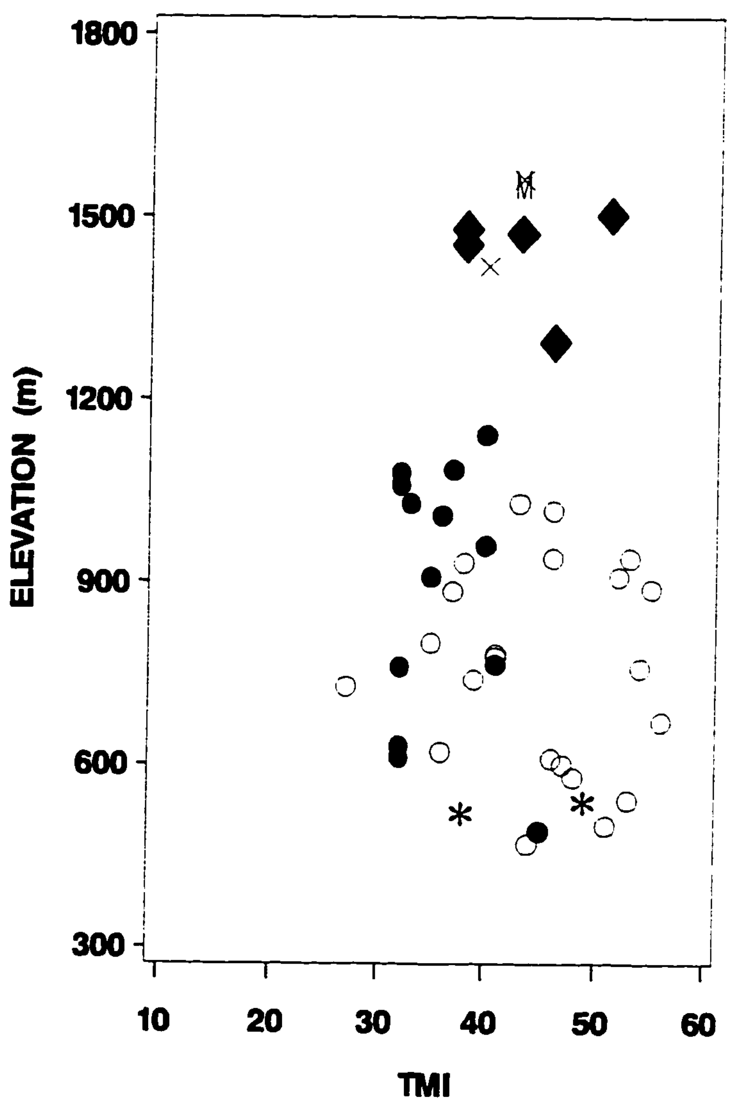


Figure 5.21. Gradient diagram showing the distribution of vegetation classes on infertile sites in the Slickrock watershed. Stands are classified by their respective vegetation class and are plotted by elevation and topographic moisture (TMI). Increasing TMI values correspond to increasingly xeric conditions. Vegetation classes are represented by the following symbols: • = **Acidic Cove and Slope Forests**, ♦ = **High-Elevation Mixed Hardwood Forests**, * = **Montane Oak Forests**, M = **Shrub Balds**, X = **Rock Outcrops**, o = **Xeric Evergreen Forests**.

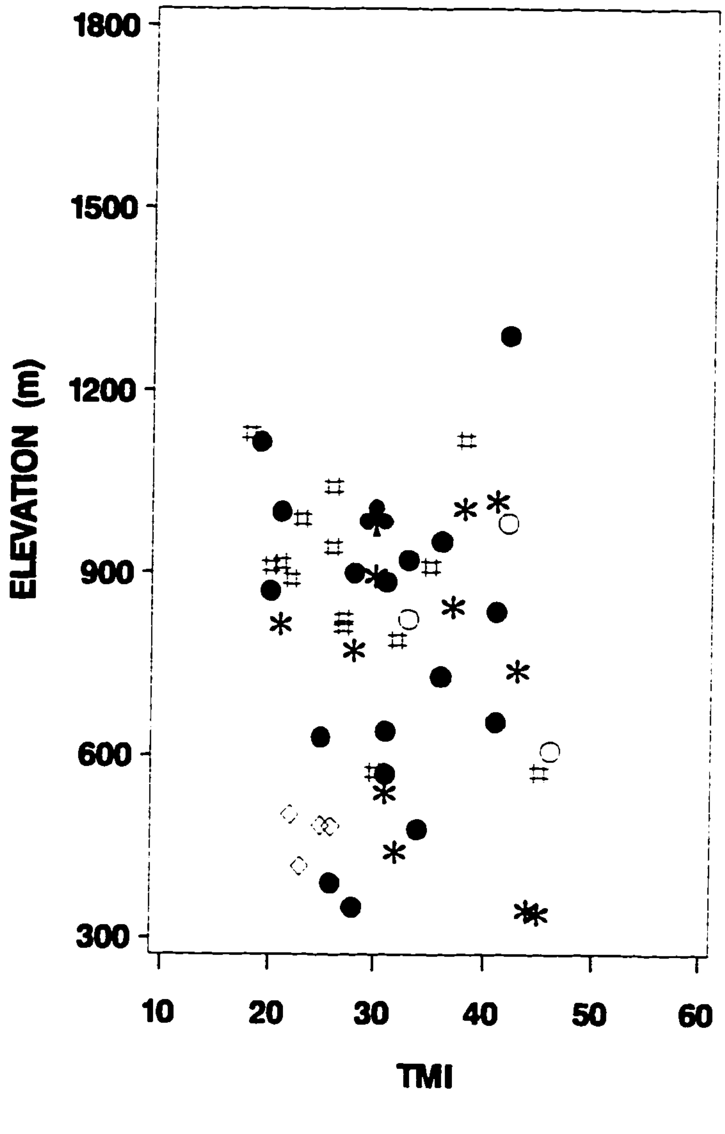
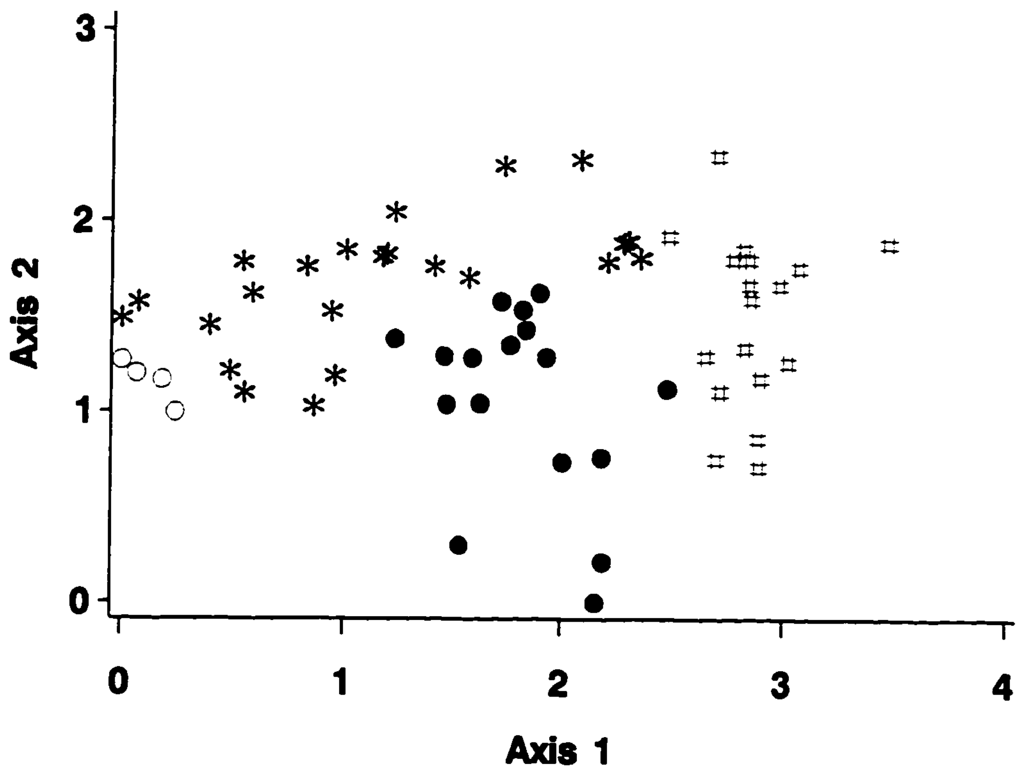


Figure 5.22. Gradient diagram showing the distribution of vegetation classes on fertile sites in the Slickrock watershed. Stands are classified by their respective vegetation class and are plotted by elevation and topographic moisture (TMI). Increasing TMI values correspond to increasingly xeric conditions. Vegetation classes are represented by the following symbols: • = **Acidic Cove and Slope Forests**, * = **Montane Oak Forests**, ♣ = **Non-Alluvial Wetlands**, # = **Rich Cove and Slope Forests**, O = **Xeric Evergreen Forests**.

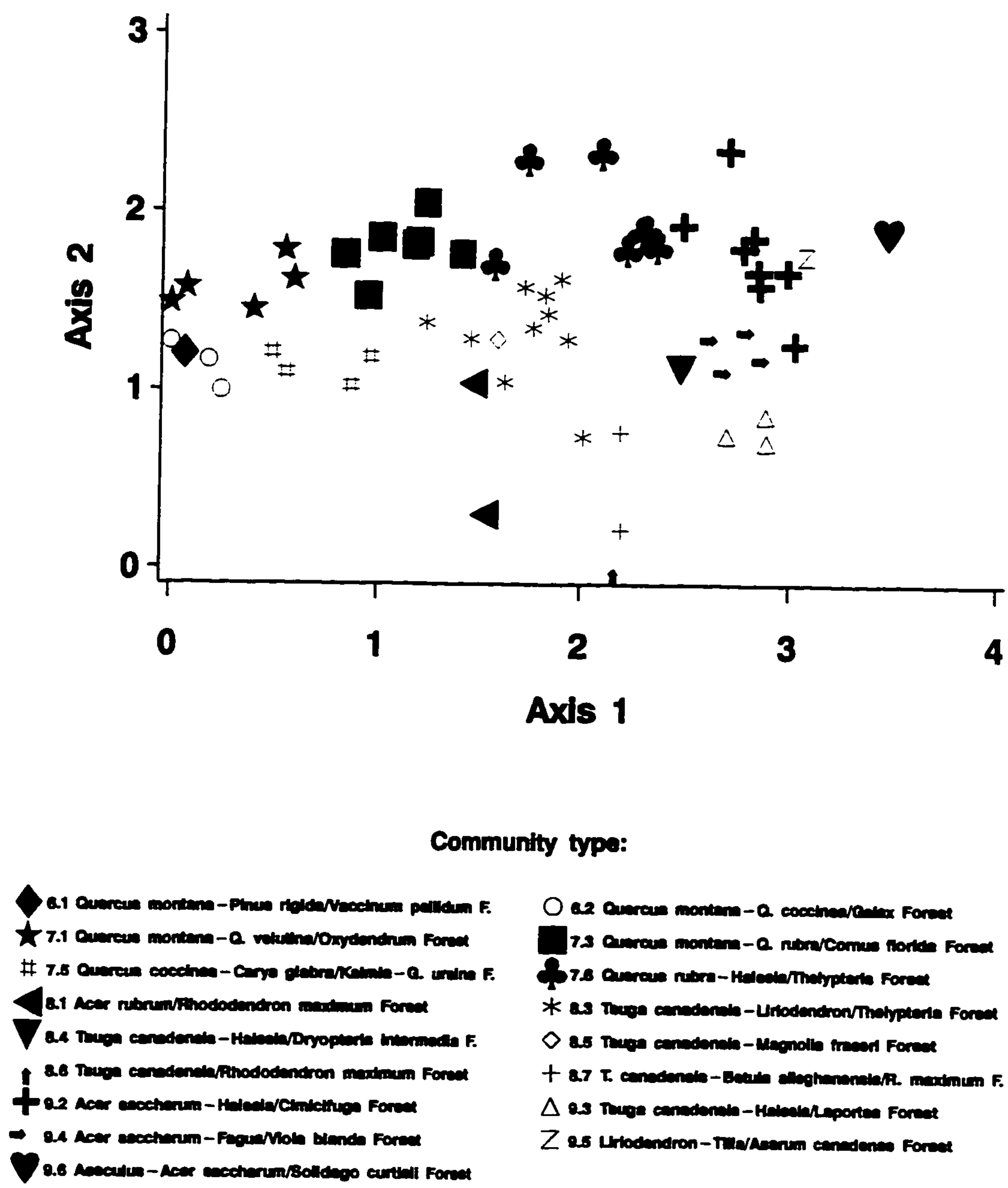
Figure 5.23. Diagram for DCA ordination showing the distribution of stands in the Little Santeetlah watershed (including stands from Horse Cove) in the **Acidic Cove and Slope Forests, Montane Oak Forests, Rich Cove and Slope Forests** and **Xeric Evergreen Forests** classes on the two major compositional gradients.



Vegetation Class:

○ 6. Xeric Evergreen Forests
* 7. Montane Oak Forests
● 8. Acidic Cove and Slope Forests
9. Rich Cove & Slope Forests

Figure 5.24. Diagram for DCA ordination showing the distribution of community types in the Little Santeetlah watershed (including stands from Horse Cove) in the **Acidic Cove and Slope Forests**, **Montane Oak Forests**, **Rich Cove and Slope Forests** and **Xeric Evergreen Forests** classes on the two major compositional gradients.


3
2
1
0
Axis 2
0
1
2
3
4
Axis 1
Community type:
6.1 Quercus montana–Pinus rigida/Vaccinium pallidum F.
7.1 Quercus montana–Q. velutina/Oxydendrum Forest
7.5 Quercus coccinea–Carya glabra/Kalmia–Q. ursina F.
8.1 Acer rubrum/Rhododendron maximum Forest
8.4 Tsuga canadensis–Halesia/Dryopteris intermedia F.
8.6 Tsuga canadensis/Rhododendron maximum Forest
9.2 Acer saccharum–Halesia/Cimicifuga Forest
9.4 Acer saccharum–Fagus/Viola blanda Forest
9.6 Aesculus–Acer saccharum/Solidago curtisii Forest
6.2 Quercus montana–Q. coccinea/Galax Forest
7.3 Quercus montana–Q. rubra/Cornus florida Forest
7.6 Quercus rubra–Halesia/Thelypteris Forest
8.3 Tsuga canadensis–Liriodendron/Thelypteris Forest
8.5 Tsuga canadensis–Magnolia fraseri Forest
8.7 T. canadensis–Betula alleghaniensis/R. maximum F.
9.3 Tsuga canadensis–Halesia/Laportea Forest
9.5 Liriodendron–Tilia/Asarum canadense Forest

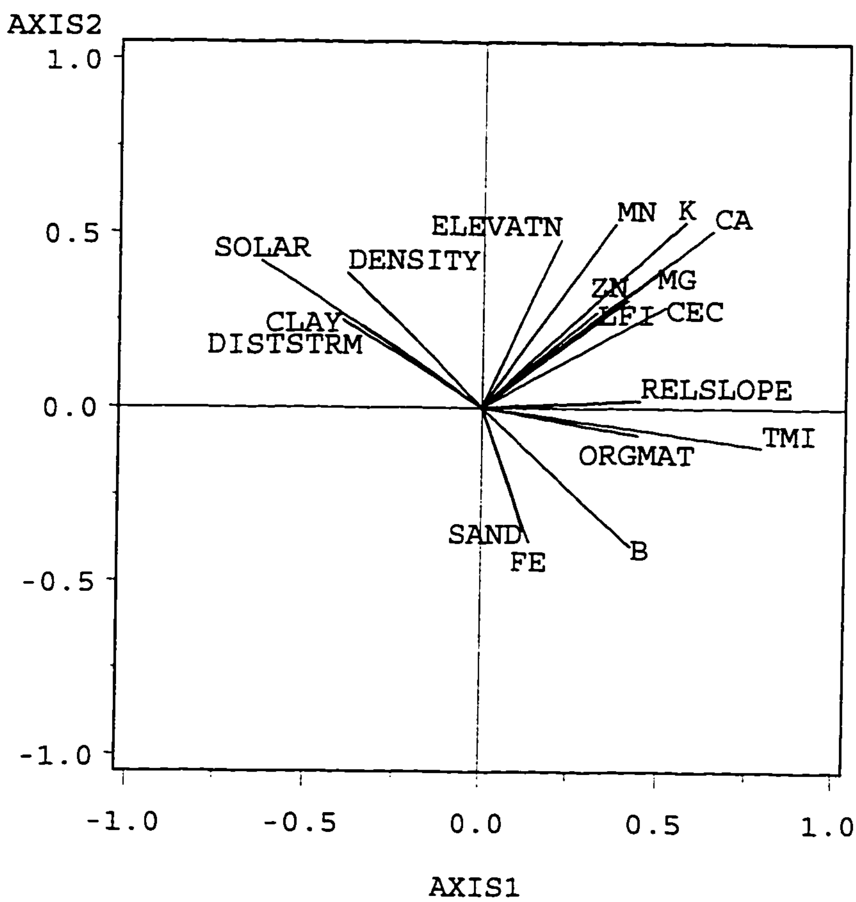
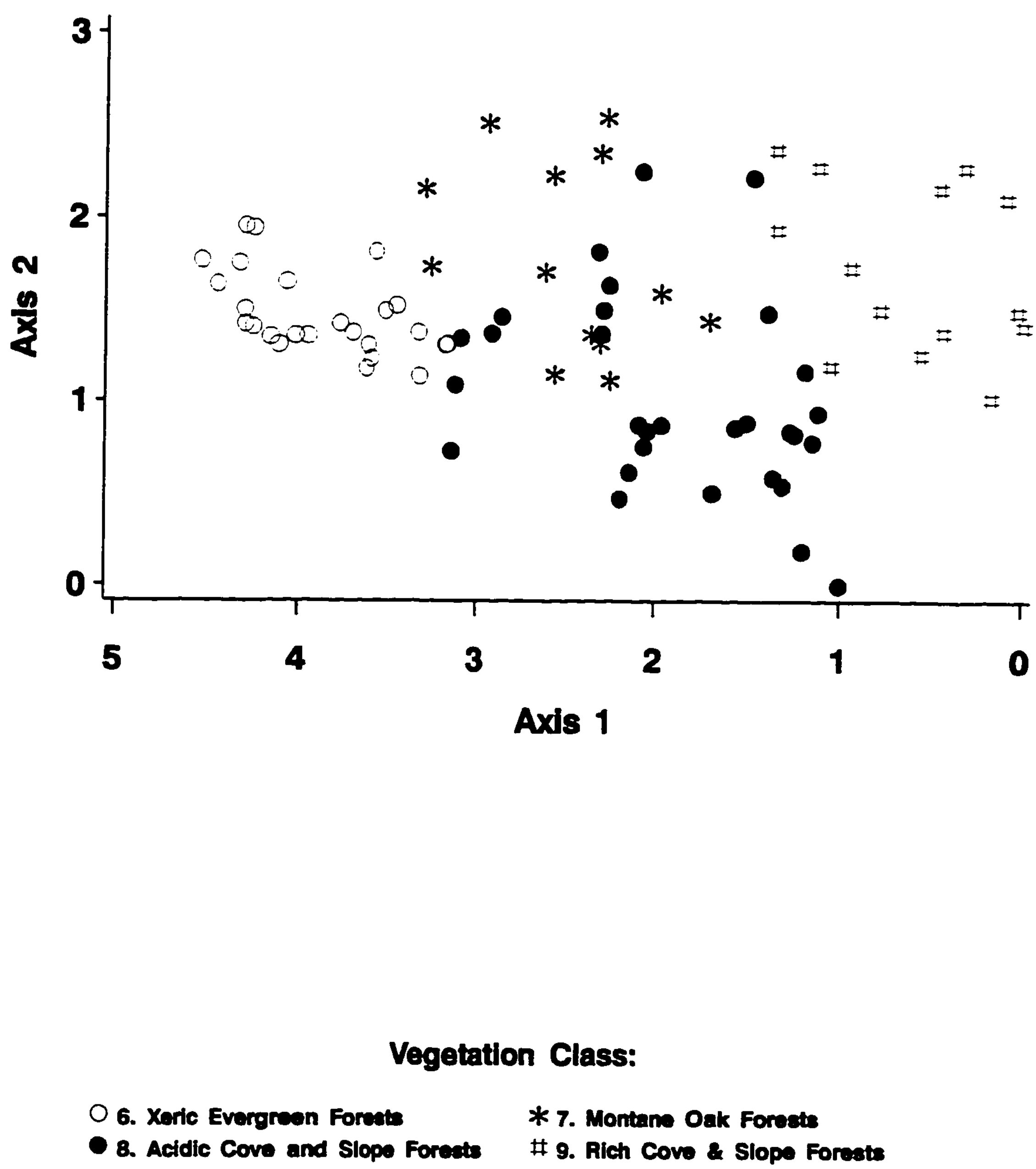


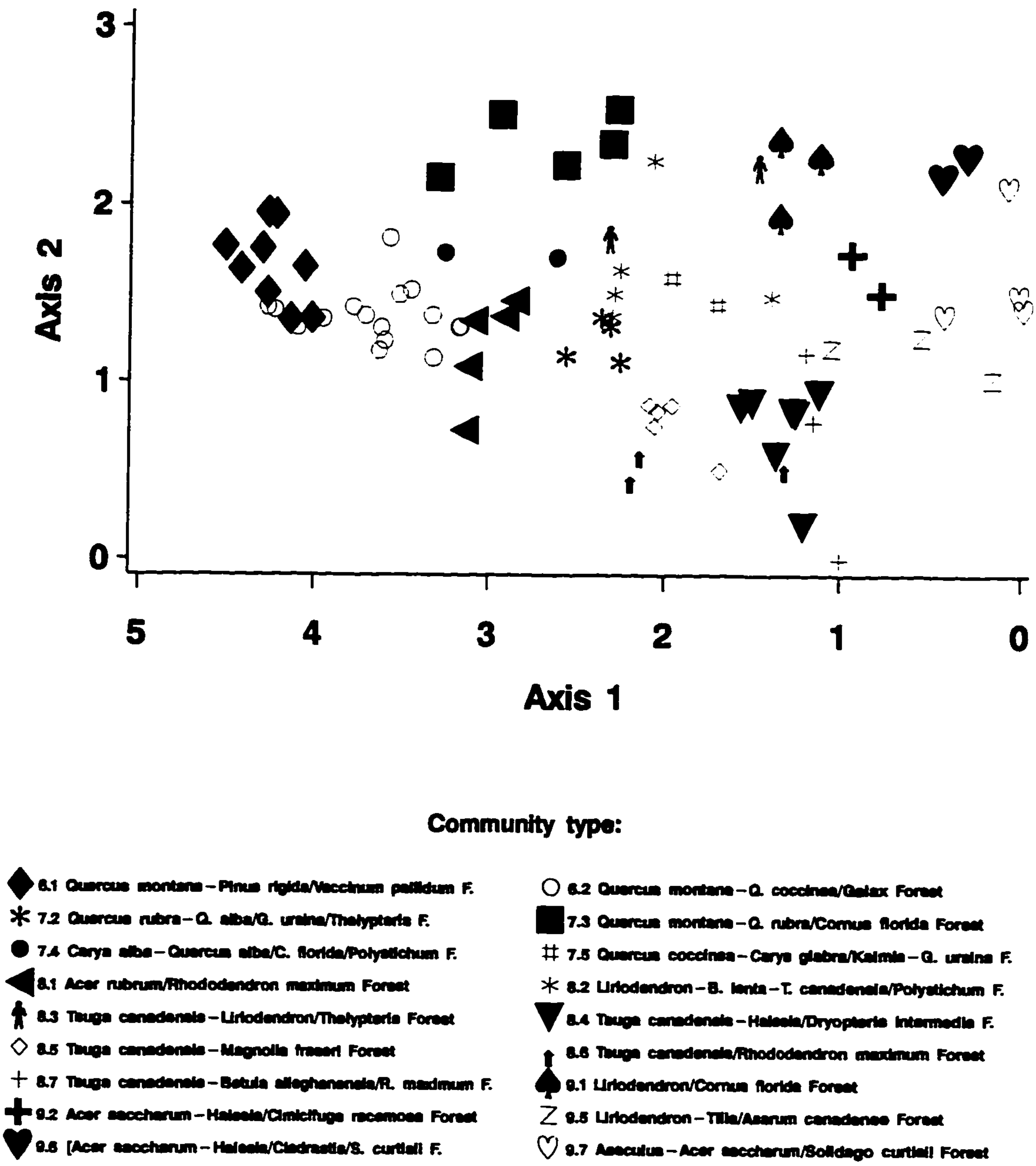
Figure 5.25. Vector diagram for DCA ordination of stands in the Little Santeetlah watershed in the **Acidic Cove and Slope Forests, Montane Oak Forests, Rich Cove and Slope Forests** and **Xeric Evergreen Forests** classes showing association between species composition and major environmental gradients. DISTSTRM=distance down slope to cove, RELSLOPE=relative slope position, with increasing values corresponding to higher position, SECCV=section curvature. Small LFI values represent unprotected upper-slopes progressing through to high values representing concave lower-slopes. Small TMI values represent low site moisture potential while large values represent high site moisture.

Figure 5.26. Diagram for DCA ordination showing the distribution of stands in the Slickrock watershed (including stands from Deep Creek) in the **Acidic Cove and Slope Forests, Montane Oak Forests, Rich Cove and Slope Forests** and **Xeric Evergreen Forests** classes on the two major compositional gradients.



3
2
1
0
Axis 2
5
4
3
2
1
0
Axis 1
Vegetation Class:
○ 6. Xeric Evergreen Forests
* 7. Montane Oak Forests
● 8. Acidic Cove and Slope Forests
⌗ 9. Rich Cove & Slope Forests

Figure 5.27. Diagram for DCA ordination showing the distribution of community type in the Slickrock watershed (including stands from Deep Creek) in the **Acidic Cove and Slope Forests**, **Montane Oak Forests**, **Rich Cove and Slope Forests** and **Xeric Evergreen Forests** classes on the two major compositional gradients.



3
2
1
0
Axis 2
5
4
3
2
1
0
Axis 1
Community type:
6.1 Quercus montana – Pinus rigida/Vaccinium pallidum F.
6.2 Quercus montana – Q. coccinea/Galax Forest
7.2 Quercus rubra – Q. alba/G. ursina/Thelypteris F.
7.3 Quercus montana – Q. rubra/Cornus florida Forest
7.4 Carya alba – Quercus alba/C. florida/Polystichum F.
7.5 Quercus coccinea – Carya glabra/Kalmia – G. ursina F.
8.1 Acer rubrum/Rhododendron maximum Forest
8.2 Liriodendron – B. lenta – T. canadensis/Polystichum F.
8.3 Tsuga canadensis – Liriodendron/Thelypteris Forest
8.4 Tsuga canadensis – Halesia/Dryopteris intermedia F.
8.5 Tsuga canadensis – Magnolia fraseri Forest
8.6 Tsuga canadensis/Rhododendron maximum Forest
8.7 Tsuga canadensis – Betula alleghaniensis/R. maximum F.
9.1 Liriodendron/Cornus florida Forest
9.2 Acer saccharum – Halesia/Cimicifuga racemosa Forest
9.5 Liriodendron – Tilia/Asarum canadense Forest
9.6 [Acer saccharum – Halesia/Cladrastis/S. curtisii F.
9.7 Aesculus – Acer saccharum/Solidago curtisii Forest

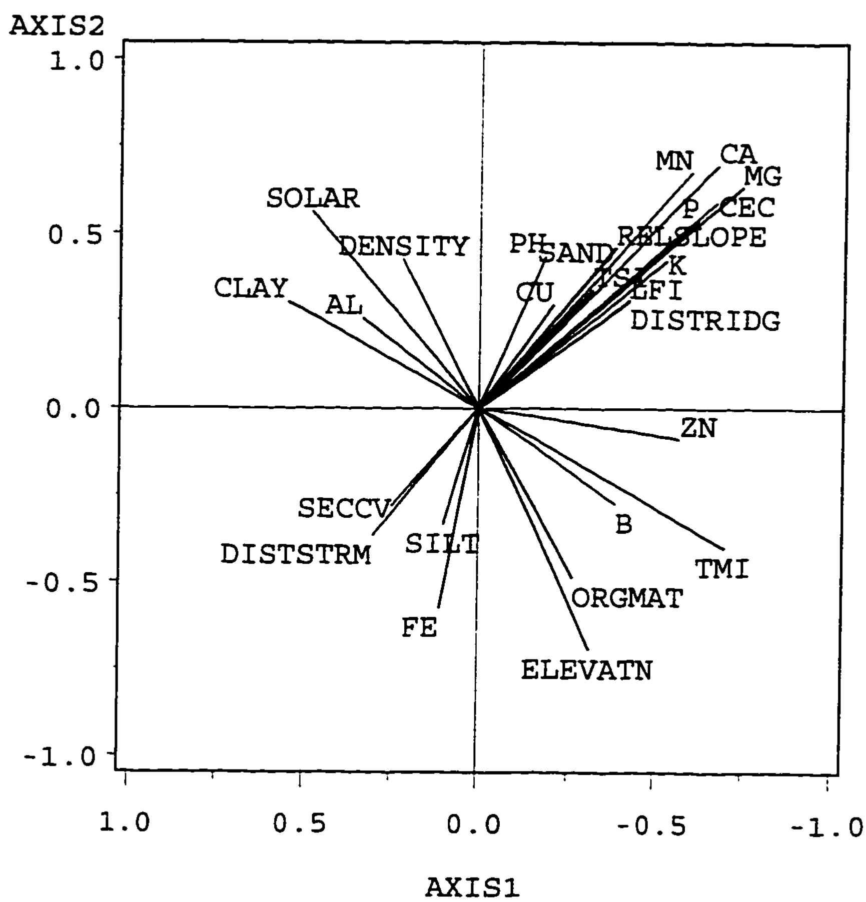


Figure 5.28. Vector diagram for DCA ordination of stands in the Slickrock watershed in the **Acidic Cove and Slope Forests, Montane Oak Forests, Rich Cove and Slope Forests** and **Xeric Evergreen Forests** showing association between species composition and major environmental gradients. DISTRIDG=distance to ridge, DISTSTRM=distance down slope to cove, RELSLOPE=relative slope position, increasing values correspond to higher position. Small LFI values=unprotected upper-slopes, high values=protected concave lower-slopes. Increasing TMI values correspond to increasing site moisture potential. Low TSI values represent convex upper-slopes, high values represent concave lower-slopes.

In Little Santeetlah the four mid- and low-elevation vegetation classes are separated from one another primarily by soil fertility (Ca, K, Mn in Little Santeetlah; Ca, Mn, Mg, cation exchange capacity in Slickrock) and topographic position (solar radiation, TMI). In both watersheds elevation and soil texture are of secondary importance in both analyses (Figures 25,26,27). Elevation has a stronger association with the vegetation patterns in Slickrock, perhaps relating to the strong rainfall/temperature gradient that parallels changes in elevation. Ordination scatterplots reiterate the patterns observed in the gradient diagrams, with less distinct separation between particularly the **Acidic Cove and Slope Forests** and the **Montane Oak Forests** in Slickrock.

The range of community types present in each watershed is indicative of environmental and historical differences between these valleys. As previously mentioned, the dominance of the **Xeric Evergreen Forests** in Slickrock reflects the presence of dryer, lower-elevation areas in this watershed. However, differences in watershed orientation probably account for the restriction of the **Quercus montana-Quercus rubra/Cornus florida Forest** to Little Santeetlah. Similar southeast-facing conditions are absent in the northerly-facing Slickrock valley. By contrast, confinement of the **Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest** in the **Acidic Cove and Slope Forests** class to Slickrock most likely is the result of differences in the disturbance history rather than lack of suitable habitat in Little Santeetlah.

For community types present in both watersheds the Slickrock stands consistently have subtly different slope positions to those present in Little Santeetlah. For example, the **Quercus rubra-Halesia/Thelypteris Forest** typically inhabits mid- and upper-slope positions and secondary ridgelines in Little Santeetlah, whereas Slickrock stands in this type are situated on lower-slope positions. Such differences in topographic position suggest dryer environmental conditions in Slickrock and that mid-slope positions in this watershed have equivalent conditions to upper-slope and ridgeline sites in Little Santeetlah.

The results of the above Little Santeetlah-Slickrock comparisons suggest that differences in the distribution of coarse-scale vegetation classes reflect differences in the disturbance history of the two watersheds. However, more subtle, finer-scale compositional differences between community types within each vegetation class, relate to differences in watershed elevational range, orientation and climate as well as historical differences.

Impact of past disturbances on vegetation in Joyce Kilmer

Logging and chestnut blight in the early twentieth century have greatly influenced the present-day distribution of individual species and the composition and structure of community types in Joyce Kilmer. The widespread presence of species such as *Betula lenta* and *Liriodendron* are indicative of past disturbance by logging in the Slickrock, Deep Creek and Horse Cove watersheds, and disturbance by chestnut death in the old-growth forests of Little Santeetlah. In second-growth forests the effects of chestnut blight have been overridden by impacts associated with logging. Other disturbance evidence is more disturbance-specific. Inconsistent canopy composition, the young-age of canopy species, patchy understory composition and the dominance of *Rhododendron maximum* on mid-slopes are evidence for disturbance by logging rather than chestnut death and reflect the greater and more widespread impact of logging.

Evidence from stumps, logs, persisting sprouts and past site descriptions (see Braun 1950, Lorimer 1976, 1980) suggests that chestnut, *Castanea dentata*, was once a major species over much of Joyce Kilmer. Although logging and subsequent fire may have destroyed some of the historic distribution of chestnut in the second-growth watersheds, this species appear to have reached highest abundance in the southeast-facing Little Santeetlah valley. Similarly, other studies throughout the Southern Appalachians have noted that chestnut was most abundant on south-facing sites and was a canopy (co)dominant across a broad range of topographic positions on such sites (Braun 1950, Whittaker 1956, Arends 1981, MacKenzie 1993).

Stump size and number indicate that chestnut reached highest and most widespread abundance in the **Montane Oak Forests** of Little Santeetlah. Chestnut appears to have been most abundant on mid- and upper-slopes in mid-elevations (in the **Quercus montana-Quercus rubra/Cornus florida Forest** and the **Quercus montana-Quercus velutina**

/Oxydendrum Forest). High-elevation ridge and upper-slopes community types (the **Quercus rubra-Halesia/Thelypteris Forest** and the **Quercus rubra/Thelypteris Forest**) were also (co)dominated by chestnut. This species was also widespread across mid- and lower-elevations in the **Tsuga canadensis-Magnolia fraseri Forest** and the ***Tsuga canadensis-Liriodendron/Mitchella subtype*** of the **Acidic Cove and Slope Forests** vegetation class. The presence and abundance of chestnut in the **Rich Cove and Slope Forests** appears to have been more variable, with considerable cover in some stands of the ***Liriodendron-Tilia-Halesia/Cimicifuga sub-type*** situated in Poplar Cove (also see Lorimer 1976, 1980). Sprout densities and stumps suggests that chestnut was less abundant and had a more scattered in distribution in Slickrock. This species had comparatively consistent, low-cover in the **Xeric Evergreen Forests**, but was probably only an occasional component of the **Montane Oak Forests** and the **Acidic Cove and Slope Forests**.

Based on information from previous studies (see Keever 1953, Woods & Shanks 1959, Arends 1981, Johnson & Ware 1982, Chapter 4) and the present study, I surmise that in forests of mid- and high-elevations chestnut was replaced by *Acer rubrum*, *Betula lenta*, *Liriodendron*, *Quercus montana*, *Quercus rubra* and *Oxydendrum*. Replacement took the form of seed regeneration, growth of existing seedlings and saplings, and vegetative infilling of existing *Quercus* trees. *Halesia* may also have partly replaced chestnut on more mesic mid- and high-elevation sites (Woods & Shanks 1959, Arends 1981) in the **Quercus rubra/Thelypteris Forest**, the **Quercus rubra-Halesia/Thelypteris Forest** and the **Tsuga canadensis-Magnolia fraseri Forest**. In more mesic sites in the Smoky Mountains, Woods & Shanks (1959) described a "rapid shift from "pure" chestnut to hemlock" with *Tsuga* colonizing from nearby *Tsuga*-dominated forests. Similar successional changes appear to have taken place in mid- and low-elevation, lower-slope forests in the Little Santeetlah. For example, the eastern, low-elevation ridge of Poplar Cove (in the plot 525 environs), now inhabited by a 90-year old *Tsuga* pole stand, was once dominated by chestnut (Braun 1950, Lorimer 1976) as scattered chestnut logs today still indicate.

The rapid and overwhelming replacement by *Tsuga* in mesic sites once dominated by chestnut contrasts with slower and more less obvious replacement in more xeric stands previously dominated by chestnut (Woods & Shanks 1959). Arends (1981) found that chestnut was typically replaced by species that it was formerly associated with in a stand. The replacement of chestnut in most Little Santeetlah community types appears to follow this pattern. However, Woods & Shanks (1959) suggest that *Tsuga* was perhaps a component of neighboring community types rather than a component of the "pure" mesic chestnut stands. A similar pattern was probably true in Joyce Kilmer. I am not suggesting that chestnut reached highest densities in mesic, low-elevation stands, but rather that chestnut replacement was more rapid in these stands. Both Whittaker (1956) and Woods & Shanks (1959) suggest that this species was most abundant on moderately-sloped, rocky soils; densities of woody debris in Joyce Kilmer suggest a similar pattern.

DeLapp (1978) suggested that canopy openings caused by chestnut death may have enhanced species diversity, augmenting the diversity of forests once (co) dominated by chestnut. Indeed, the **Quercus montana-Quercus rubra/Cornus florida Forest**, the **Quercus rubra-Halesia/Thelypteris Forest** and the **Tsuga canadensis-Liriodendron /Thelypteris Forest**, all once inhabited by chestnut, have high species richness (Table 5.9). However, chestnut was also a component of the **Quercus montana-Quercus velutina/ Oxydendrum Forest** and the **Tsuga canadensis-Magnolia fraseri Forest**, which have comparatively low diversity in comparison to average values in their respective vegetation classes. Although I can describe structural changes and coarse-scale compositional changes associated with chestnut death in the old-growth forests of Little Santeetlah it is impossible to determine the extent of changes in fine-scale diversity.

Canopy break-up caused by chestnut death most likely altered understory conditions. Higher light levels in the understory may have changed forest floor composition. Woods & Shanks (1959) suggest that chestnut death increased the dominance of more xeric species or initiated their invasion into a stand. Such a hypothesis might partly explain understory compositional differences between the **Tsuga canadensis-Halesia/Laportea Forest** in the **Rich Cove and Slope Forests** class and the ***Tsuga canadensis-Liriodendron /Mitchella sub-type*** in the **Acidic Cove and Slope Forests** class. These two groups have similar site positions (although the latter does extend further up-slope) in close proximity to one another. Past presence of chestnut in the latter sub-type might account for the present-day compositional differences between these two groups. Less mesic *Mitchella repens* and *Thelypteris novaeboracensis* are dominant in the latter sub-type, whereas *Dryopteris intermedia, Laportea canadensis, Solidago curtisii* and *Tiarella cordifolia* are prominent in the **Tsuga canadensis-Halesia/Laportea Forest**. However, *Tsuga canadensis* typically dominates more mesic conditions than *Castanea dentata* (Whittaker 1956), suggesting that the herbaceous cover in the **Tsuga canadensis-Halesia/Laportea Forest** was probably always dominated by more mesic species.

Lack of oak regeneration in *Quercus*-dominated community types has been widely observed throughout eastern North America (see Lorimer 1989, Abrams 1992, Chapters 3 & 4). My summary information shows that oaks are not regenerating in any of the **Montane Oak Forests** community types restricted to Slickrock, suggesting that although intense disturbance, such as logging and fire, did cause regeneration, the effects of these disturbances are long gone. Fire suppression since these disturbances may have inhibited regeneration in recent years. It is also possible that, owing to past disturbances, these stands have a dense, even-aged canopy and that there is unlikely to be much *Quercus* regeneration until the canopy breaks up. My results for **Montane Oak Forests** in Little Santeetlah show a contrasting pattern. Although mesic, mid-slope community types (the **Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest**, the **Quercus montana-Quercus rubra/Cornus florida Forest**) and upper-slope types (the **Quercus rubra-Halesia/ Thelypteris Forest**) have limited or no regeneration, the more xeric **Quercus montana-Quercus velutina/Oxydendrum Forest** has some regeneration of *Quercus coccinea, Q. montana* and *Q. velutina*. *Quercus rubra* is also regenerating in the **Quercus rubra/ Thelypteris Forest** in the **High-Elevation Mixed Hardwood Forests** vegetation class. Both types inhabit xeric conditions, but also previously had a high chestnut component.

Forest openings, caused by chestnut death may have created suitable environmental conditions for *Quercus* regeneration. Alternatively, xeric site conditions alone may be sufficient for regeneration of this genus. The latter hypothesis is supported by *Q. coccinea* and *Q. montana* regeneration in the two **Xeric Evergreen Forests** types which inhabit similar, but much more xeric, lower-elevation sites. However, these Slickrock types have been at least partially logged and disturbed by at least minor chestnut loss. By contrast, the **Quercus rubra/Acer pensylvanica/Gaylussacia ursina/Thelypteris Forest**, which inhabits mid-elevation ridgelines in Slickrock, lacks oak regeneration. Sites in this type were logged, but probably had little chestnut. It is also possible that the canopies of upper-slope sites are damaged by wind and ice disturbance which would also provide more light for oak regeneration.

It is impossible to isolate the specific factors that promoted *Quercus* regeneration. However, it seems most likely that xeric conditions with some limited disturbance may have enhanced *Quercus* regeneration in the Joyce Kilmer landscape. Summary data suggests a similar pattern in the xeric *Quercus*-dominated old-growth forests of Linville Gorge (Chapter 3). Chestnut, however, does not appear to have been a major species at Linville Gorge (Chapter 3). I have observed *Quercus* regeneration in a xeric, old-growth **High-Elevation Mixed Hardwood Forests** type at Shining Rock Wilderness (Chapter 4). Xeric **Montane Oak Forests** types at Joyce Kilmer lacking *Quercus* regeneration have high *Acer rubrum* and *Tsuga canadensis* regeneration, whereas *Halesia* and *Liriodendron* sapling densities are high in the more mesic types.

Apart from present analysis, the study of vegetation of the Linville Gorge Wilderness (Chapter 3) and Whittaker's (1956) study in the western Smoky Mountains, all previous Southern Appalachian studies have described vegetation-environment relationships in landscapes widely disturbed by logging and fire in the early part of this century. Such widespread and intense disturbance may have altered species distribution patterns and vegetation-environment relationships in second-growth forests. However, there has been no quantitative information available to compare second-growth forests with old-growth stands from a close geographic proximity. The opposing aspects of the two major watersheds in this present study prevent detailed comparisons of species composition. However, comparisons of broad-scale vegetation-environment relationships can be made. My results indicate that although vegetation classes in the two watersheds are distributed across a similar set of environmental gradients, differences in site conditions between individual classes in the disturbed Slickrock watershed are blurred and indistinct in comparison those associated with the old-growth stands of Little Santeetlah.

The presence of spatially restricted, species-rich *Tsuga* forests and *Tsuga* forests with a herbaceous understory illustrate the distinctiveness of Joyce Kilmer in relation to much of the Southern Appalachian Mountains. The low-elevation position of the **Tsuga canadensis-Halesia/Laportea Forest** differs from similar, but mid-elevation forests described in the near-by Great Smoky Mountains. The diversity of **Montane Oak Forests, Acidic Cove and Slope Forests** and **Rich Cove and Slope Forests** types in this Wilderness also separates it from many Southern Appalachian landscapes and highlights the importance of preserving this Wilderness. Moreover, the fact that Joyce Kilmer contains one of the few remaining large, intact areas of old-growth forest further magnifies the significance of this Wilderness and the importance of base-line information for formulating appropriate management strategies for this unique portion of the Southern Appalachian Mountains.

5.7 Overall trends and future research needs

Logging and chestnut blight that occurred in the early part of this century have influenced the distribution and composition of present-day community types in Joyce Kilmer. The effects of logging are more visible than the typically subtle changes associated with chestnut death. The second-growth forests in this Wilderness are less predictable from site characteristics than those in the old-growth forests of Little Santeetlah. This study has shown that second-growth forests have less distinct associations with specific site factors than old-growth forests. Few researchers have monitored vegetation-site relationships of second-growth forests to determine whether these become more discrete with time. This restricts our overall understanding of second-growth communities and limits our ability to project their future development. I put forward the need to monitor a series of permanent plots in Joyce Kilmer to quantify successional changes in both old- and second-growth community types.

This study describes the diversity of community types present in Joyce Kilmer. Both the **Montane Oak Forests** and **Rich Cove and Slope Forests** include a broader range of community types than has typically been documented in other landscapes in the Southern Appalachian region. Little is known about the dynamics of the **Montane Oak Forests** or high-elevation and rocky-cove community types in the **Rich Cove and Slope Forests**. Lack of understanding of the dynamics of these community types restricts our ability for effective management. More detailed study of these communities is required.

Summary information provides some insight to the question of oak regeneration in *Quercus*-dominated community types. A lack of oak regeneration has been documented throughout much of eastern North America (see Lorimer 1989, Abrams 1992, Chapters 3 & 4). My summary information shows that *Quercus* species have higher regeneration in the more xeric, upper-slope and ridgeline old-growth **Montane Oak Forests** community types in Little Santeetlah and the logged, second-growth **Xeric Evergreen Forests**. Dry conditions, associated with xeric sites may provide suitable environmental conditions for *Quercus* regeneration. Moreover, the loss of chestnut from many stands in these types, may also have helped create appropriate establishment conditions. Research closely examining *Quercus*-dominated forest dynamics throughout the Southern Appalachian Mountains is needed to determine whether this genus is regenerating in xeric communities elsewhere and to identify a disturbance frequency and intensity necessary to maintain *Quercus* regeneration.

The presence of *Tsuga canadensis* in Joyce Kilmer gives some insight into the possible consequences of a suppressed disturbance regime. *Tsuga canadensis* not only dominates community types in the **Acidic Cove and Slope Forests**, but is also present as an understory species in many community types, particularly in the **Montane Oak Forests** class. This trend has been noted previously in **Montane Oak Forests** present in other Southern Appalachian landscapes (e.g., Chapter 4). In an absence of periodic, low-intensity disturbance I expect *Tsuga* presence will continue to increase and could eventually become a major component of these communities. It is worth noting, however, that the southward-moving hemlock adelgid may ultimately inhibit or reverse *Tsuga* infiltration. Increases in

Tsuga dominance could markedly change the character of present **Montane Oak Forests**. Evergreen *Tsuga* would reduce light conditions throughout the lower strata of these community types and, in conjunction with the acidic content and slow decomposition of its leaves, could drastically change the composition and species richness levels of **Montane Oak Forests** community types. This further demonstrates the need to better understand the disturbance regimes required by specific community types and individual species within Joyce Kilmer, and possible consequences of increased *Tsuga* presence within **Montane Oak Forests**. Such information would be beneficial for management of forests throughout other areas of the Southern Appalachians.

The species-rich **Rich Cove and Slope Forests** dominated by *Tsuga* distinguishes this region from most of the Southern Appalachian Mountains. These forests have a lower-elevation distribution than those described by Golden (1974) in the Great Smoky Mountains, which highlights their uniqueness. Further research is needed to fully understand the dynamics of these forests. Moreover, the possible invasion of the hemlock adelgid makes more urgent increased understanding of these forests before they are permanently lost.

Elevation, topographic position and soil characteristics have been identified as the major environmental factors controlling the distribution of vegetation across Joyce Kilmer. More detailed research is needed to understand the specific links between elevation, topography, soil nutrients and vegetation attributes such as community composition and species richness.

This study is one of the few that has quantified the composition and structure of vegetation of a Southern Appalachian mid- to high-elevation mountain landscape outside the Great Smoky Mountains. My results do show similarities in vegetation composition with the latter area, but biogeographic differences in species distribution maintain significant compositional differences between community types in these two areas. The small percentage of Southern Appalachian landscapes with extensive areas old-growth forest highlights the significance of the Little Santeetlah watershed and the importance of understanding the composition and dynamics of community types within this watershed.

CHAPTER 6. GEOGRAPHIC VARIATION IN FOREST COMPOSITION AND VEGETATION-ENVIRONMENT RELATIONSHIPS ACROSS THE SOUTHERN APPALACHIAN MOUNTAIN REGION

6.1 Rationale

The overall objective of this chapter is to quantify geographic variation in forest vegetation across the Southern Appalachians and determine which factors are most likely responsible for the geographic variation across this region. The results of my landscape analyses (Chapters 3-5) suggest landscape-level variation in the composition of broad vegetation classes. These results point to differences in the relationships between vegetation and major environmental gradients as described for these three landscapes and those described elsewhere (e.g., Whittaker 1956, McLeod 1988). However, it is difficult to understand the differences among these landscapes without examining them in a regional framework.

In an analysis of 9 landscapes (Table 2.1), I ask (1) whether the environmental gradients most strongly correlated with vegetation patterns within individual landscapes are consistent across the region, (2) whether vegetation classes have a consistent position with respect to the major environmental gradients across the region, (3) to what extent is the composition of individual vegetation classes consistent across the region, and finally, (4) whether the environmental factors most strongly correlated with vegetation patterns vary at landscape- , subregional- and regional-scales.

6.2 Methods

6.2.1 Regional nomenclature

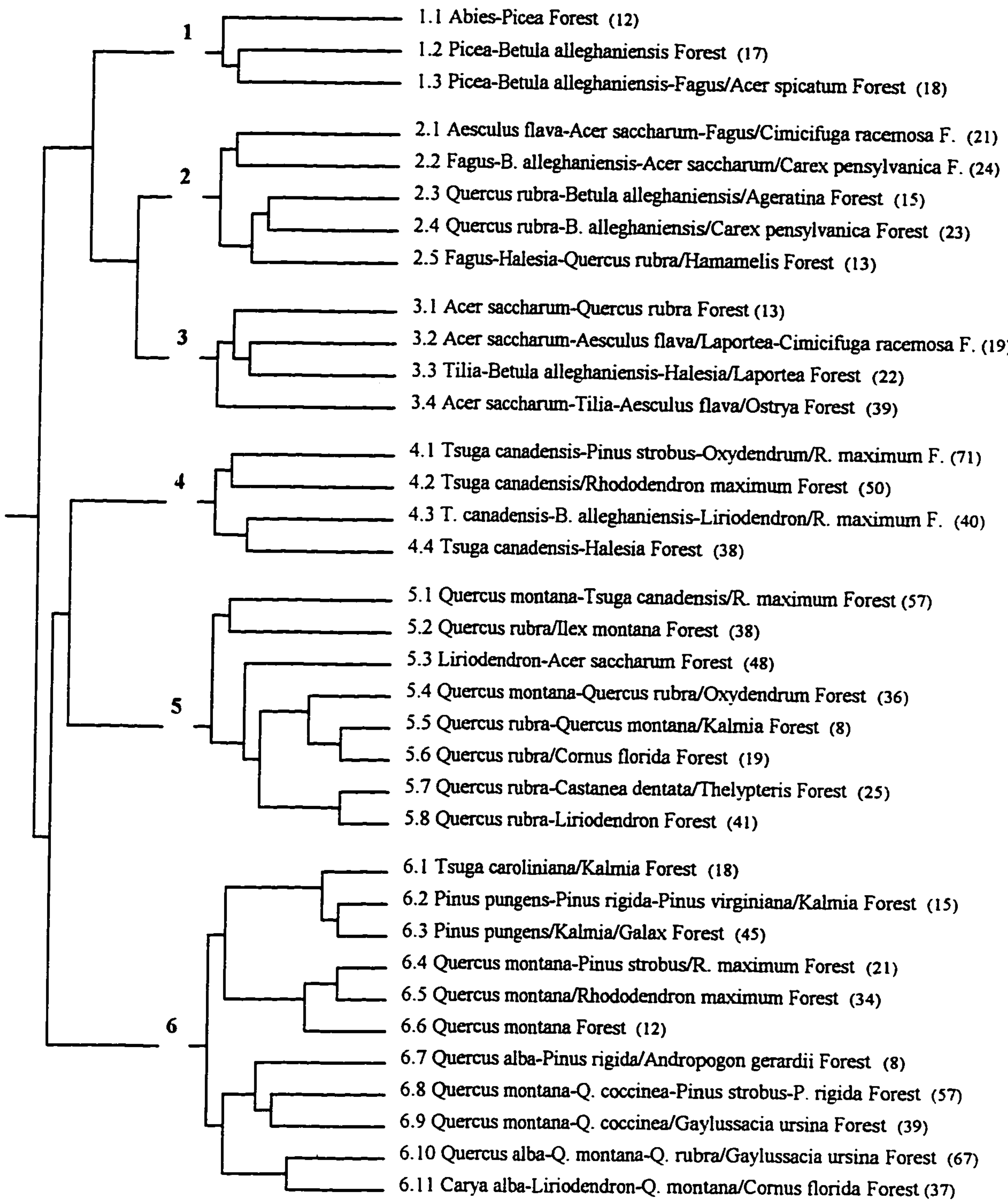
The nomenclature for and taxonomic understanding of North Carolina vascular plant species have changed considerably over the 20-year period during which the datasets used in this study have been collected (Table 2.1). Consequently, nomenclature had to be modified to assure consistent use across all datasets (Appendices 8, 9). Where possible, names were updated to those recognized by Weakley (1997) where completed, and otherwise Kartesz (1994). Although in several cases taxa have been split into more narrowly defined groups, these were mostly merged under the oldest name (typically that recognized by Radford *et al.* 1968), because taxa could not be unambiguously reassigned in the older datasets. In a few instances the old name could be unambiguously changed due to distinct geographic ranges. The taxonomic level with lowest resolution was accepted for taxa that had been identified at different taxonomic levels across the various datasets; for example, subspecies or varieties often had to be aggregated to the species level. Taxonomically similar taxa that were apparently difficult for some workers to separate in the field were combined to avoid errors resulting from misidentifications. For example, *Carya ovata* was merged with *C. glabra* and *Carex blanda* was merged with *Carex laxiflora*.

6.2.2 Regional Classification

Comparisons of clustering methods conducted during the development of the 3 landscape-scale studies showed that for the delineation of distinctive vegetation types Ward's method was consistently superior to the other methods tried (Chapter 2). All regional classifications were constructed based on Ward's method.

Initial classification attempts resulted in stands being clustered geographically, primarily because of the narrow geographic distributions of a substantial number of shrub and understory species. To establish a broad, regional-scale vegetation framework for comparisons of vegetation patterns in contrasting landscapes, an initial 1120-plot analysis was conducted using strictly tree species. A TRIM value of 2.5 identified 28 stands as outliers (see Chapter 2 for details of clustering methods used). Seven of these stands, representing forest seeps, stunted heath forest and river margin forest, were excluded from further analyses. The remaining twenty one stands were retained on the basis of similarity in species composition with one of the vegetation classes identified and stand position within an NMDS ordination.

Figure 6.1. Dendrogram showing the hierarchical relationships of the 1113 stands using Ward's clustering algorithm. The upper section of the hierarchy (on the left) shows the classification of tree data into six major vegetation classes: (1) **Spruce-Yellow Birch Forests**, (2) **High-Elevation Mixed Hardwood Forests**, (3) **Rich Cove and Slope Forests**, (4) **Acidic Cove and Slope Forests**, (5) **Montane Oak Forests** and (6) **Xeric Oak-Pine Forests**. Divisions on the right show the community types identified by classifying each vegetation class using all vascular species. The number of stands per community type are given.



Six broad-scale vegetation classes were identified in the initial cluster analysis; these are consistent with the primary classes described in the landscape-scale analyses (Figure 6.1). Classes were accepted at r-squared = 0.2503. Divisions below this level classes became progressively restricted in geographic distribution.

A separate cluster analysis was conducted for stands within each vegetation class so as to identify community types and to enable fine-scale comparisons between landscapes. Each analysis was based on all vascular species with a frequency of ≥3. Compositional variation between community types was assessed using all species, as understory herbaceous and shrub species typically show greater response to variation in soil characteristics and site moisture than tree species (Graves & Monk 1985).

6.2.3 Regional vegetation-environment relationships

The consistency of vegetation-environment relationships across the 9 landscapes was examined using NMDS ordination (described in detail in Chapter 2). A correlation analysis of all potential site factors was used to eliminate highly correlated variables from these analyses. Using these criterion base saturation (highly correlated with pH; r=0.98, P=0.0001) and magnesium (highly correlated with Ca; r=0.83, P=0.0001) were eliminated from the analyses.

Principal Components Analysis (PCA) of latitude and longitude was used to determine relative stand position along the major southwest- northeast axis of the mountains, and the orthogonal northwest-southeast axis of the mountains. The PCA factors were orthogonally rotated using VARIMAX. Rotated Factor 1 explained 0.947 of the variation in the latitude gradient and Factor 2 explained 0.947 of the longitude gradient. Site elevation, slope and aspect were included in the set of environmental variables. Digital values for solar radiation, TMI, profile and section curvature and relative slope position were extracted for all digitally referenced plots (Table 6.1; see Chapter 2 for calculations and full details). Silt, clay, sand, 12 nutrients, density and pH were included except for landscapes where specific soil characteristics were lacking (Table 6.1, see Chapter 2 for details).

The NMDS ordinations were computed in DECODA (Minchin 1995) using 10 random starting configurations. Four ordinations were computed for each dataset. The four ordination set represented solutions with 1 to 4 dimensions for the landscape analyses and solutions with 2 to 5 dimensions for the regional and sub-regional analyses. Higher multidimensionality in the latter analyses suggested that a 5-dimensional ordination solution might provide more meaningful information than a solution based a single dimension. The starting configuration with the lowest minimum stress levels was used. Stand scores from ordination solutions with a different number of dimensions (e.g., two, three and four dimensions) were fitted to each other, using procrustes rotation, to determine which ordination provided the most adequate summary of compositional dissimilarities among the stands. The 3 dimensional solution was chosen in all analyses used in this regional study. The compositional axes are expressed as half-changes, with the full turnover of a species in 4 units.

Regressions of individual environmental factors and stand scores on two of the first three NMDS axes (Axis 1xAxis 2, Axis 1xAxis 3) were used to identify environmental variables highly associated with these compositional axes. The relationships were plotted on a biplot vector diagram with the angle determined by the ratios of the fitted coefficients for the regressions and the lengths by the strength of the correlation.

6.3 Consistency of landscape-scale gradient structure

NMDS-based ordinations were used to determine the consistency of the association between environmental factors and vegetation composition within individual landscapes across the Southern Appalachian Mountain region. The first and secondary compositional gradients (Axis 1, Axis 2) identified using NMDS are presented using a scatterplot. Stands are plotted by their scores on Axis 1 and Axis 2 (e.g., Figure 6.2) and are classified by their vegetation class. Biplots show the relationship between vegetation composition and individual environmental variables. Two biplots are shown, representing the association of environmental factors with the first three NMDS compositional gradients, specifically between Axis 1 and Axis 2 and between Axis 1 and Axis 3 (e.g., Figures 6.3, 6.4).

Table 6.1. Environmental information available for each landscape. Number of plots per study with the full complement of soil nutrients are given. Minor deviations from the full complement are listed under variables partially sampled. Studies with a reduced set of soil nutrients measured are listed by specific nutrients in the Limited Nutrients section. Numbers of stands with soil texture and digitally derived topographic information are also listed. Total number of forest stands and number of stands trimmed from the classification are also given.

		Full nutrient complement:		**Limited nutrients:**			
Study Area	**Number of forest stands**	*Full nutrients*	*Variables partially sampled*	*Variables sampled*	**Soil Texture**	**Digital Variables**	**Trimmed stands**
Black Mountains	137	-----	-----	119 plots:P, Ca, Mg, K, Mn	-----	136	1
Chattooga River	74	74 except*	*54 plots: B, Fe, N Na, S 0 plots: density	-----	-----	54	2
Grandfather Mountain	70	70	-----	-----	69	69	-----
Joyce Kilmer	177	177	-----	-----	177	177	-----
Linville Gorge	162	162	-----	-----	162	162	1
Nantahala Mountains	103	103 except*	*86 plots: Cu, Basesat, Zn	-----	86	103	3
Smoky Mountains	107	53	-----	an additional 53 plots:pH	106	106	-----
Shining Rock	140	140	-----	-----	139	139	-----
Thompson River	150	-----	-----	101 plots: Ca,CEC Mg, Mn, Basesat	-----	150	-----

The nine landscapes were divided into 3 landscapes classes. High-elevation landscapes represent the Black Mountains, Grandfather Mountain and Shining Rock. The 3 mid-elevation landscapes include Joyce Kilmer, the Nantahalas and the Smoky Mountains. The 3 low-elevation landscapes include the Chattooga River, Linville Gorge and the Thompson River. Gradient structure comparisons are discussed using these three landscape classes.

6.3.1 High-elevation landscapes

In all three high-elevation landscapes (Black Mountains, Grandfather Mountain and Shining Rock), major vegetation gradients represented by NMDS Axis 1 and Axis 2 have strongest association with elevation and soil fertility (with consistently strongest representation by Mn, but also associated Ca, cation exchange capacity, pH). Axis 1 and Axis 3 have strongest associations with elevation and topographic-moisture (represented by the topographic moisture index (TMI), relative slope position, solar radiation) (Figures 6.2-6.10). Thus, elevation, Mn and topographic-moisture are recognized as the key environmental gradients associated with vegetation composition in high-elevation landscapes. It should be noted here that topographic-moisture and elevation represent "complex" gradients, made up of a range of direct environmental gradients. For example, changes in elevation correspond to changes in temperature, rainfall and humidity.

In high-elevation landscapes, vegetation is primarily distributed along an elevational gradient (Figures 6.2-6.10), with a soil fertility gradient typically running orthogonal to elevation. Soil fertility is generally strongly correlated with the first and second compositional gradients. Topographic-moisture (represented by a combination of TMI, relative slope position or solar radiation) has strongest association with tertiary compositional gradients at Shining Rock, the Black Mountains and Grandfather Mountain. Rotated latitude and longitude are also important at the latter two landscapes, corresponding in part to the distribution of sampling sites, with high-elevation areas oriented southwest-northeast and dry low-elevation areas perpendicular to the east of the high mountains. In the landscapes with the full range of nutrients analyzed, Fe is positively correlated with elevation. High Fe levels are typically found in highly acidic soils (Brady 1974). Organic matter is also positively associated with elevation and Fe at Shining Rock and Grandfather Mountain. Increasing Fe and organic matter levels suggest a general decrease in soil fertility and decomposition rates with increasing elevation.

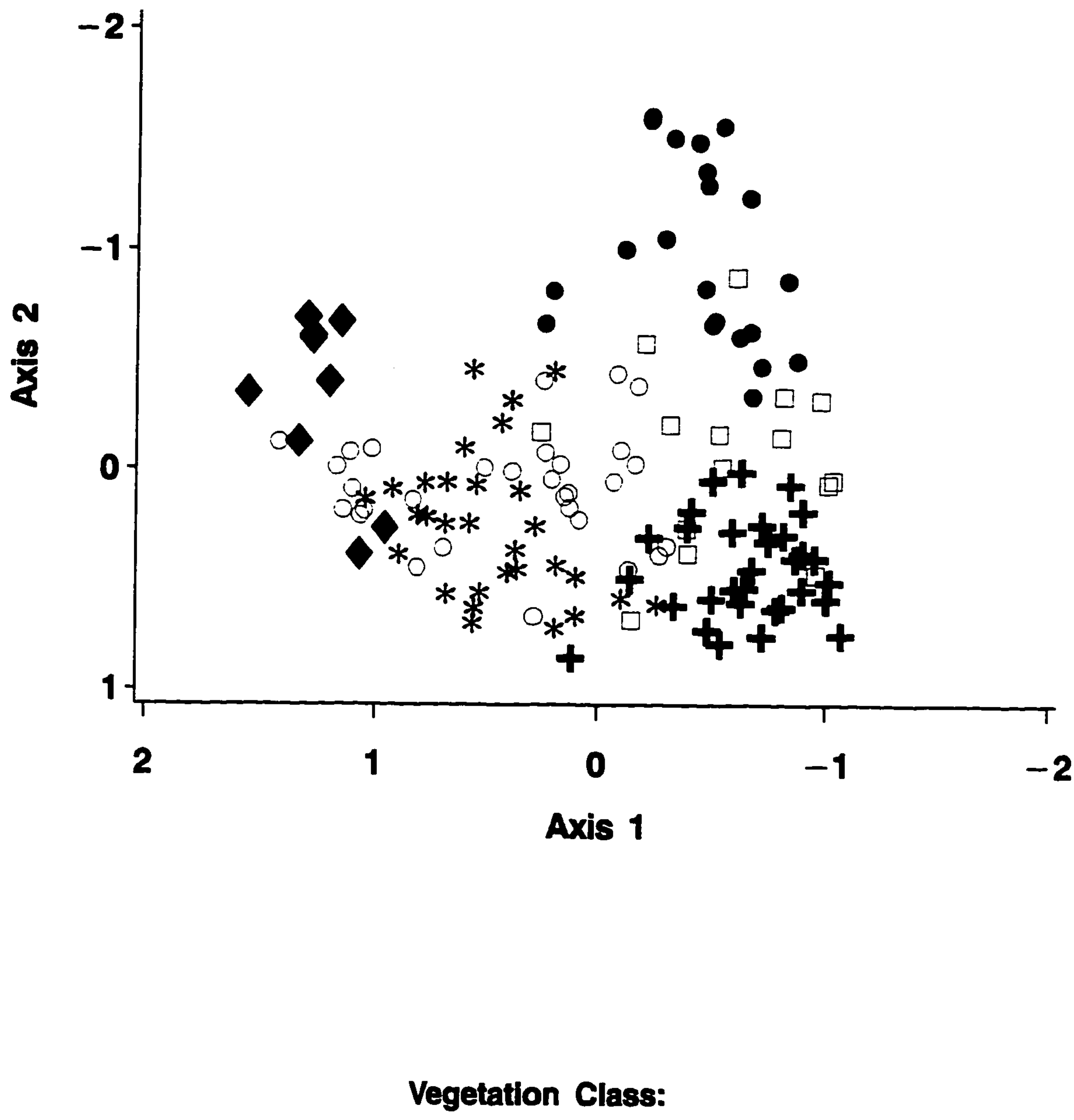
6.3.2 Mid-elevation landscapes

Elevation and soil fertility (represented by predominantly Ca and Mn) are the two major environmental gradients associated with vegetation composition in 2 of the 3 mid-elevation landscapes (Figures 6.11-6.19). Stand composition in all mid-elevation landscapes is highly correlated with topographic position, which is represented by TMI, relative slope position and solar radiation. At Joyce Kilmer the relationship between elevation and vegetation is weaker, with elevation associated with the third compositional gradient. Fe is positively correlated with elevation in all three mid-elevation landscapes, following the pattern visible in the high-elevation landscapes. Elevation has a stronger correlation with vegetation composition in the Smoky Mountains than in the other two mid-elevation landscapes. Moreover, in contrast to the latter two landscapes, topographic position has stronger associations with stand scores on Axis 1 and Axis 2 of the Smoky Mountains ordination than do soil nutrients. Weaker associations between vegetation and soil fertility possibly relate to the limited availability of soil nutrient information, although stands with soil information are well distributed across the first three compositional axes. The association between vegetation and longitude in the Smoky Mountains is a surrogate for changes in elevation. In contrast to the high-elevation landscapes, the results for the Nantahala Mountains, and for Joyce Kilmer to a lesser extent, identify strong associations between vegetation patterns and soil texture (represented by soil density, clay, silt and sand).

6.3.3 Low-elevation landscapes

In contrast to the gradient patterns described for the high- and mid-elevation landscapes, vegetation in the 3 low-elevation landscapes (Chattooga River, Linville Gorge, Thompson River) are distributed primarily by topographic characteristics and soil fertility

Figure 6.2. Diagram for NMDS ordination of the Black Mountains landscape showing the distribution of stands classified by vegetation classes on the two major compositional gradients.



Axis 2
-2
-1
0
1
Axis 1
2
1
0
-1
-2
Vegetation Class:
Spruce-Yellow Birch Forests
Rich Cove and Slope Forests
Montane Oak Forests
High-Elevation Mixed Hardwood Forests
Acidic Cove and Slope Forests
Thermic Oak-Pine Forests

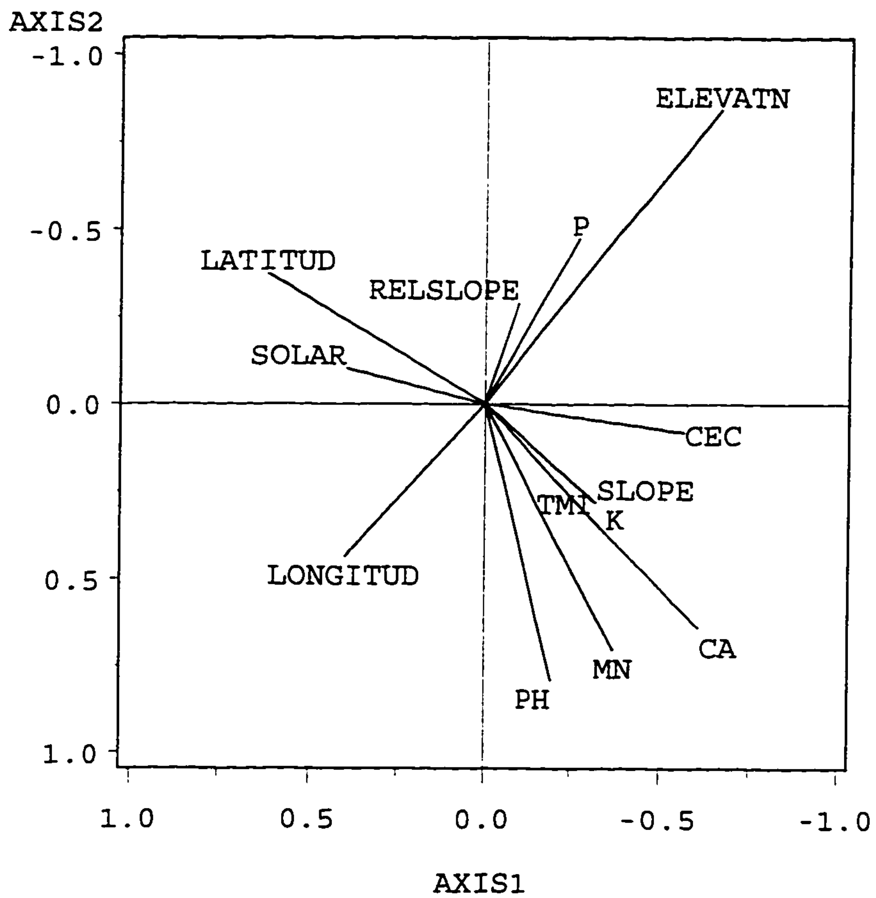


Figure 6.3. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the Black Mountains landscape showing association between species composition and major environmental gradients. Low TMI values represent low site moisture potential whereas large values represent high moisture.

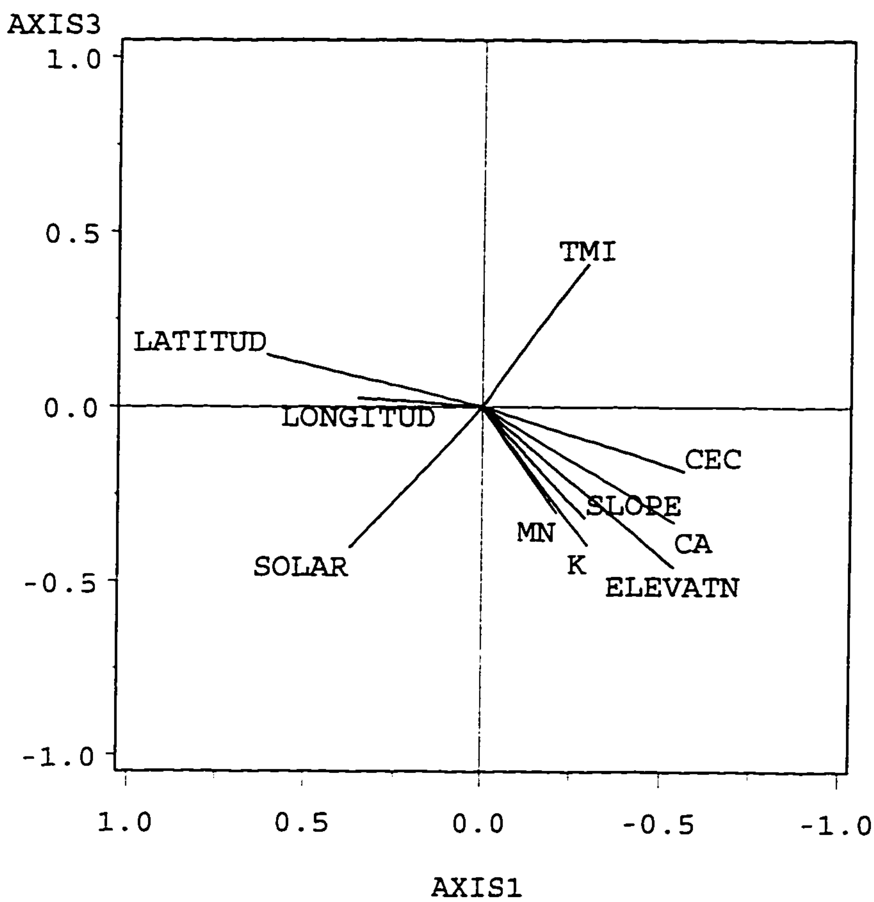
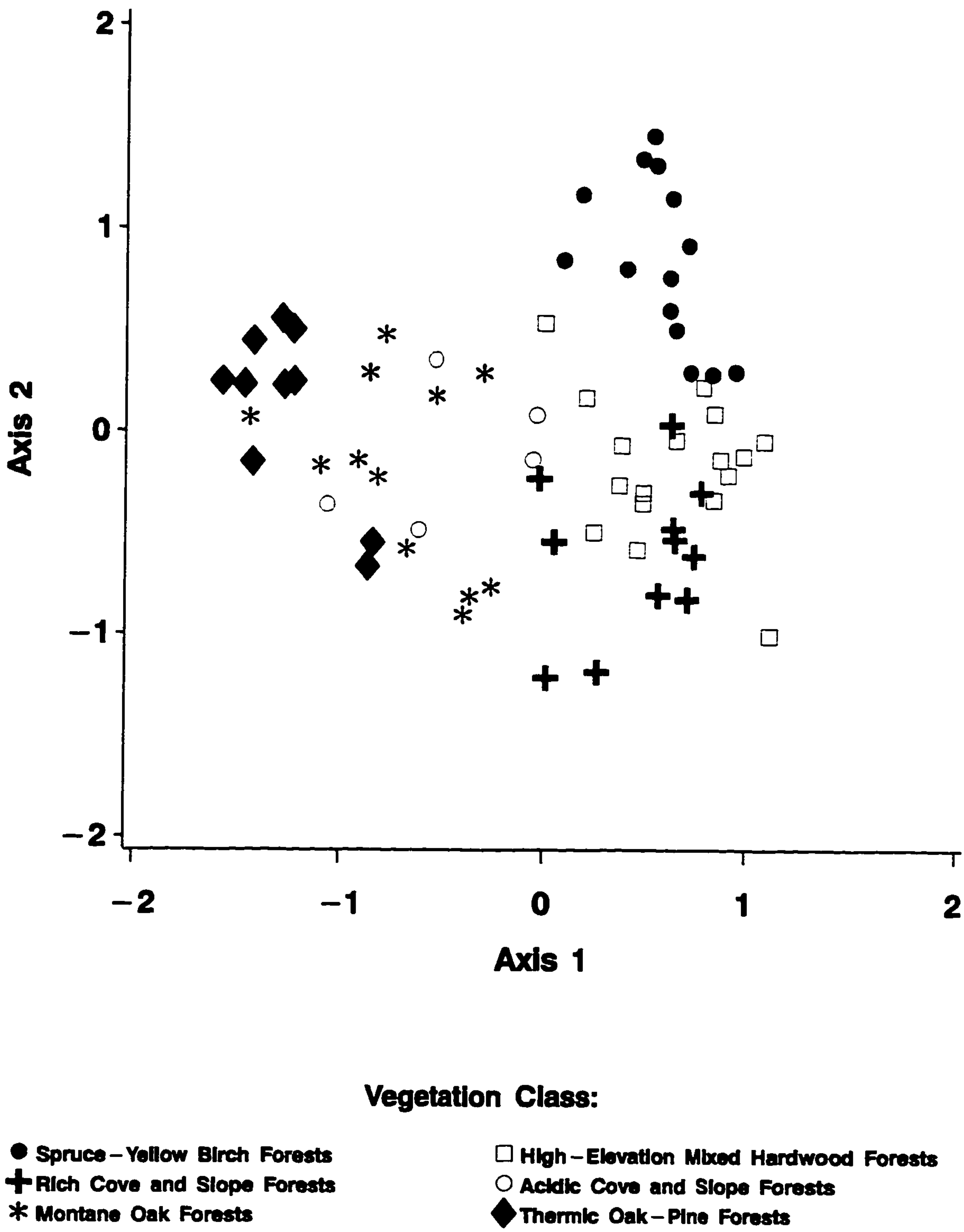


Figure 6.4. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the Black Mountains landscape showing association between species composition and major environmental gradients. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.5. Diagram for NMDS ordination of the Grandfather Mountain landscape showing the distribution of stands classified by vegetation classes on the two major compositional gradients.


2
1
0
−1
−2
Axis 2
−2
−1
0
1
2
Axis 1
Vegetation Class:
Spruce−Yellow Birch Forests
Rich Cove and Slope Forests
Montane Oak Forests
High−Elevation Mixed Hardwood Forests
Acidic Cove and Slope Forests
Thermic Oak−Pine Forests

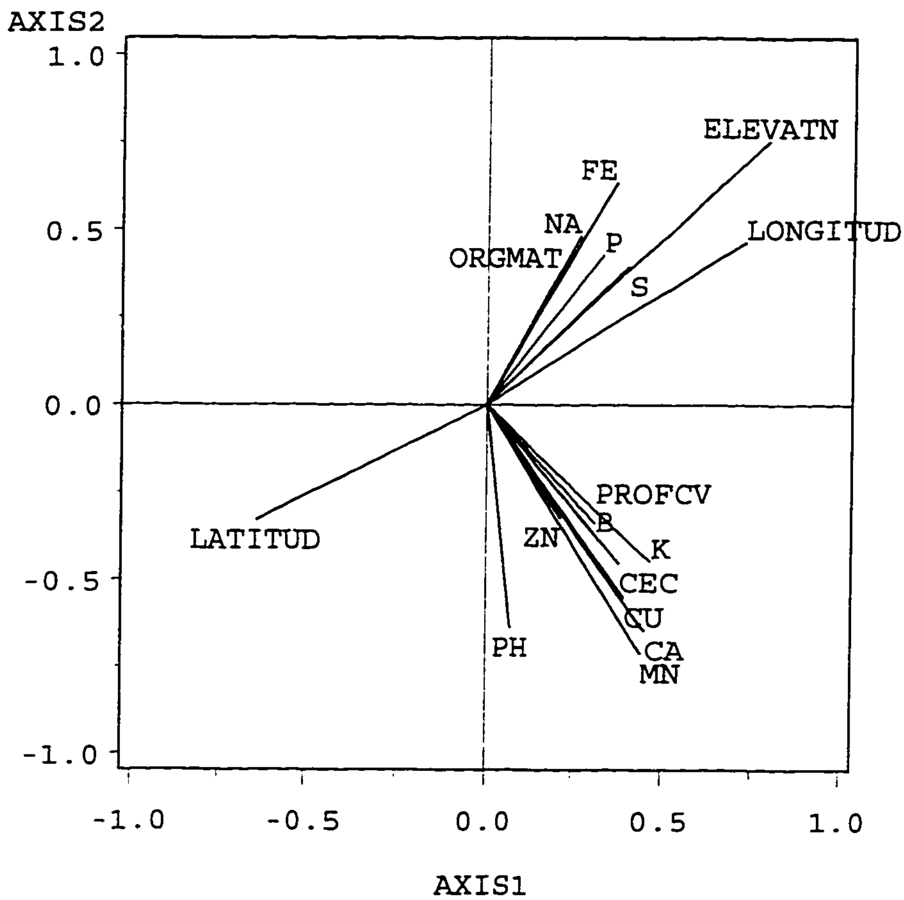


Figure 6.6. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the Grandfather Mountain landscape showing association between species composition and major environmental gradients. PROFCV represents profile curvature.

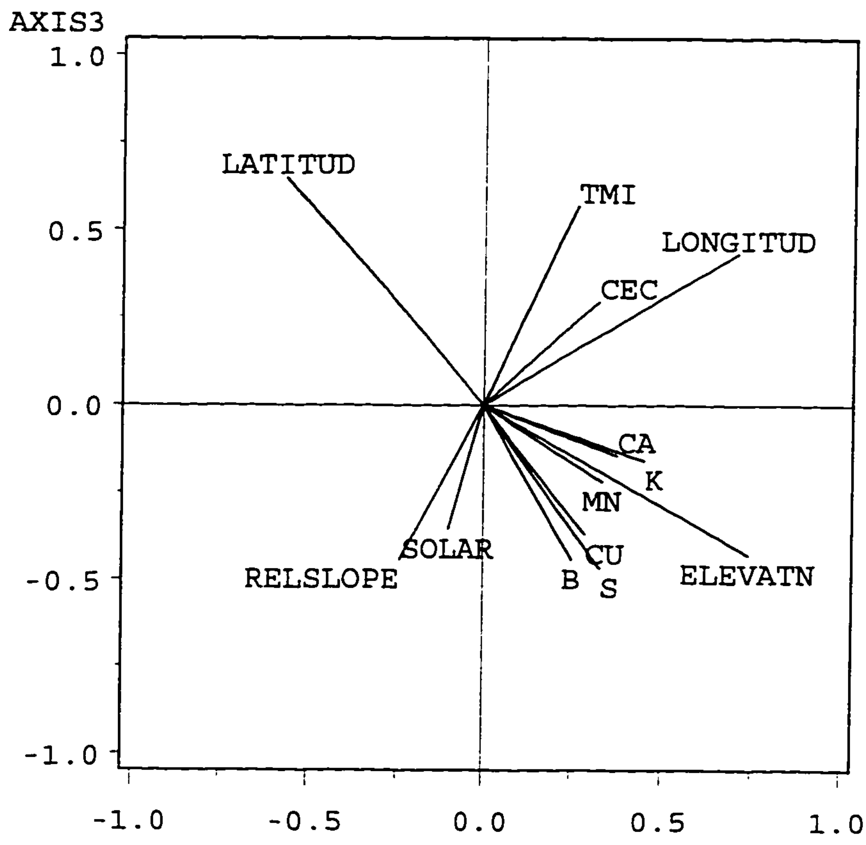
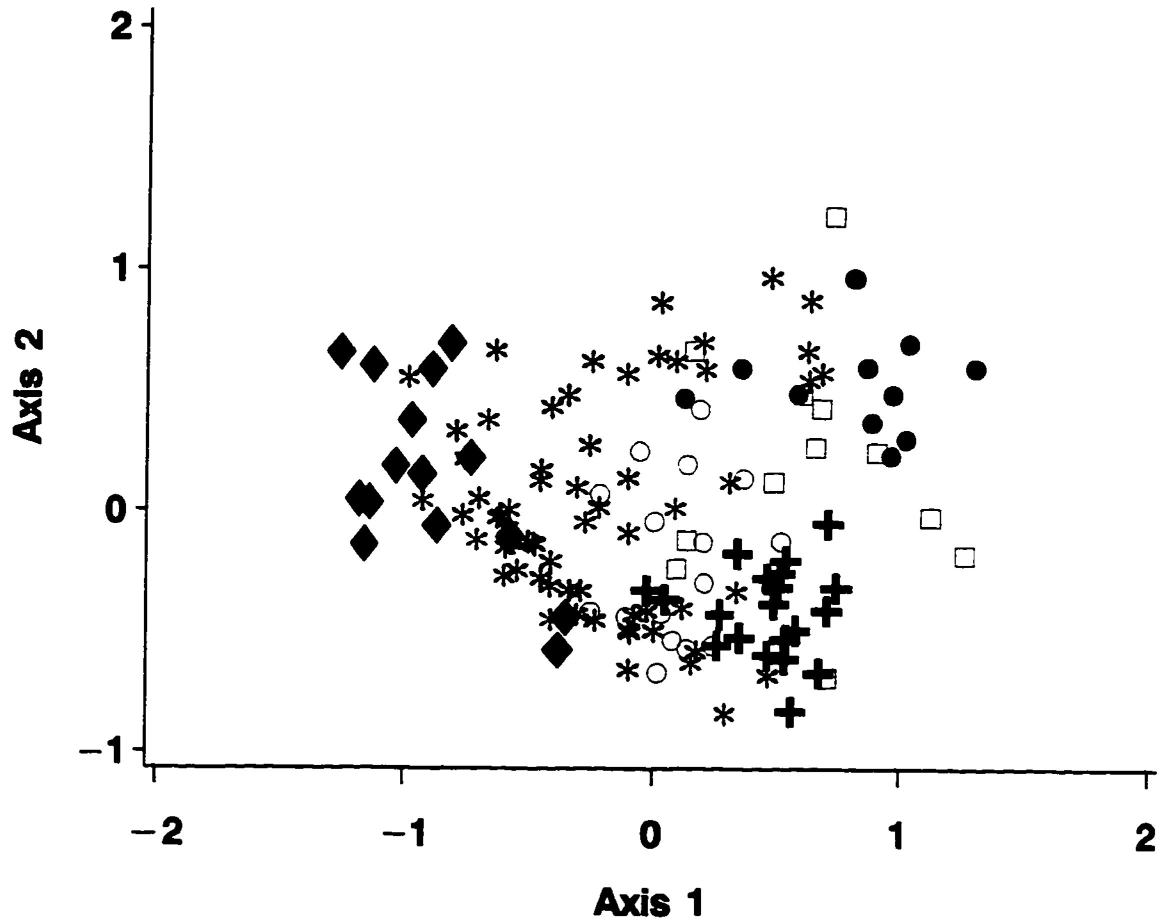


Figure 6.7. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the Grandfather Mountain landscape showing association between species composition and major environmental gradients. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.8. Diagram for NMDS ordination of the Shining Rock landscape showing the distribution of stands classified by vegetation classes on the two major compositional gradients.



Vegetation Class:

● Spruce – Yellow Birch Forests
✚ Rich Cove and Slope Forests
✱ Montane Oak Forests
□ High – Elevation Mixed Hardwood Forests
○ Acidic Cove and Slope Forests
◆ Thermic Oak – Pine Forests

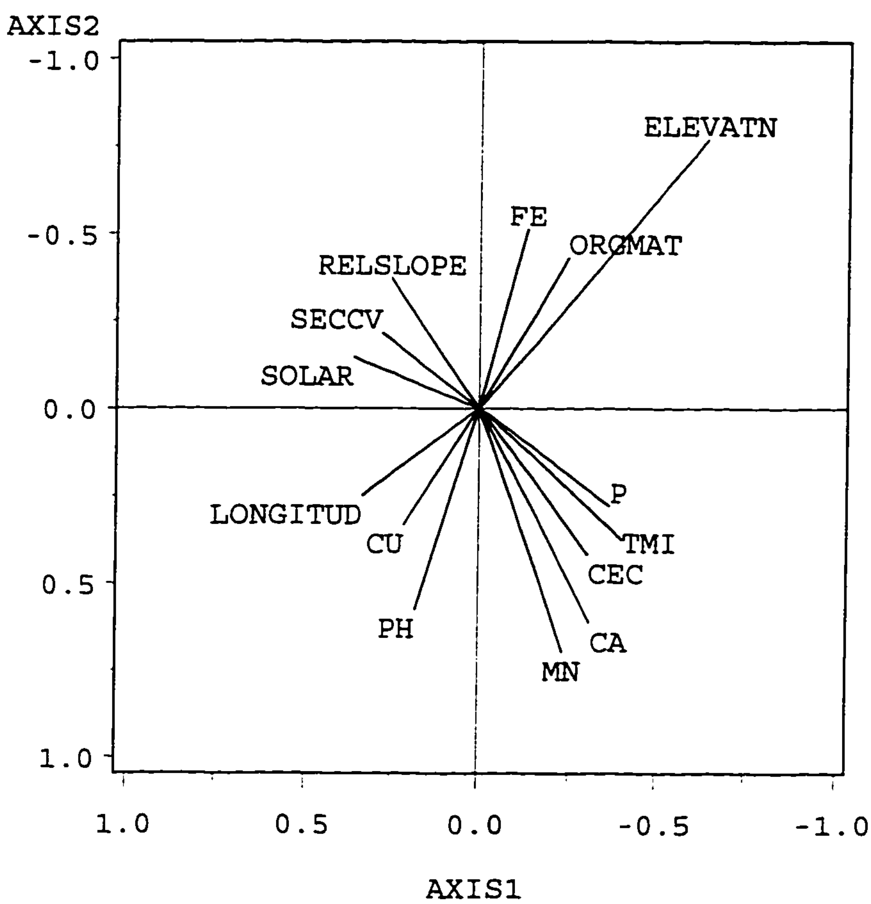


Figure 6.9. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the Shining Rock landscape showing association between species composition and major environmental gradients. SECCV represents section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

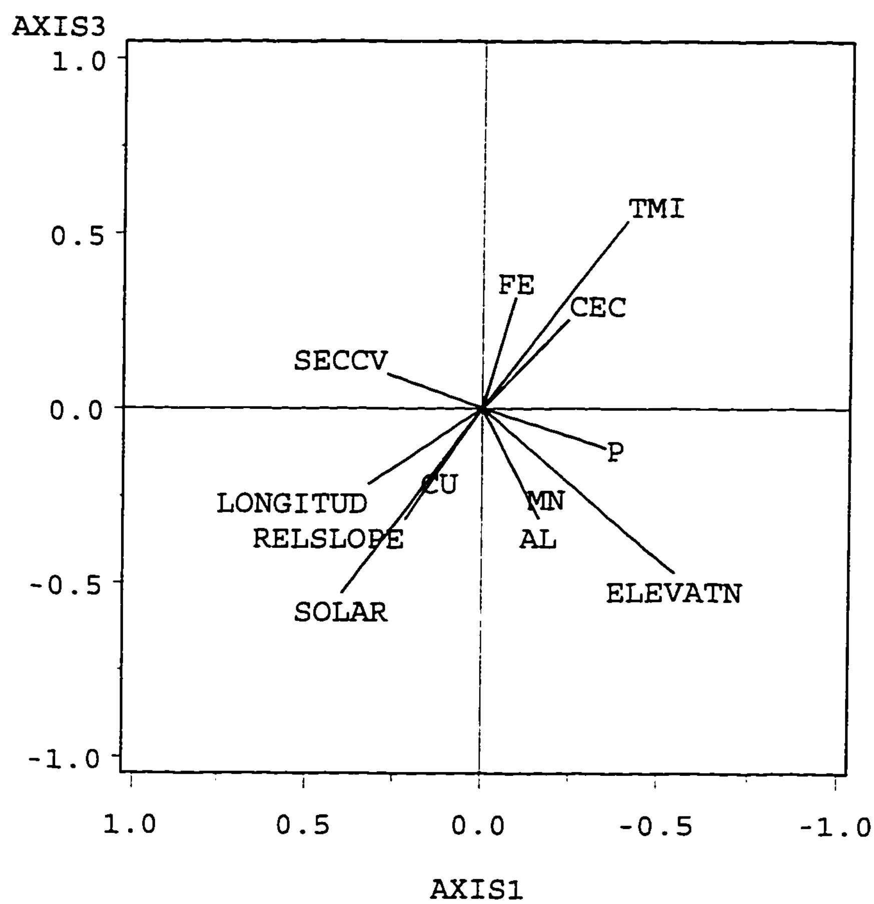
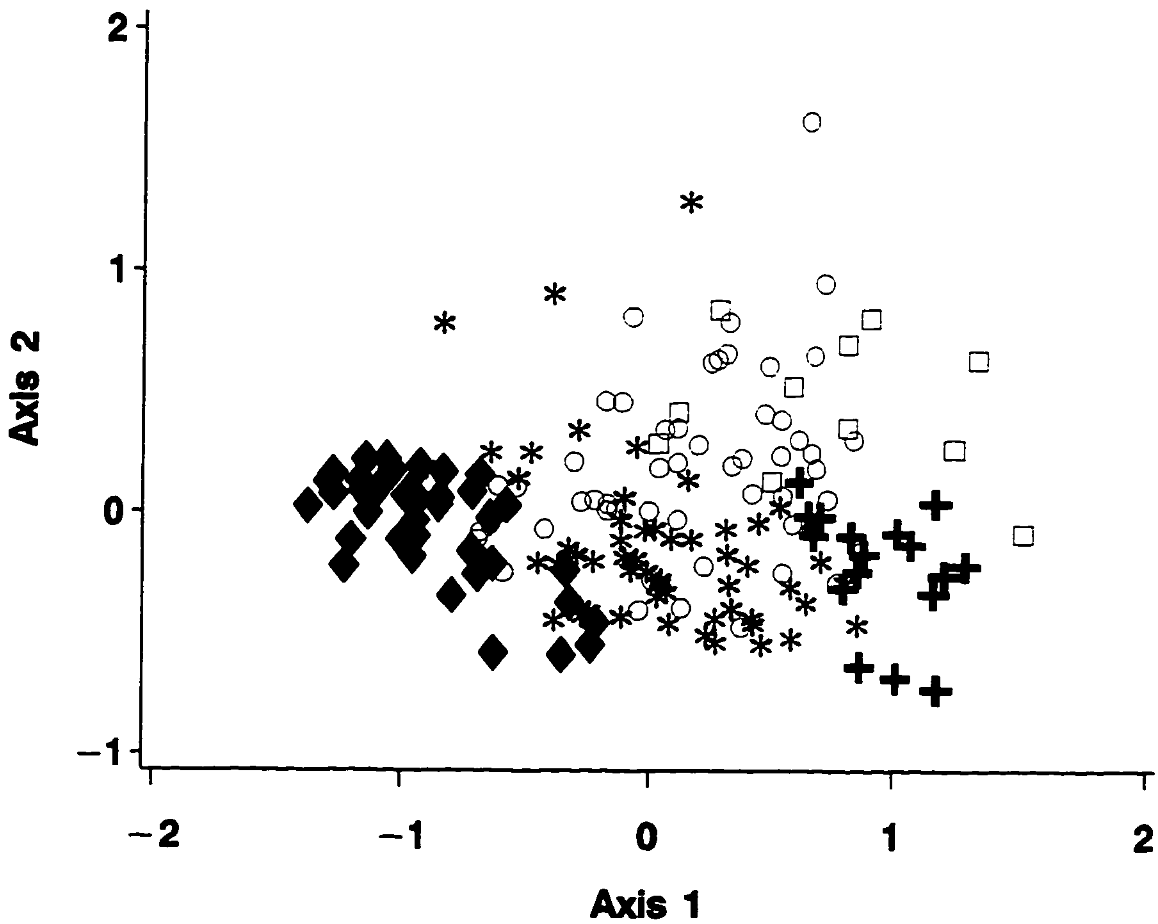


Figure 6.10. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the Shining Rock landscape showing association between species composition and major environmental gradients. SECCV represents section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.11. Diagram for NMDS ordination of the Joyce Kilmer landscape showing the distribution of stands classified by vegetation classes on the two major compositional gradients.



Vegetation Class:

- □ High-Elevation Mixed Hardwood Forests
- ○ Acidic Cove and Slope Forests
- ◆ Thermic Oak-Pine Forests
- ✚ Rich Cove and Slope Forests
- ✱ Montane Oak Forests

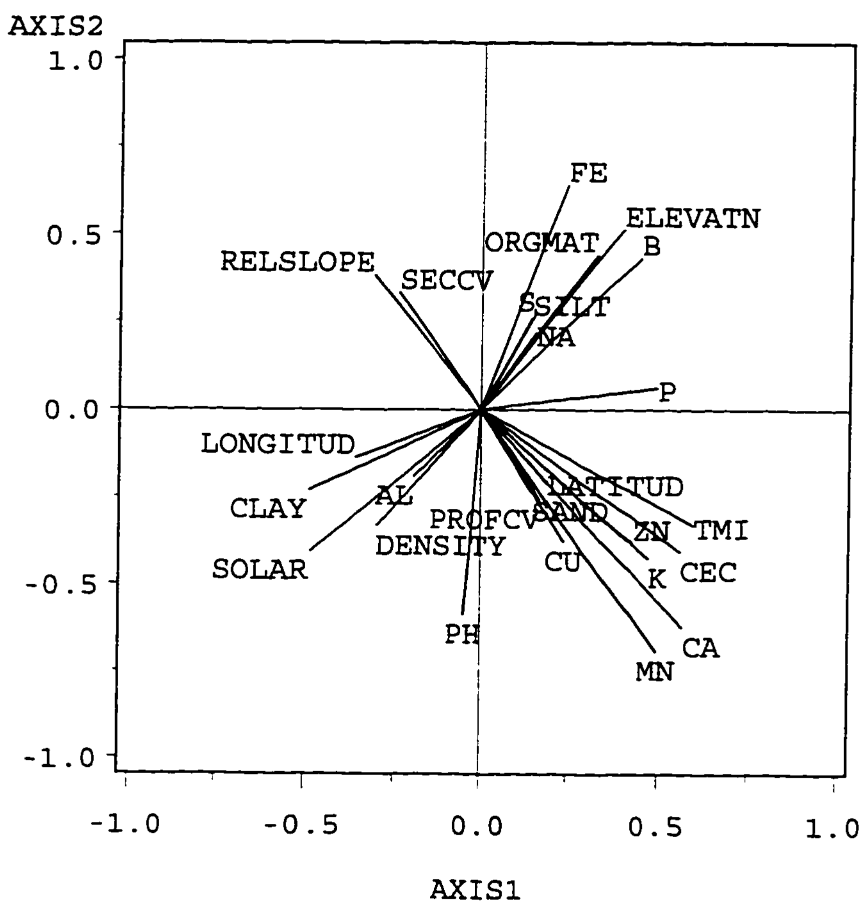


Figure 6.12. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the Joyce Kilmer landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature, SECCV =section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

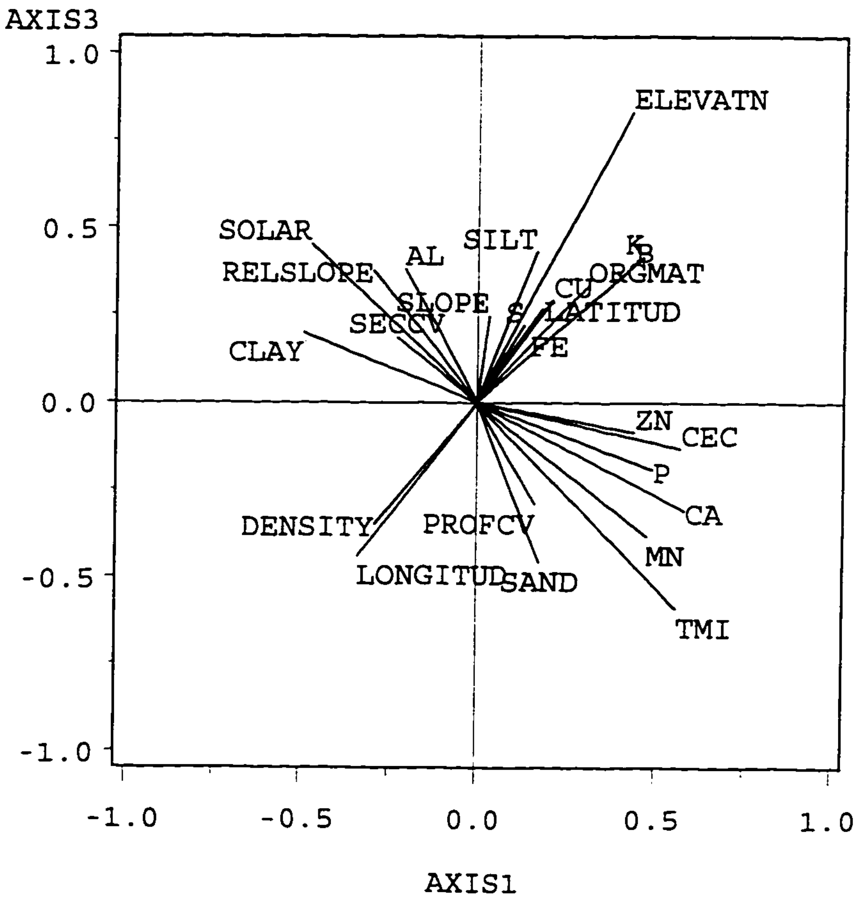
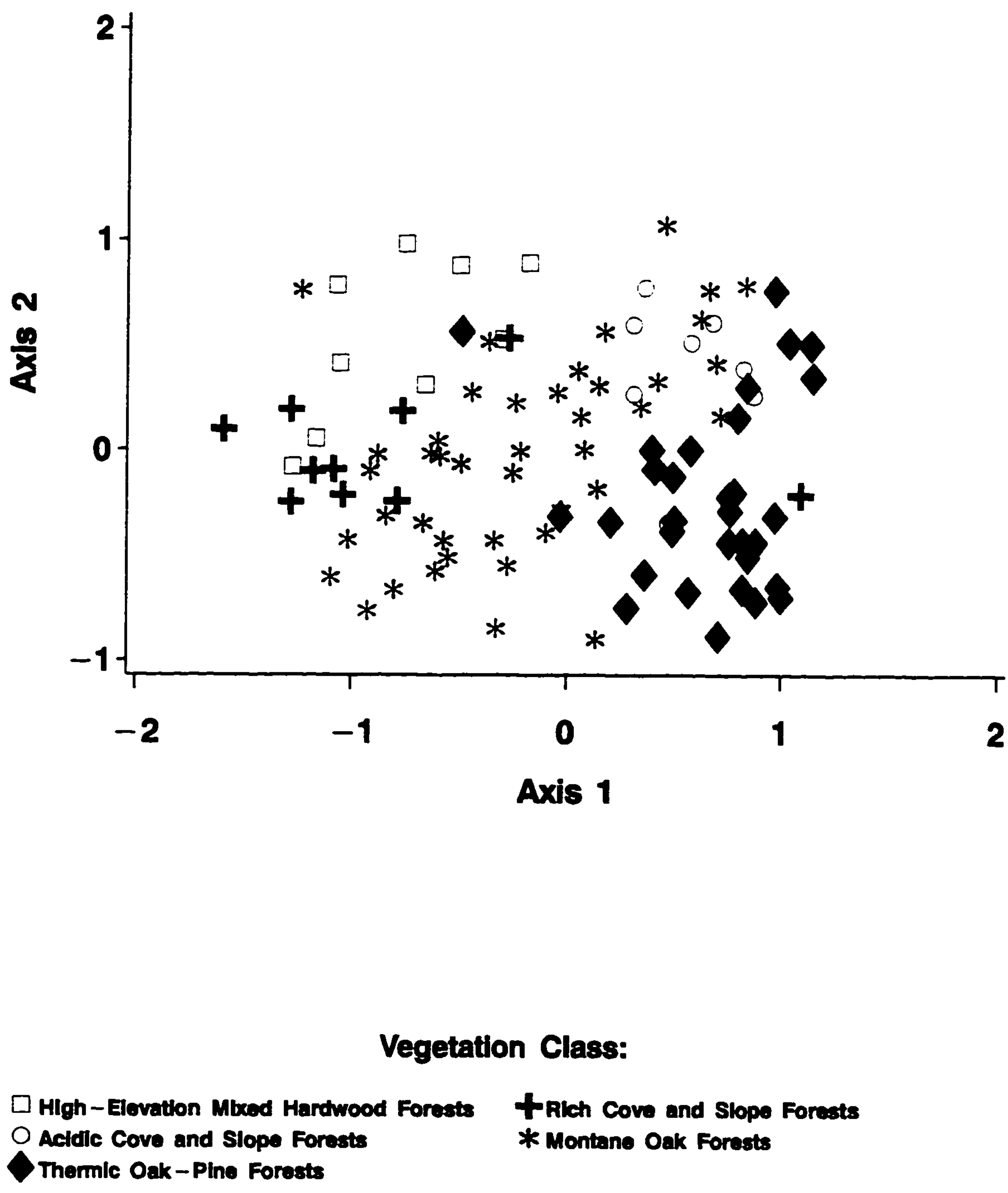


Figure 6.13. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the Joyce Kilmer landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature, SECCV=section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.14. Diagram for NMDS ordination of the Nantahala Mountains landscape showing the distribution of stands classified by vegetation classes on the two major compositional gradients.



Axis 2
Axis 1
2
1
0
−1
−2
−1
0
1
2
Vegetation Class:
High−Elevation Mixed Hardwood Forests
Rich Cove and Slope Forests
Acidic Cove and Slope Forests
Montane Oak Forests
Thermic Oak−Pine Forests

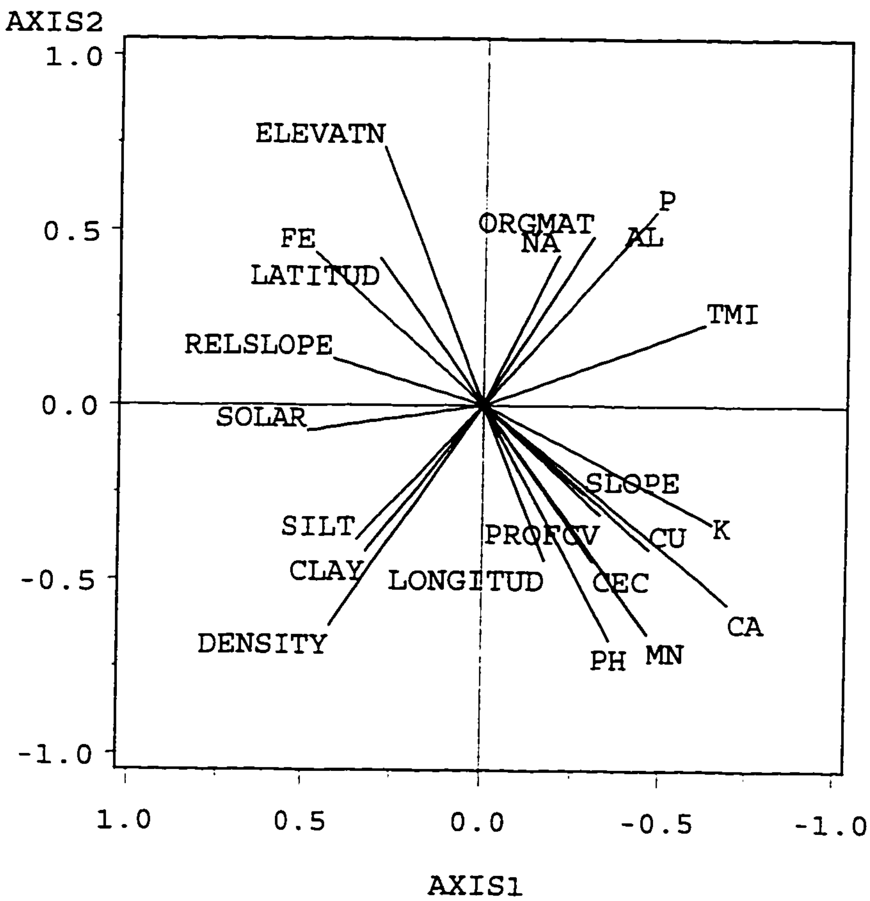


Figure 6.15. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the Nantahala Mountains landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

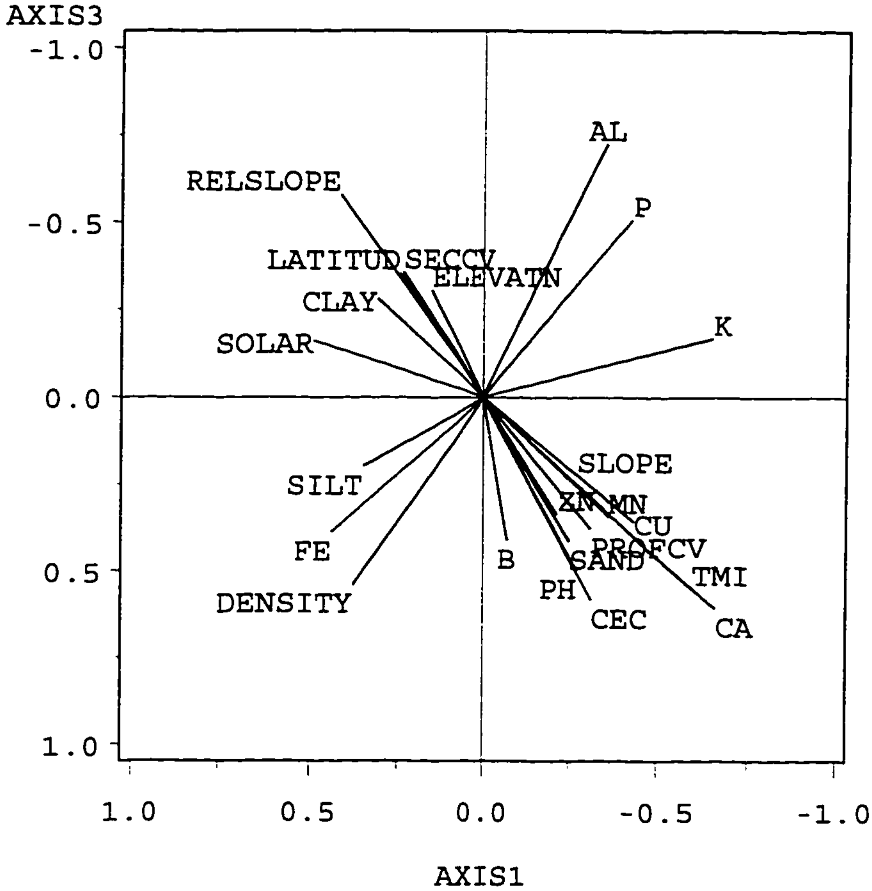
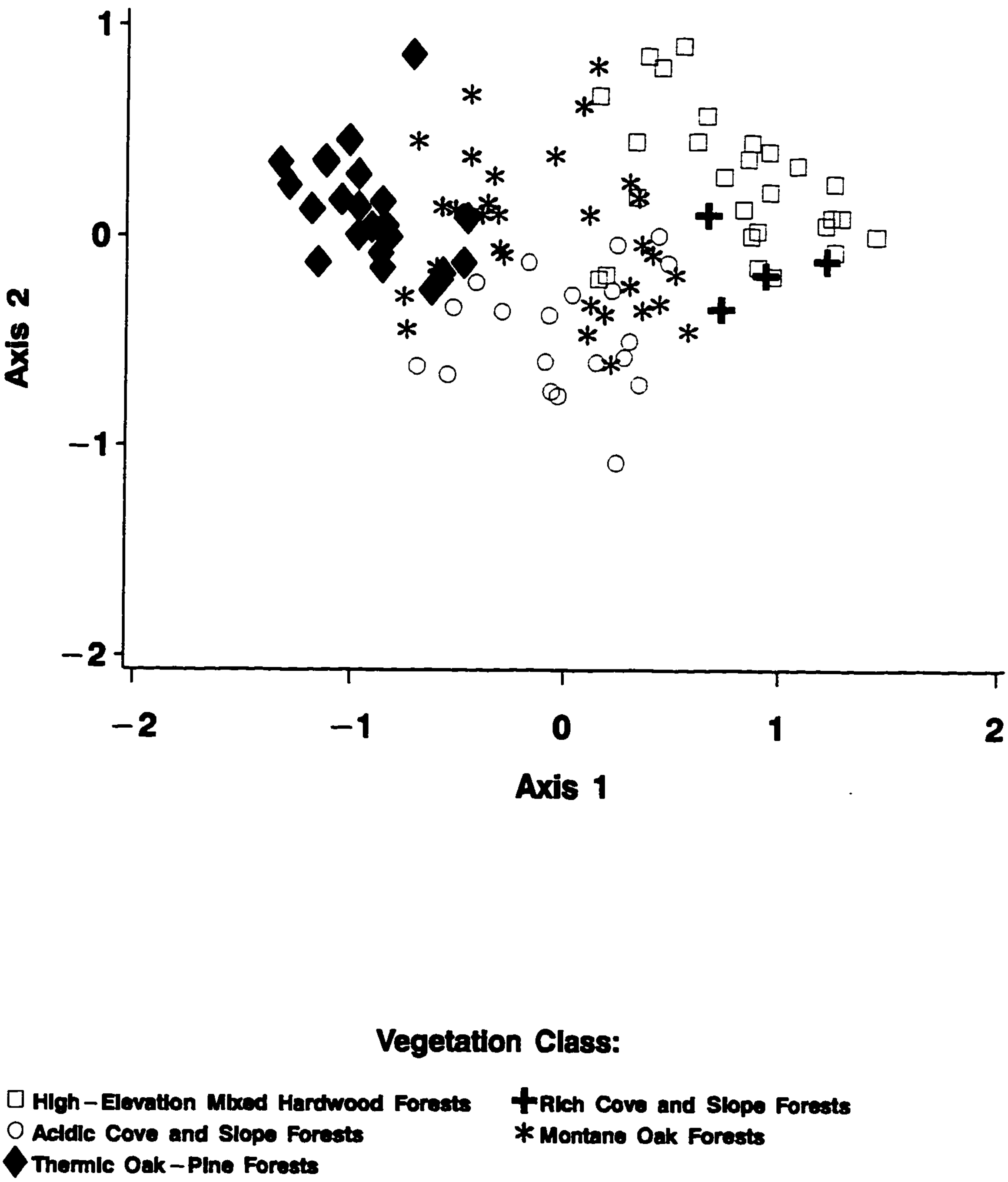


Figure 6.16. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the Nantahala Mountains landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature, SECCV=section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.17. Diagram for NMDS ordination of the Smoky Mountains landscape showing the distribution of stands classified by vegetation classes on the two major compositional gradients.



Axis 2
Axis 1
1
0
−1
−2
−2
−1
0
1
2
Vegetation Class:
High−Elevation Mixed Hardwood Forests
Acidic Cove and Slope Forests
Thermic Oak−Pine Forests
Rich Cove and Slope Forests
Montane Oak Forests

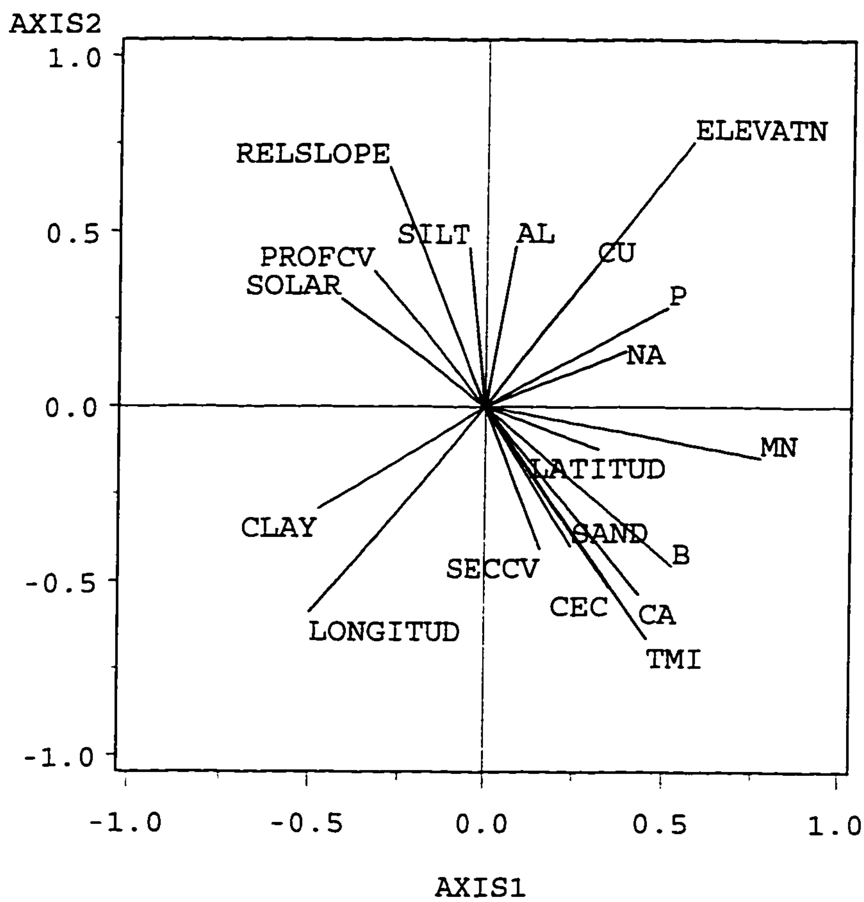


Figure 6.18. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the Smoky Mountains landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature, SECCV=section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

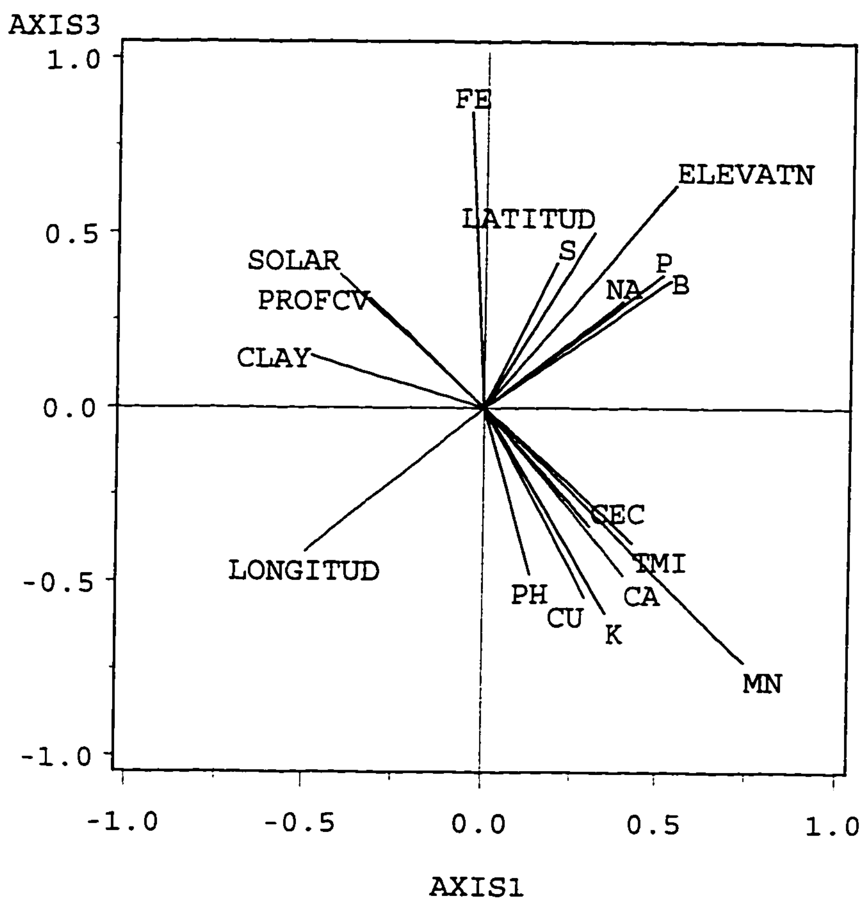
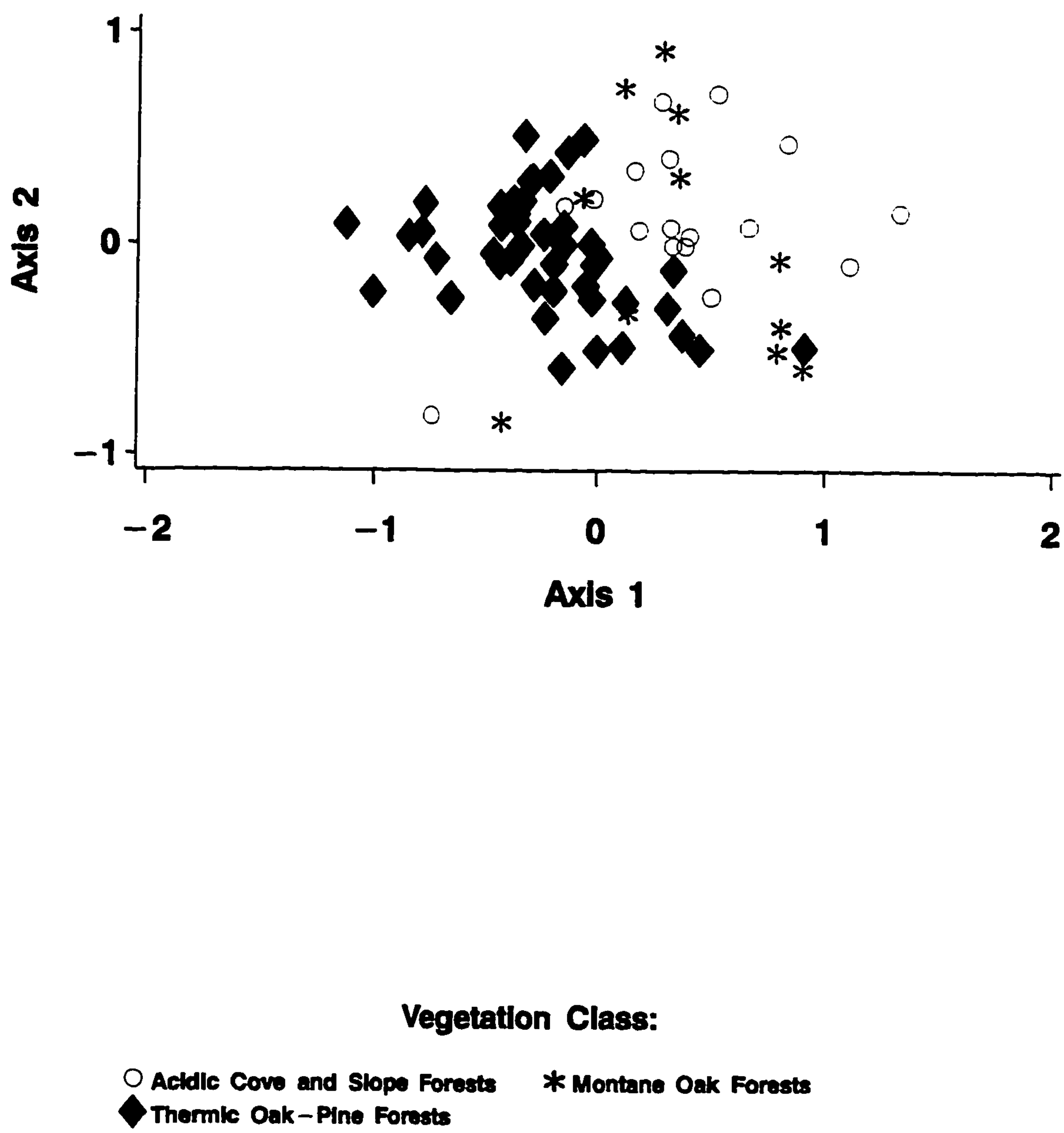


Figure 6.19. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the Smoky Mountains landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.20. Diagram for NMDS ordination of the Chattooga River landscape showing the distribution of stands classified by vegetation classes on the two major compositional gradients.


1
0
−1
−2
−1
0
1
2
Axis 2
Axis 1
Vegetation Class:
○ Acidic Cove and Slope Forests
* Montane Oak Forests
◆ Thermic Oak−Pine Forests

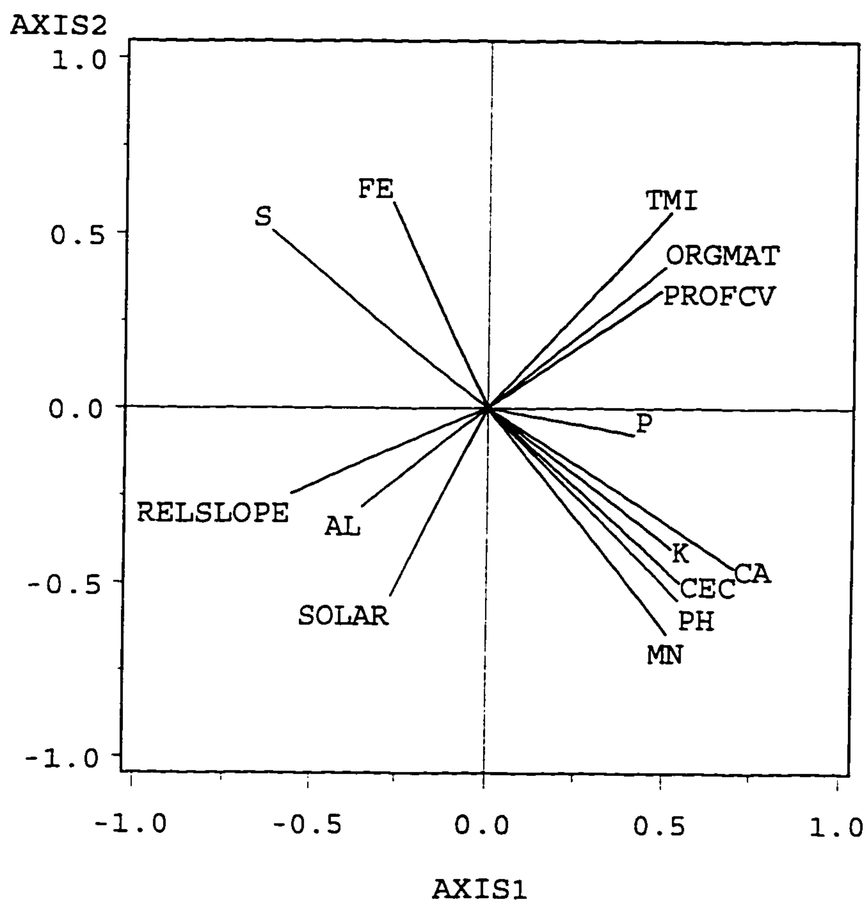


Figure 6.21. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the Chattooga River landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

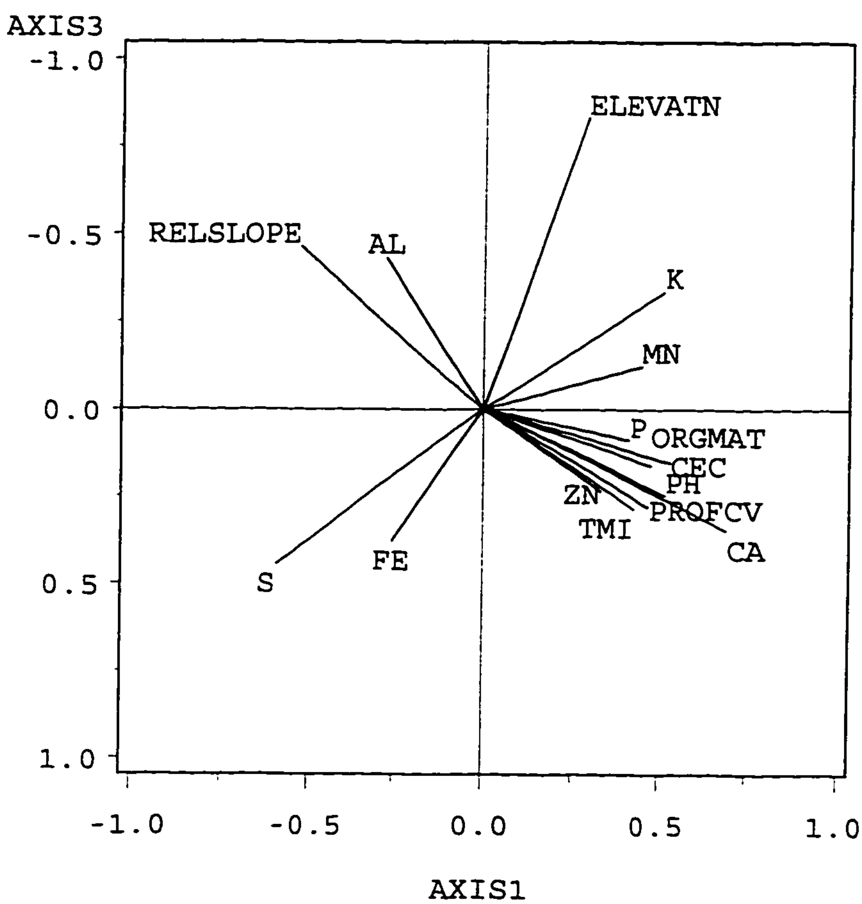
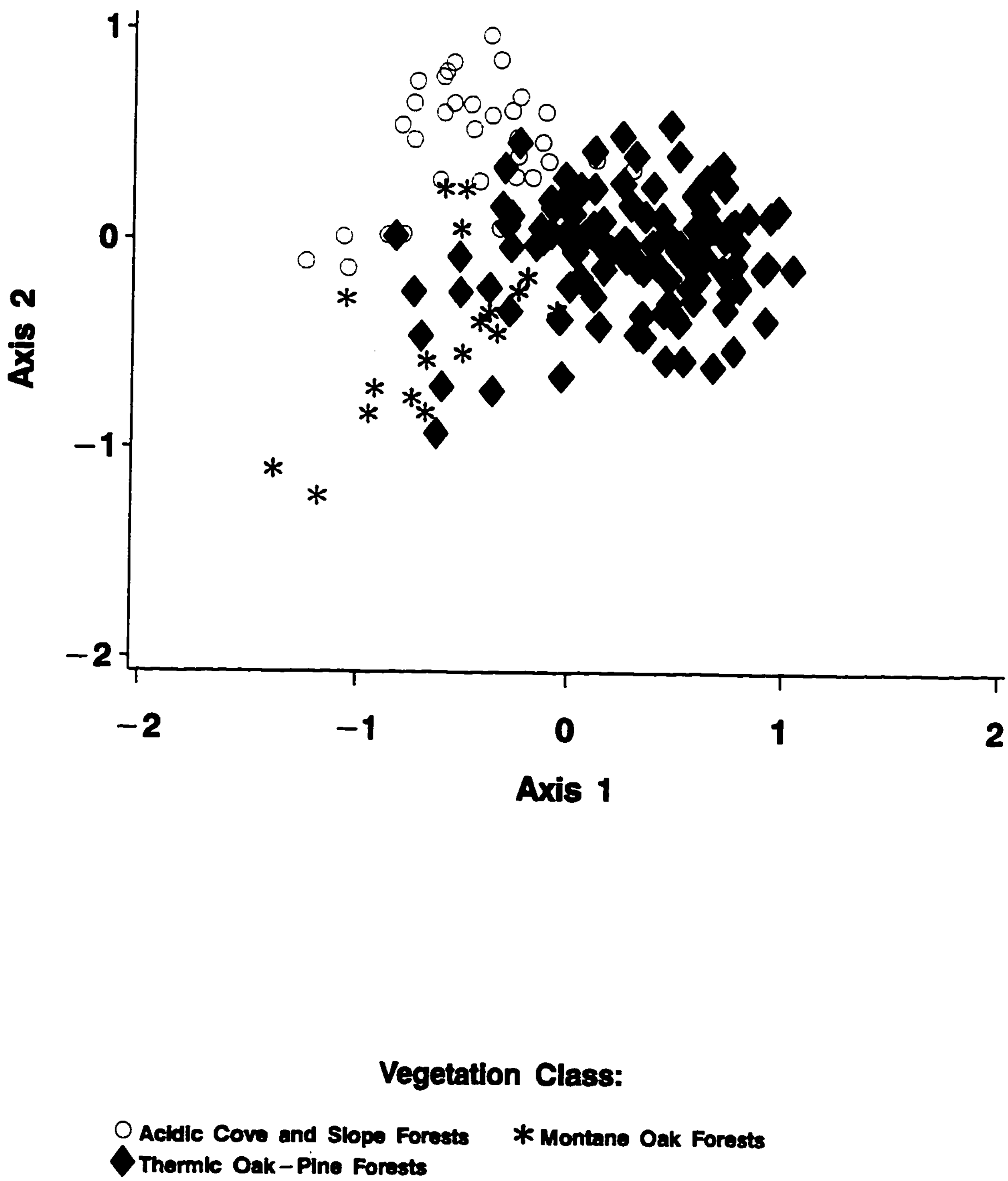


Figure 6.22. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the Chattooga River landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.23. Diagram for NMDS ordination of the Linville Gorge landscape showing the distribution of stands classified by vegetation classes on the two major compositional gradients.


1
0
−1
−2
Axis 2
−2
−1
0
1
2
Axis 1
Vegetation Class:
Acidic Cove and Slope Forests
Montane Oak Forests
Thermic Oak−Pine Forests

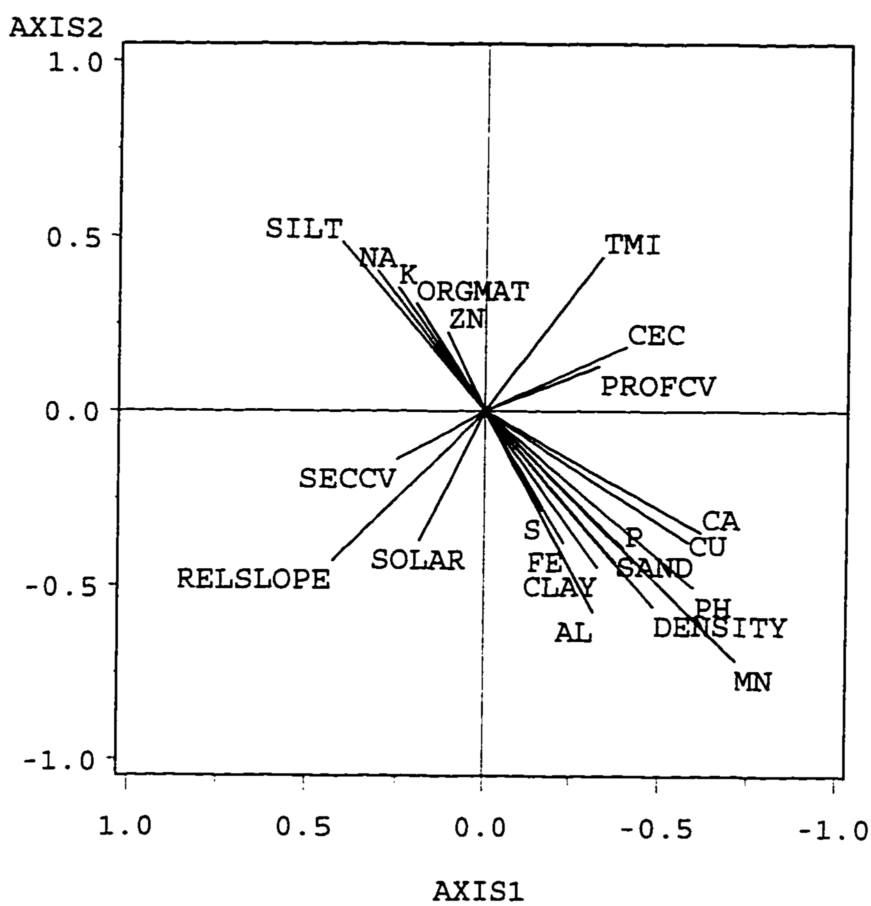


Figure 6.24. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the Linville Gorge landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

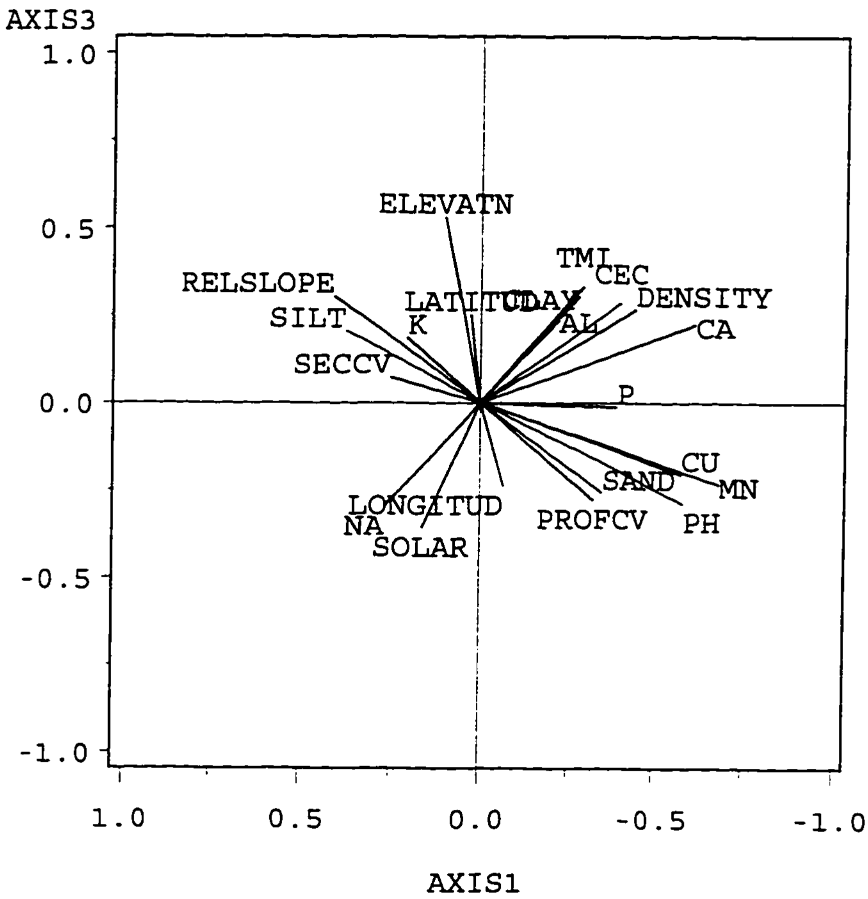
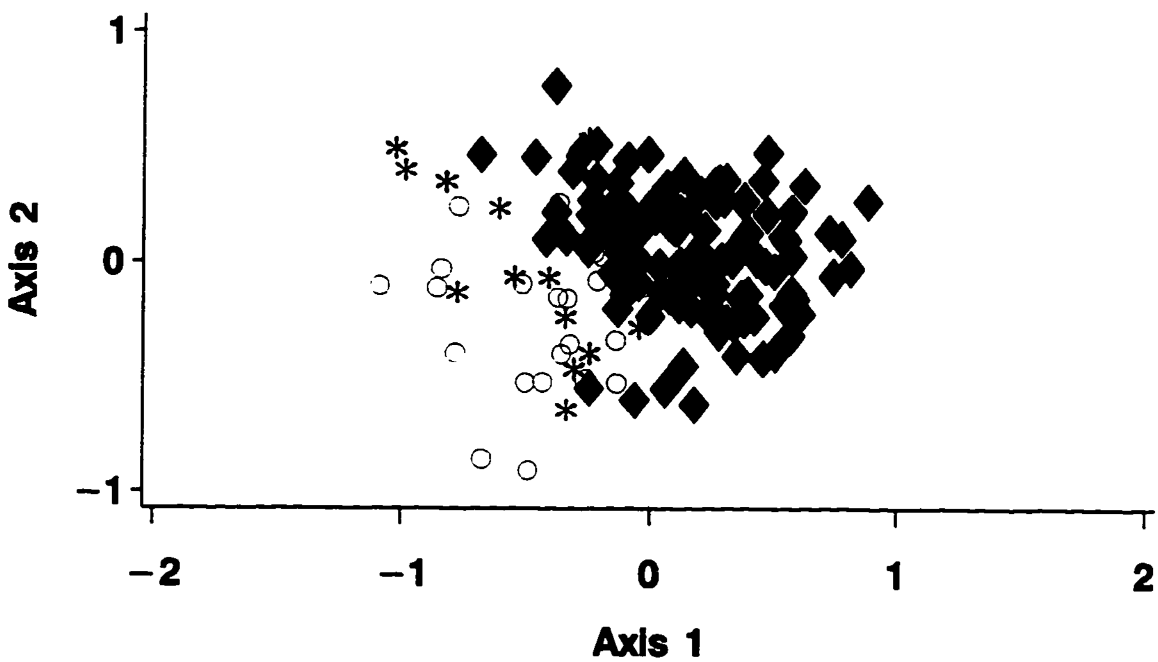


Figure 6.25. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the Linville Gorge landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.26. Diagram for NMDS ordination of the Thompson River landscape showing the distribution of stands classified by vegetation classes on the two major compositional gradients.



Vegetation Class:

○ Acidic Cove and Slope Forests ✱ Montane Oak Forests
◆ Thermic Oak−Pine Forests

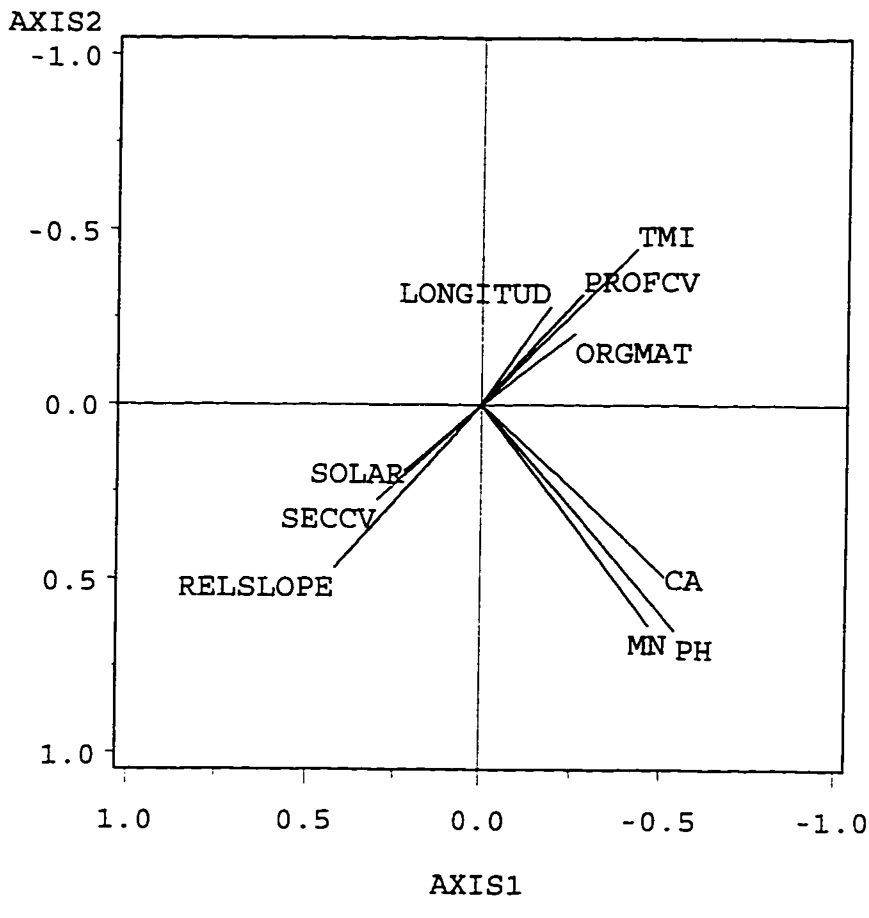


Figure 6.27. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the Thompson River landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature, SECCV=section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

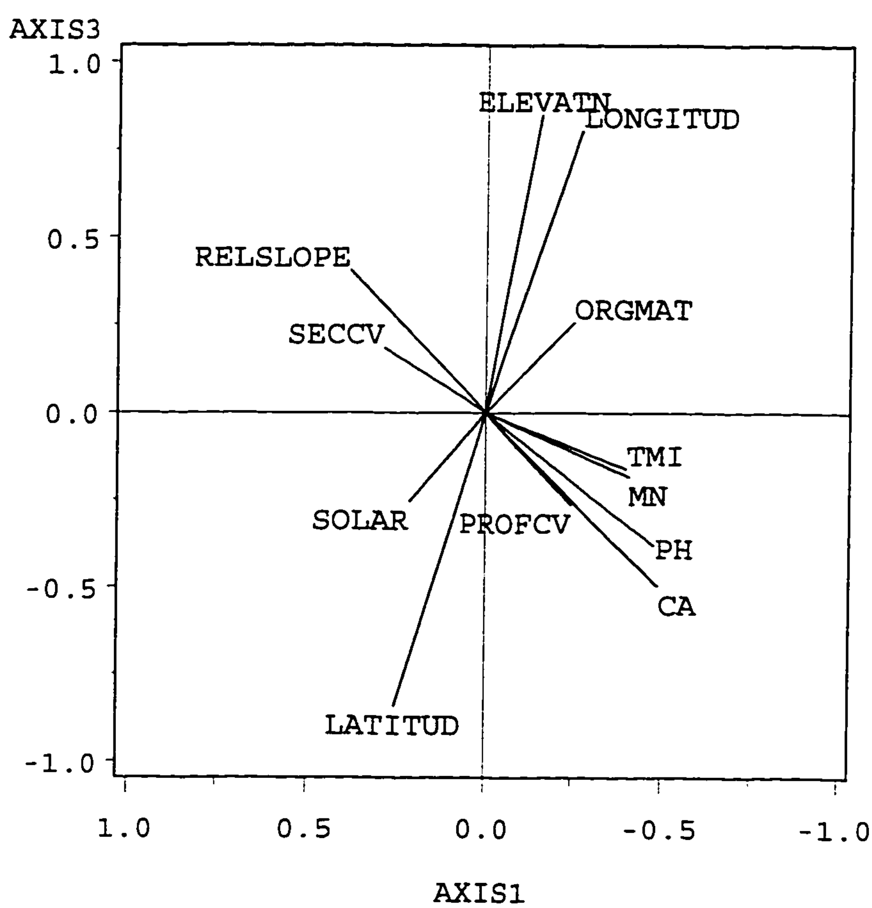


Figure 6.28. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the Thompson River landscape showing association between species composition and major environmental gradients. PROFCV=profile curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

(Figures 6.20-6.28). At Linville Gorge vegetation is primarily distributed along a soil fertility- texture (soil density, sand, silt) gradient, with Mn having the strongest association with composition. Vegetation is also distributed by relative slope position and TMI. In the two high-rainfall Escarpment landscapes, the strength of the soil fertility gradient is less overwhelming, with soil fertility (Ca, Mn, pH) and topographic position (TMI, relative slope position) having correlations of similar strength with vegetation. Strong associations between vegetation composition and Fe and S identified in the Chattooga River are not visible in the other two low-elevation landscapes. Vegetation in the Chattooga River also has stronger associations with site profile curvature and organic matter than in the other two landscapes.

At Linville Gorge, variation in soil texture corresponds with differences in the underlying parent material (Chapter 3). The consistency of the relationships between soil texture and vegetation can not be determined in the two Escarpment landscapes as these characteristics were not quantified. A study in a small tributary of the Thompson River by Mowbray & Oosting (1968), suggests that the soils of Thompson River are much coarser-textured than those in Linville Gorge. The soils in Mowbray and Oosting's study were dominated by sand (45-86% of textural component). These levels contrast with Linville Gorge where forest stands have predominantly silt-based soils (65-92% of texture component; Table 3.5)

In both Escarpment landscapes, the biplot of Axis 1 and Axis 3 suggests that the third vegetation gradient has strong associations with elevation (Figures 6.20-6.28). A similar, but weaker association is also present at Linville Gorge. In this landscape the tertiary compositional gradient has stronger correlations with soil nutrients and relative slope position. At the Thompson River the third compositional gradient is also strongly associated with rotated longitude and latitude. Longitude here probably represents a surrogate for environmental factors associated with changes in elevation that parallel the length of the Thompson River valley. Latitude is negatively correlated with elevation and possibly represents changes in elevation perpendicular to the main axis of the river valley.

6.4 Comparison of regional vegetation class distribution using a standardized gradient framework

A standard gradient framework was established to compare vegetation class distribution across the nine landscapes. Previous studies (e.g., Whittaker 1956, Callaway *et al.* 1987, McLeod 1988, Patterson 1994) have identified complex gradients of elevation, topographic-moisture and soil fertility as important in the Southern Appalachians. The ordination analyses in this regional synthesis revealed that elevation, topographic-moisture and soil nutrients had consistently strongest correlations with vegetation patterns in all 9 landscapes. Based on these findings, a standard gradient framework was established, with stands distributed by elevation and topographic-moisture (TMI) under three nutrient regimes (represented by log (Mn)) to determine whether individual vegetation classes had a consistent position with respect to elevation, soil fertility and topographic-moisture across the region.

My previous research in the Southern Appalachian Mountains (see Chapters 3-5) showed pH and Mn to have strongest association with major species compositional gradients and species diversity in comparison to all other soil variables used in these analyses. pH is often used as a measure of soil fertility and, in general, is a reasonable indicator of soil nutrient availability (Brady 1974). Manganese is known to precipitate readily in acidic, well-drained soils (Collins & Buol 1970) and probably serves as a surrogate for the combined influence of original fertility and degree of leaching. Within the pH range of the site in this study, Mn is positively correlated with pH and site moisture status. In their 5-landscape study, Newell *et al.* (*in press*) found that the range of log-transformed Mn levels within each of the 5 landscapes was less variable than pH, and thus came closer to providing a standard measure for comparison of forest distribution across nutrient levels. A similar trend was found in this study (Figures 6.29, 6.30). Newell *et al.* (*in press*) also found that on pH-based gradient diagrams, stands within a single vegetation class were not closely associated with each other, but rather were scattered across the diagram. However, on Mn-based gradient diagrams, stands were generally positioned adjacent to other members of the same vegetation class. Mn was chosen to represent soil fertility in the following standardized gradient diagrams based on more consistent ranges of log-transformed Mn values across the 9 landscapes used in this study, comparison to pH ranges and the findings of Newell *et al. (in press)*.

A set of three gradient diagrams was constructed for each landscape, representing low-nutrient, mid-nutrient and high-nutrient regimes. Stands were divided into three Mn groups, with the boundaries of the mid-nutrient class defined as approximately one half standard deviation either side of the mean (log (ppm) mean of 3.081, SD of 1.399). Infertile, low-nutrient sites included stands with ln-transformed Mn values ≤2.382, mid-nutrient = 2.383 to 3-779 and nutrient-rich stands ≥3.780. Stands were plotted on the diagram using consistent elevation and topographic-moisture axes and were identified by their respective vegetation class. Plots lacking soil information were excluded from the gradient diagram analyses. The Smoky Mountains dataset is included in the following gradient diagram comparisons, but is incomplete due to lack of Mn data for half the stands. Reference to the "2 mid-elevation landscapes" includes Joyce Kilmer and the Nantahalas that have a full complement of Mn values.

The regional classification based on tree species grouped the 1120 forest stands into 6 broad-scale vegetation classes, with 7 stands eliminated from the classification by the TRIM function. This broad-scale classification was used to examine the consistency of inter-landscape vegetation distribution and composition (Figure 6.1). Each vegetation class was separately clustered into community types that represent groups of compositionally similar stands that are recognizable in the field (Figure 6.1).

The same vegetation class nomenclature was used for both the landscape analyses in Chapters 3-5 and the regional analysis, except where the results of the quantitative regional classification suggested that the name used in the landscape studies did not adequately describe the composition of the quantitatively derived vegetation class (Table 6.2). In this way, the previously recognized **Spruce-Fir Forests** vegetation class was changed to the **Spruce-Yellow Birch Forests** vegetation class, based on the widespread dominance of *Picea rubens* and *Betula alleghaniensis* and more limited distribution of *Abies fraseri*. Similarly, elimination of "evergreen" from the **Xeric Evergreen Forests** vegetation class to

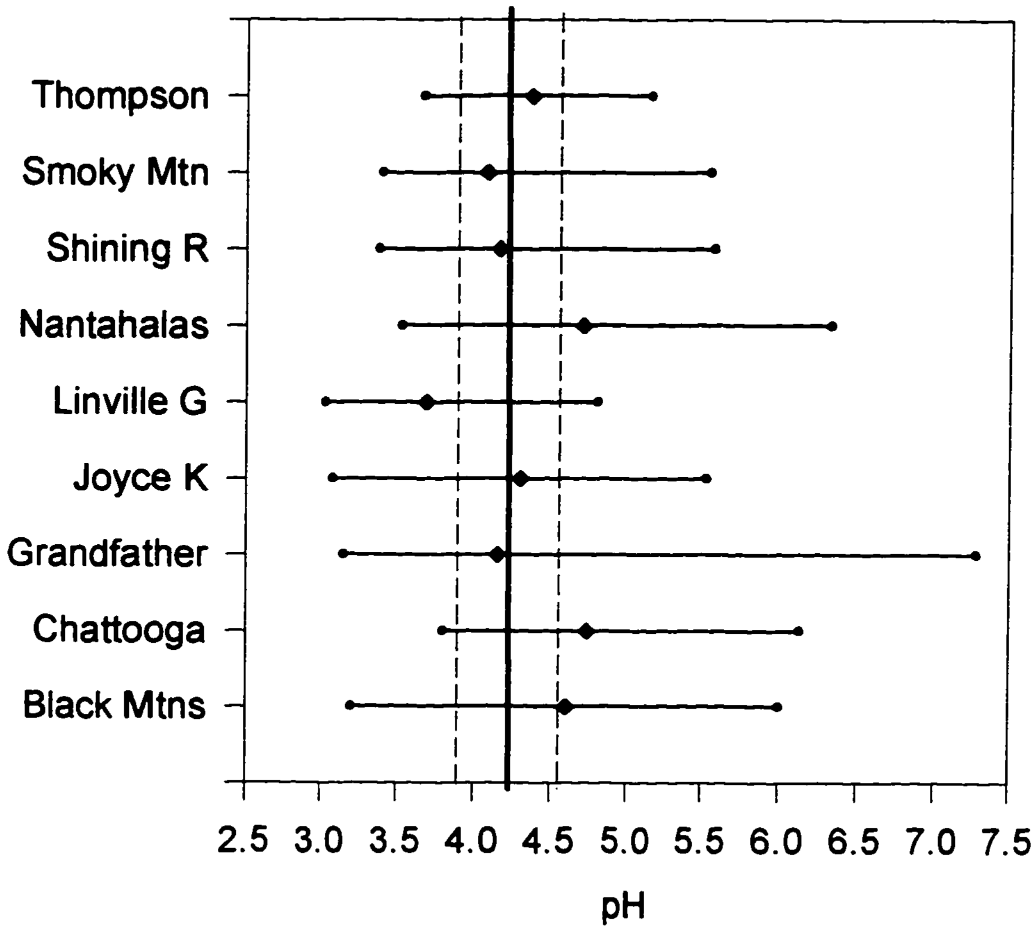


Figure 6.29. The mean (represented by a diamond) and range (represented by the thin horizontal lines) of pH values of forest stands in each study area. Overall mean across all landscapes is presented by the thick vertical line. Potential division of stands are delineated by the dashed lines, defined as one half standard deviation either side of the mean.

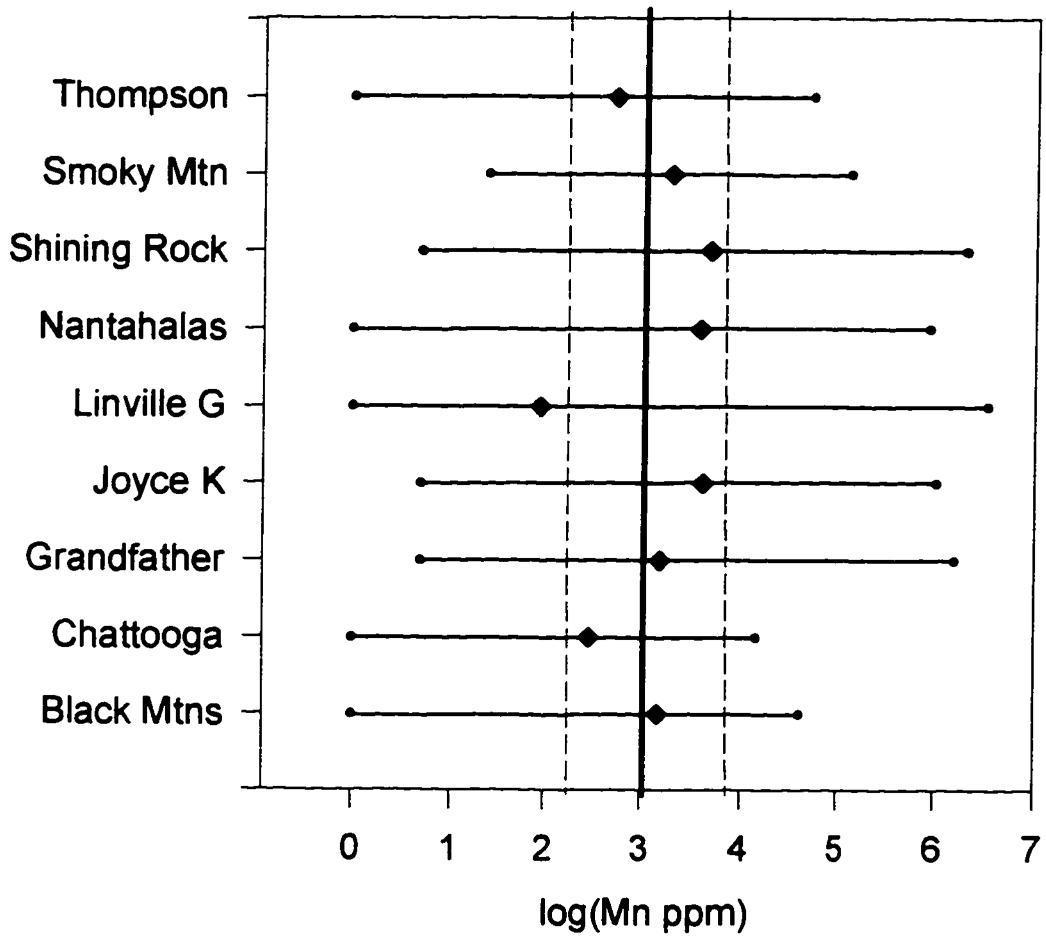


Figure 6.30. The mean (represented by a diamond) and range (represented by the thin horizontal lines) of log (ln)-transformed manganese (Mn) values (measured in ppm) of forest stands in each study area. Overall mean across all landscapes is presented by the thick vertical line. Potential division of stands are delineated by the dashed lines, defined as one half standard deviation either side of the mean.

Table 6.2. Synonymy between the vegetation class names used in the regional study (Chapter 6), landscape studies (Chapters 3-5).

Regional study:	Landscape studies:
Acidic Cove and Slope Forests	Acidic Cove and Slope Forests
High-Elevation Mixed Hardwood Forests	High-Elevation Mixed Hardwood Forests
Montane Oak Forests	Montane Oak Forests
Rich Cove and Slope Forests	Rich Cove and Slope Forests
Spruce-Yellow Birch Forests	Spruce-Fir Forests
Thermic Oak-Pine Forests	Xeric Evergreen Forests

the **Thermic Oak-Pine Forests** class was made on the basis that only a portion of the community types within this class are dominated by evergreen species. The change from "xeric" to "thermic" was undertaken to recognize the dominance of this vegetation class on warm sites rather than those strictly associated with dry, but infertile conditions.

The **Spruce-Yellow Birch Forests** are restricted to high-elevation regions of Black Mountains, Shining Rock and Grandfather and Roan Mountains (Figures 6.31-6.33). It should be noted that these forests are also a distinctive feature of the Great Smoky Mountains, but were not represented in the dataset used in this study. This class is dominated by *Picea rubens*, *Abies fraseri* and *Betula alleghaniensis*. The **Spruce-Yellow Birch Forests** are distributed across all three nutrient regimes in the Black Mountains, Grandfather Mountain and Shining Rock landscapes, but are typically found on mid- and low-nutrient sites. This class is distributed across a broad range of topographic positions in all three landscapes. There is a comparatively clear elevational separation of **Spruce-Yellow Birch Forests** stands from other vegetation classes at the Black and Grandfather Mountains, whereas **Spruce-Yellow Birch Forests** stands at Shining Rock are found at similar elevations to both the **Montane Oak Forests** and the **High-Elevation Mixed Hardwood Forests**. This perhaps reflects the lasting effects of broad-scale logging and intense fire early this century, or a broader range of nutrient conditions at high elevations.

The **High-Elevation Mixed Hardwood Forests** represent the deciduous-dominated high-elevation forests. These typically occur at high-elevations below the **Spruce-Yellow Birch Forests** in the 3 high-elevation landscapes and represent the major high-elevation vegetation in the 3 mid-elevation landscapes (Figures 6.31-6.33). Dominant tree species include *Acer saccharum*, *Betula alleghaniensis* and *Fagus grandifolia*. The **High-Elevation Mixed Hardwood Forests** have greatest representation in the 3 high-elevation landscapes where they are distributed across a broad range of topographic positions on all three fertility regimes (Figures 6.31-6.33). This class is most clearly separated by elevation from mid- and low-elevation vegetation classes at the Black Mountains and at Grandfather Mountain. This contrasts to Shining Rock, where this class is present on similar environmental positions to high-elevation stands in the **Montane Oak Forests** and the **Rich**

Cove and Slope Forests. Similarly, the **High-Elevation Mixed Hardwood Forests** are not clearly separated from other vegetation classes in the 2 mid-elevation landscapes. In mid-elevation landscapes, this class has a similar distribution with respect to soil nutrient regime, topographic and elevational position as the patterns described in high-elevation.

The **Montane Oak Forests** class dominates mid- and low-elevation slopes. Stands are typically dominated by *Quercus rubra* and lack a well-developed ericaceous understory. This class is more prevalent in the high- and mid-elevation landscapes, where it has a similar distribution with respect to elevation, soil nutrients and topographic position (Figures 6.31-6.36). In most high- and mid-elevation landscapes, the **Montane Oak Forests** class is distributed across a broad range of topographic positions. Under the fertile regime, this class is typically replaced by the **Rich Cove and Slope Forests** on moist, lower-slopes. The **Montane Oak Forests** are present on all nutrient regimes, but have greatest representation on fertile sites in all mid- and high-elevation landscapes except for Grandfather Mountain. Differences at Grandfather Mountain probably are attributable to sampling limitations rather than real differences in distribution. In the mid- and high-elevation landscapes the elevational distribution of this class changes across the fertility gradient. On infertile sites the **Montane Oak Forests** class is limited to the upper limits of its elevational range, whereas it is distributed across the broadest elevational range on fertile sites. The upper-elevational limit of this class (approximately 1500 m) is consistent across all mid- and high-elevation landscapes except at Shining Rock where it occurs above 1700 m. Intense logging and fire are the only obvious differences between Shining Rock and other mid- and high-elevation landscapes that might account for higher elevation distribution.

The **Montane Oak Forests** have limited distribution in the three low-elevation landscapes (Figures 6.37-6.39). This class is virtually absent on infertile sites in all three landscapes. In the two Southern Escarpment landscapes, this class has highest, but limited representation on the mid-nutrient sites. In the Thompson River, the **Montane Oak Forests** are clearly restricted to the lower half of the topographic-moisture gradient, whereas there is no apparent pattern in the Chattooga River. By contrast, the **Montane Oak Forests** are well represented at Linville Gorge on both mid- and high-nutrient sites where they are distributed across a broad range of topographic conditions. There is no obvious explanation for the limited distribution and abundance of this class in the two Southern Escarpment landscapes. Differences in the disturbance regime between Linville Gorge and the two Southern landscapes may partially account for this. In contrast to the comparatively undisturbed old-growth forests of Linville Gorge, the Escarpment landscapes were intensively logging and burned in the early part of this century.

Stands in the **Rich Cove and Slope Forests** are mainly dominated by *Acer saccharum*, *Aesculus flava* and *Tilia americana*. This vegetation class inhabits mid- and low-elevation coves and lower-slopes in the 3 high-elevation and 2 mid-elevation landscapes on sites with mid- and high-nutrient status (Figures 6.31-6.36). The **Rich Cove and Slope Forests** have consistently higher abundance on fertile sites. Although this class is typically restricted to low topographic positions, my results show exceptions to this pattern. At Grandfather Mountain there are two **Rich Cove and Slope Forests** stands on low-elevation ridge sites. The calcium-rich dolomite underlying these sites probably explains this unusual topographic distribution. Explanations for the low- to upper-slope distribution of **Rich Cove and Slope Forests** at Shining Rock are less obvious and are not related to geologic substrate.

The **Acidic Cove and Slope Forests** class is characterized by the dominance or codominance of *Tsuga canadensis* in the canopy and, for the most part, a dense *Rhododendron maximum* shrub layer. This class is present in all 9 landscapes, where it typically inhabits mid- and low-elevation coves and lower-slopes in the mid- and low-nutrient regimes (Figures 6.31-6.39). The abundance of **Acidic Cove and Slope Forests** stands on fertile sites in the Joyce Kilmer contrasts to the general pattern described above. Deviations in the typical pattern reflect the presence of herbaceous-dominated **Tsuga canadensis-Halesia Forest** in this landscape. This type inhabits more fertile soils than typical infertile, ericaceous-dominated **Acidic Cove and Slope Forests** community types.

The **Thermic Oak-Pine Forests** are present in all 9 landscapes. This class is characterized by the presence of a distinctive and typically ericaceous shrub layer and xeric *Pinus* and *Quercus* species. The **Thermic Oak-Pine Forests** are generally dominant on low-nutrient sites in the three high-elevation landscapes, where they are situated on mid- to upper-topographic positions (Figures 6.31-6.33). This class also occurs on mid-nutrient sites at Shining Rock. In the two mid-elevation landscapes, this class inhabits similar high-topographic positions across all three nutrient regimes (Figures 6.34-6.36). By contrast, in the three low-elevation landscapes the **Thermic Oak-Pine Forests** are distributed across the full topographic gradient on all nutrient regimes (Figures 6.37-6.39). At the Thompson River this class is dominant on all three nutrient regimes, whereas fertile sites at the other two low-elevation landscapes are codominated by the **Montane Oak Forests** and the **Acidic Cove and Slope Forests**.

The dominance of the **Thermic Oak-Pine Forests** across both the full nutrient and topographic-moisture gradient in the three low-elevation landscapes contrasts to the mid- and high-elevation landscapes (Figures 6.37-6.39). The breadth of **Thermic Oak-Pine Forests** distribution on both the nutrient and topographic-moisture gradient may relate to widespread warm site conditions in these low-elevation landscapes. The restriction of this vegetation class to ridgelines in the mid- and high-elevation landscapes suggests that in these landscapes warm temperatures are only associated with dry, infertile upper-slopes and ridgelines. The widespread distribution of this class across the three low-elevation landscapes inhibits detailed comparisons of vegetation distribution between these landscapes. To overcome this problem I compared the distribution of individual community types within the **Thermic Oak-Pine Forests** (described in more detail below) across the three low-elevation landscapes in an attempt to clarify compositional differences between these three landscapes.

Despite broad-scale similarities in the distribution of the **Thermic Oak-Pine Forests** across the three low-elevation landscapes, there are marked fine-scale compositional differences, with the presence and distribution of community types varying between the three landscapes (Figures 6.40-3.42). These analyses suggest that community types have more defined association with topographic-moisture and soil nutrients in the two Southern Escarpment Gorges. However, this reflects the limitations of my classification and difficulties of accurately quantifying the topographic-moisture regime of secondary

Figure 6.31. Gradient diagram of the Black and Craggy Mountains showing the distribution of forest vegetation classes identified using Ward's clustering method (see Figure 6.1). The three diagrams represent the three standard nutrient levels. Stands are classified by their vegetation class and are plotted by elevation and topographic moisture (TMI). Increasing TMI values correspond to increasingly xeric conditions. Vegetation classes are represented by the following symbols: • = **Spruce-Yellow Birch Forests**, □ = **High-Elevation Mixed Hardwood Forests**, + = **Rich Cove and Slope Forests**, o = **Acidic Cove and Slope Forests**, * = **Montane Oak Forests**, ♦ = **Xeric Oak-Pine Forests**.

BLACK AND CRAGGY MOUNTAINS

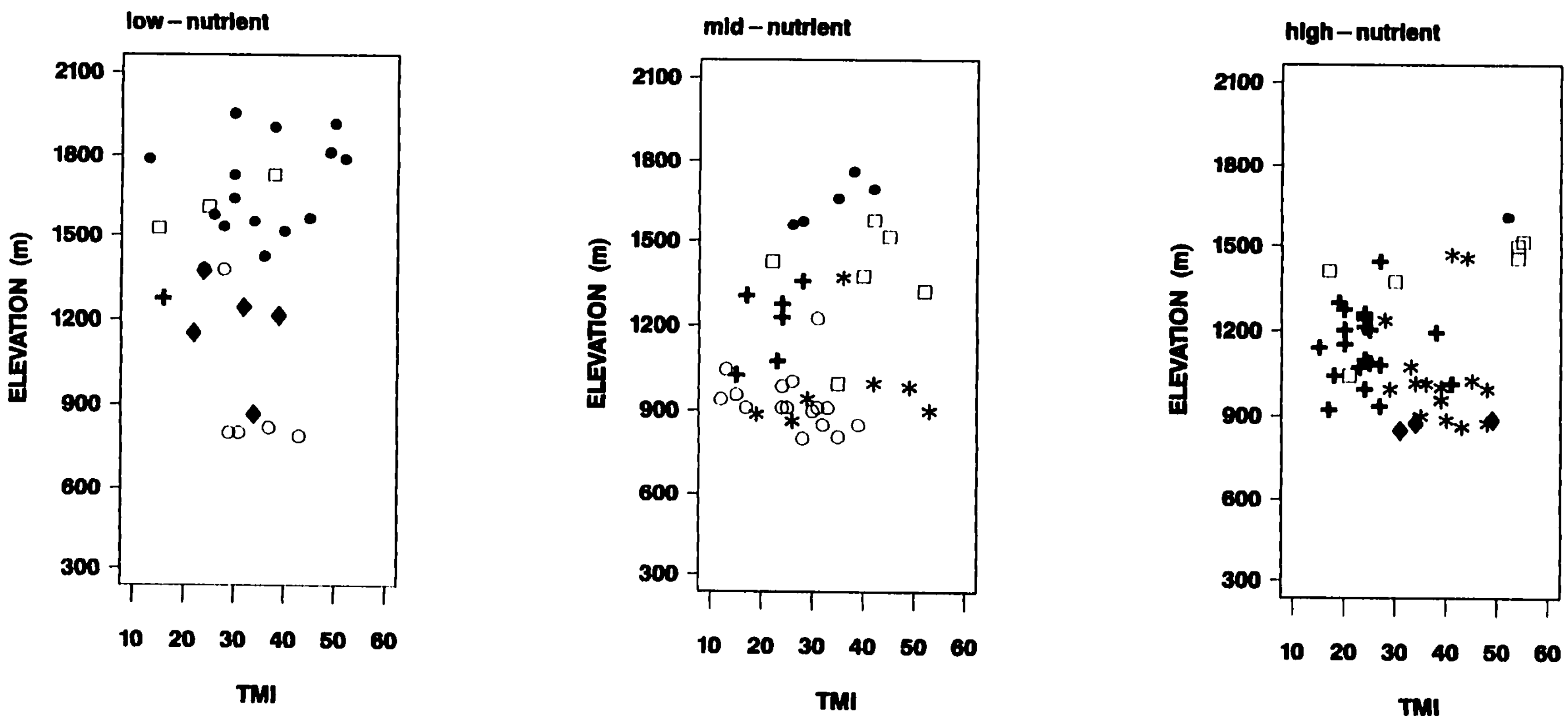


Figure 6.32. Gradient diagram of the Grandfather and Roan Mountains (Grandfather Mountain) showing the distribution of forest vegetation classes. See Figure 6.31 for details.

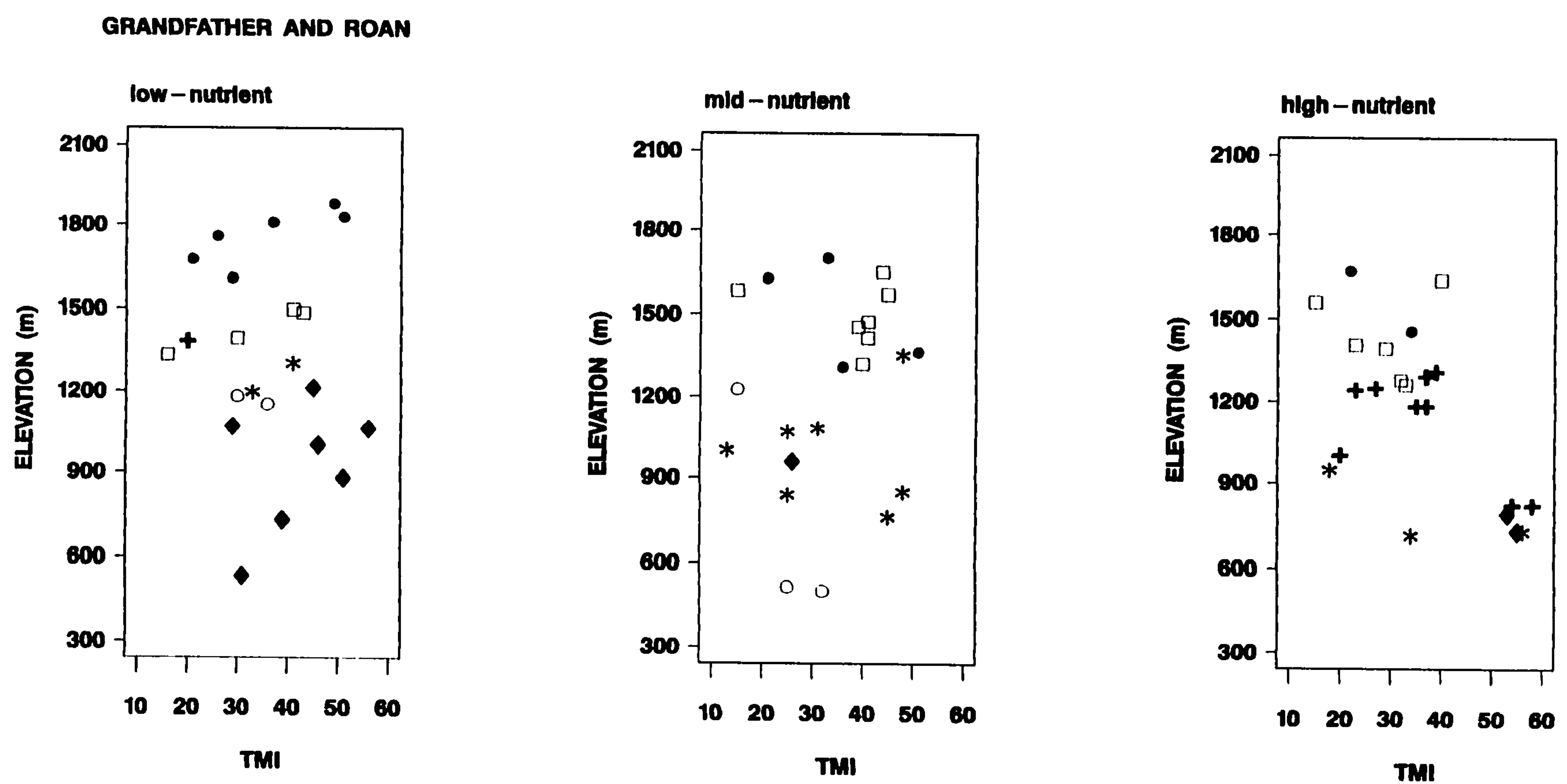

GRANDFATHER AND ROAN
low – nutrient
mid – nutrient
high – nutrient
ELEVATION (m)
2100
1800
1500
1200
900
600
300
10
20
30
40
50
60
TMI

Figure 6.33. Gradient diagram of Shining Rock Wilderness showing the distribution of forest vegetation classes. See Figure 6.31 for details.

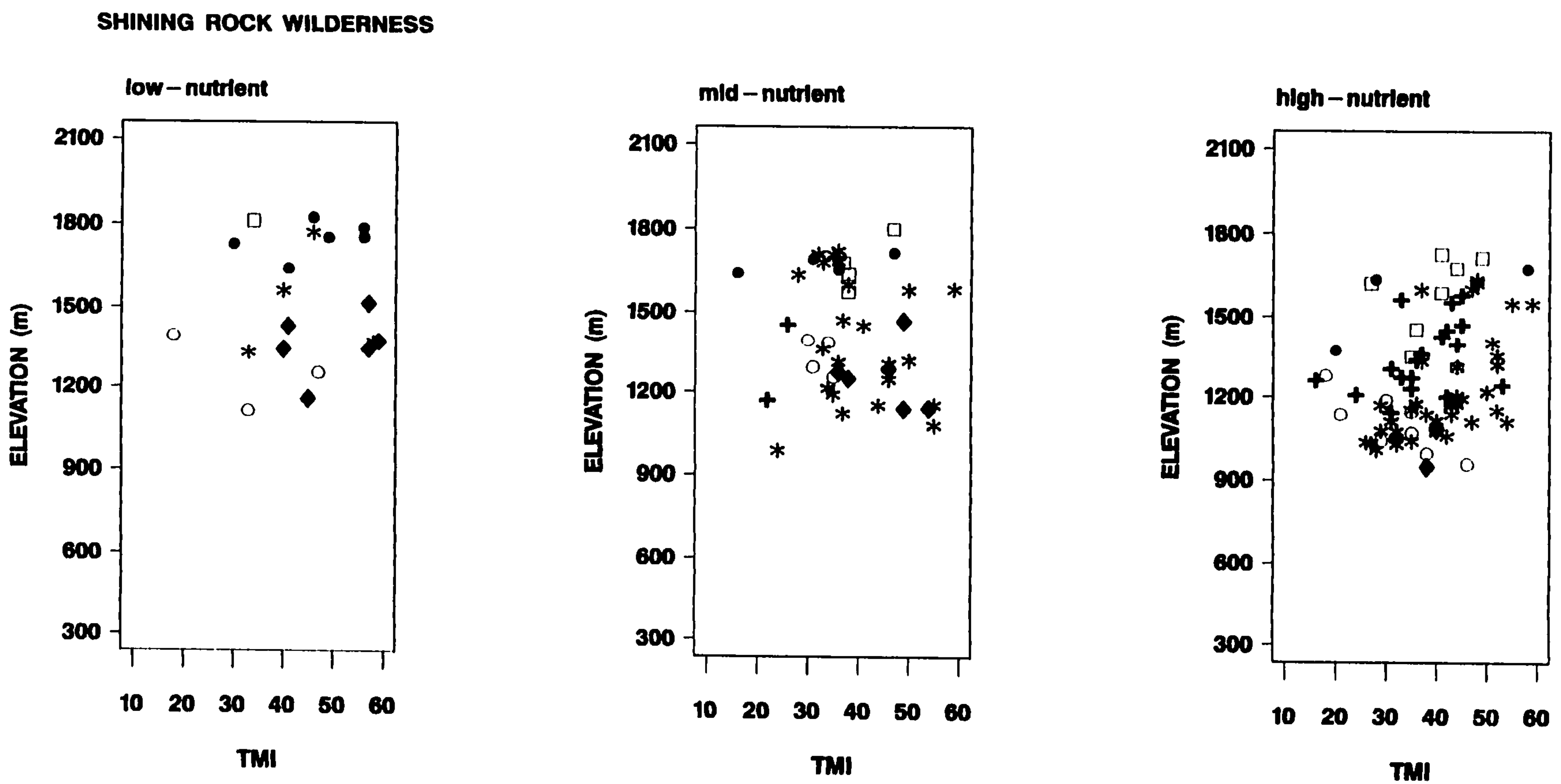

SHINING ROCK WILDERNESS
low – nutrient
mid – nutrient
high – nutrient
ELEVATION (m)
2100
1800
1500
1200
900
600
300
10
20
30
40
50
60
TMI

Figure 6.34. Gradient diagram of the Joyce Kilmer/Slickrock Wilderness (Joyce Kilmer/ Slickrock) showing the distribution of forest vegetation classes. See Figure 6.31 for details.

JOYCE KILMER/SLICKROCK

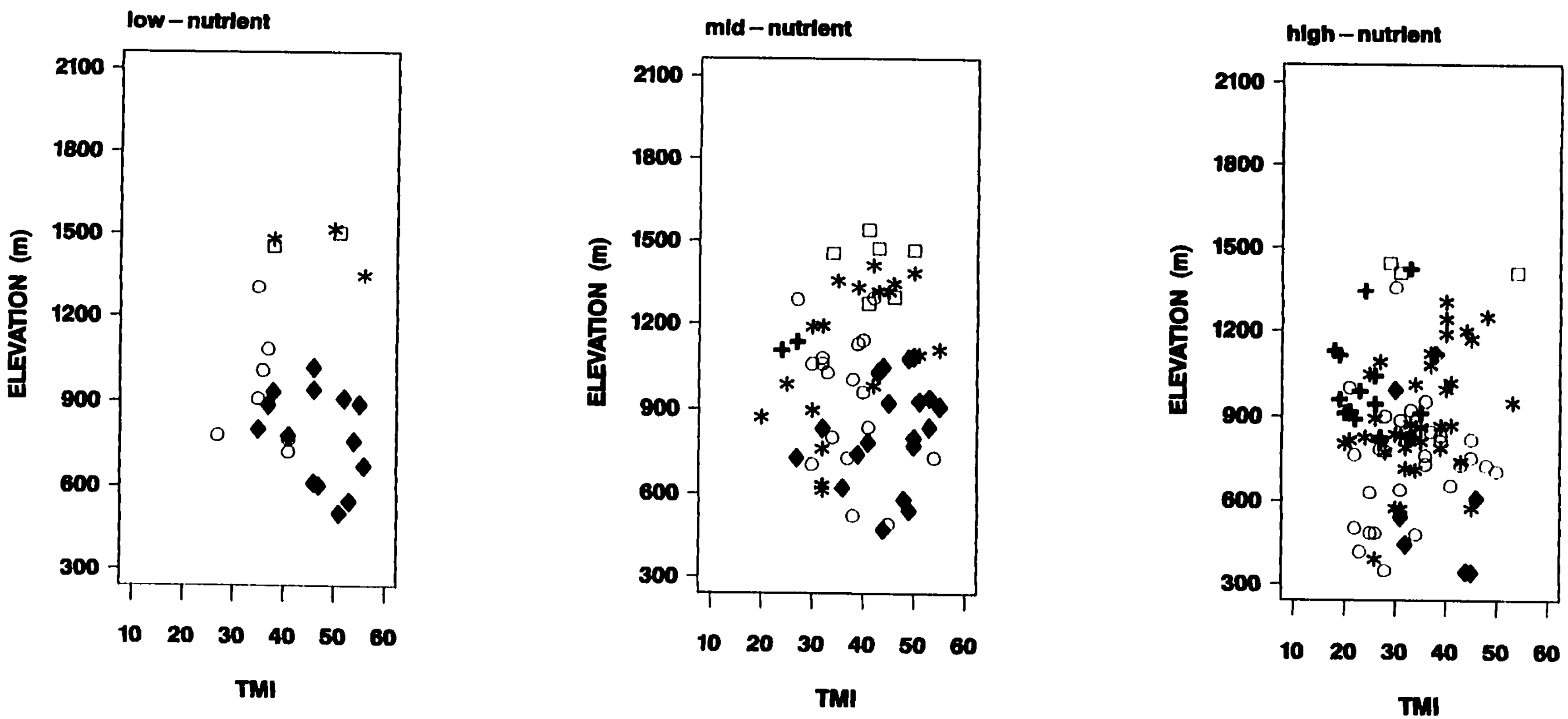


Figure 6.35. Gradient diagram of the Nantahala Mountains showing the distribution of forest vegetation classes. See Figure 6.31 for details.

NANTAHALA MOUNTAINS

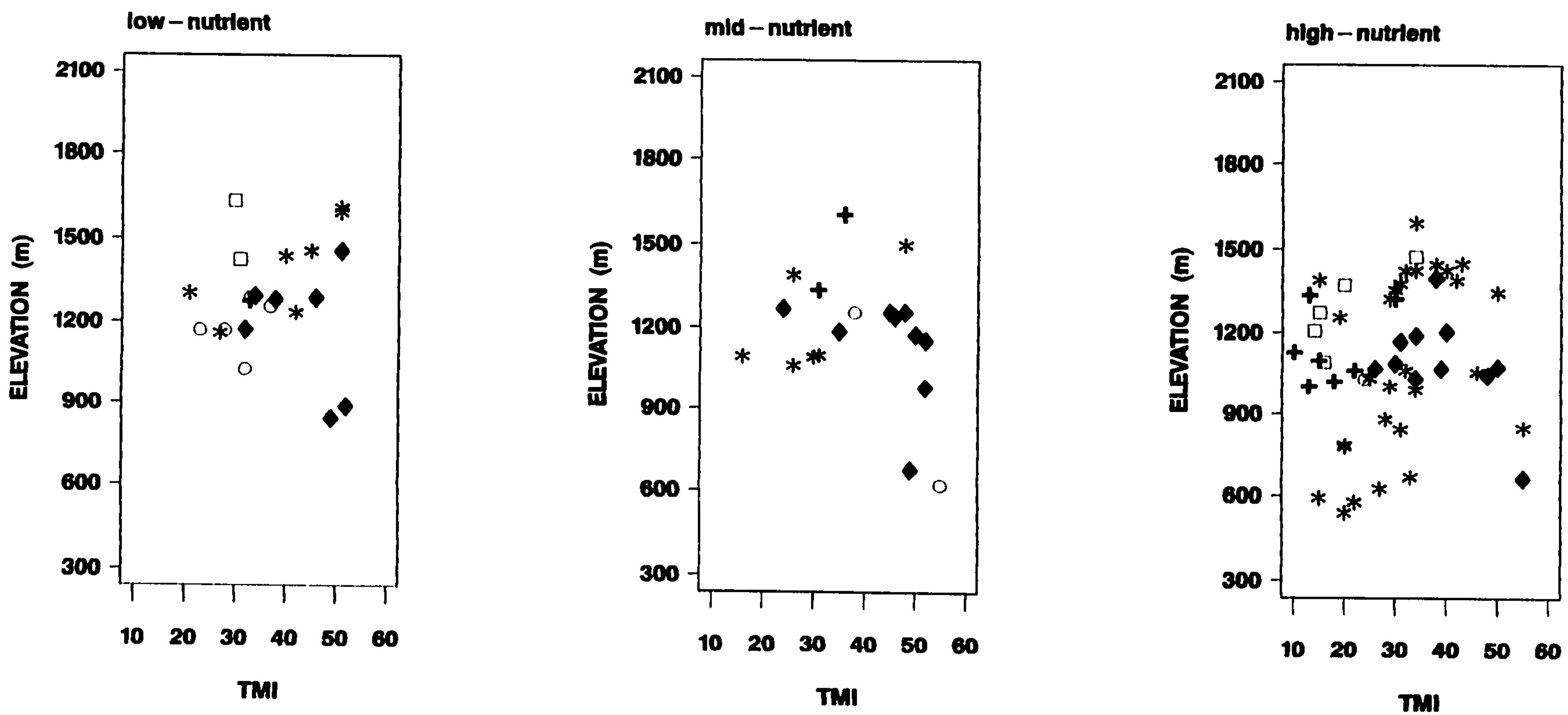
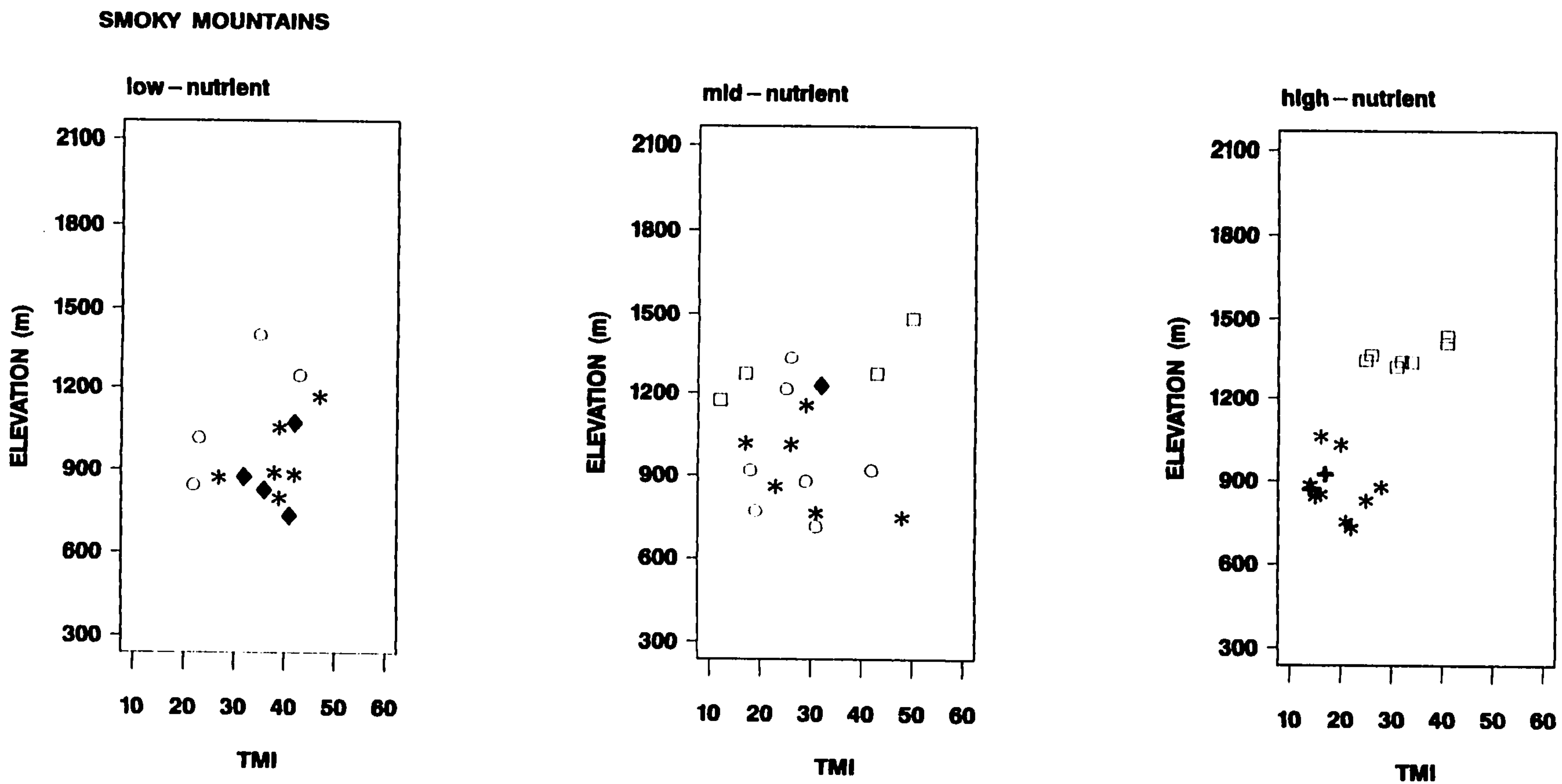


Figure 6.36. Gradient diagram of the Smoky Mountains showing the distribution of forest vegetation classes. See Figure 6.31 for details.



SMOKY MOUNTAINS
low – nutrient
mid – nutrient
high – nutrient
ELEVATION (m)
2100
1800
1500
1200
900
600
300
10
20
30
40
50
60
TMI

Figure 6.37. Gradient diagram of the Chattooga River Gorge (Chattooga River) showing the distribution of forest vegetation classes. See Figure 6.31 for details.

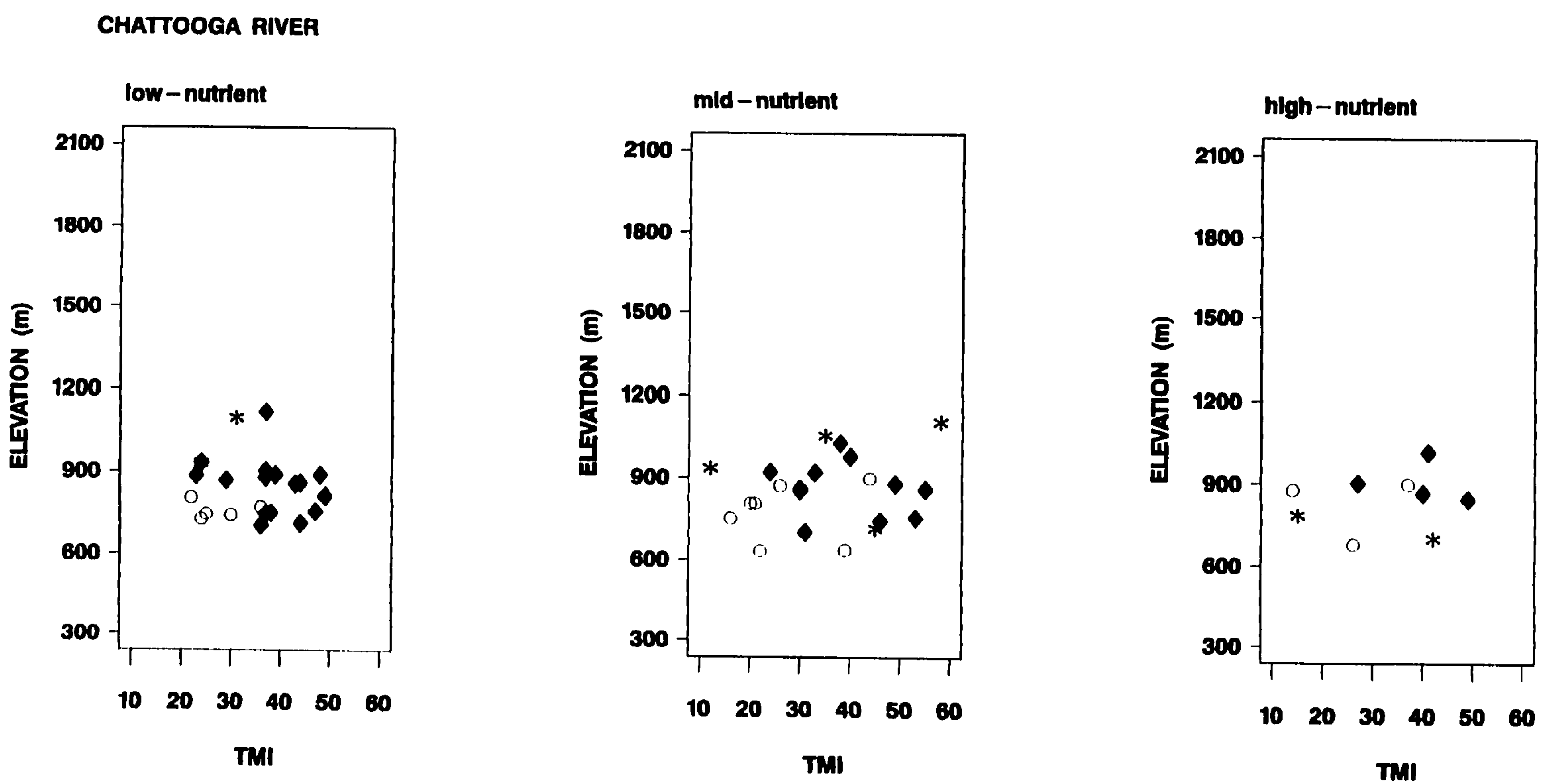

CHATTOOGA RIVER
low – nutrient
mid – nutrient
high – nutrient
ELEVATION (m)
2100
1800
1500
1200
900
600
300
TMI
10
20
30
40
50
60

Figure 6.38. Gradient diagram of the Linville Gorge Wilderness showing the distribution of forest vegetation classes. See Figure 6.31 for details.

LINVILLE GORGE WILDERNESS

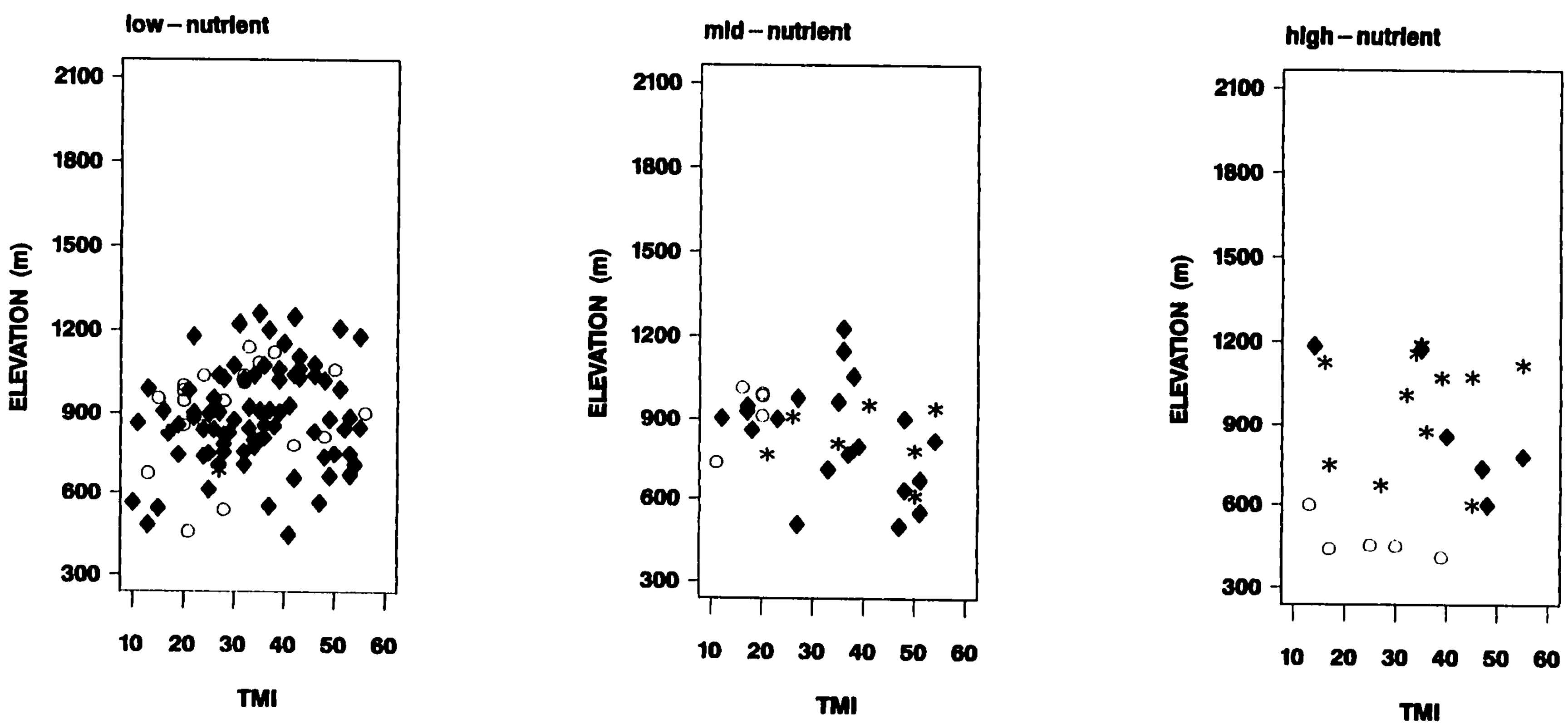


Figure 6.39. Gradient diagram of the Thompson River Gorge (Thompson River) showing the distribution of forest vegetation classes. See Figure 6.31 for details.

THOMPSON RIVER

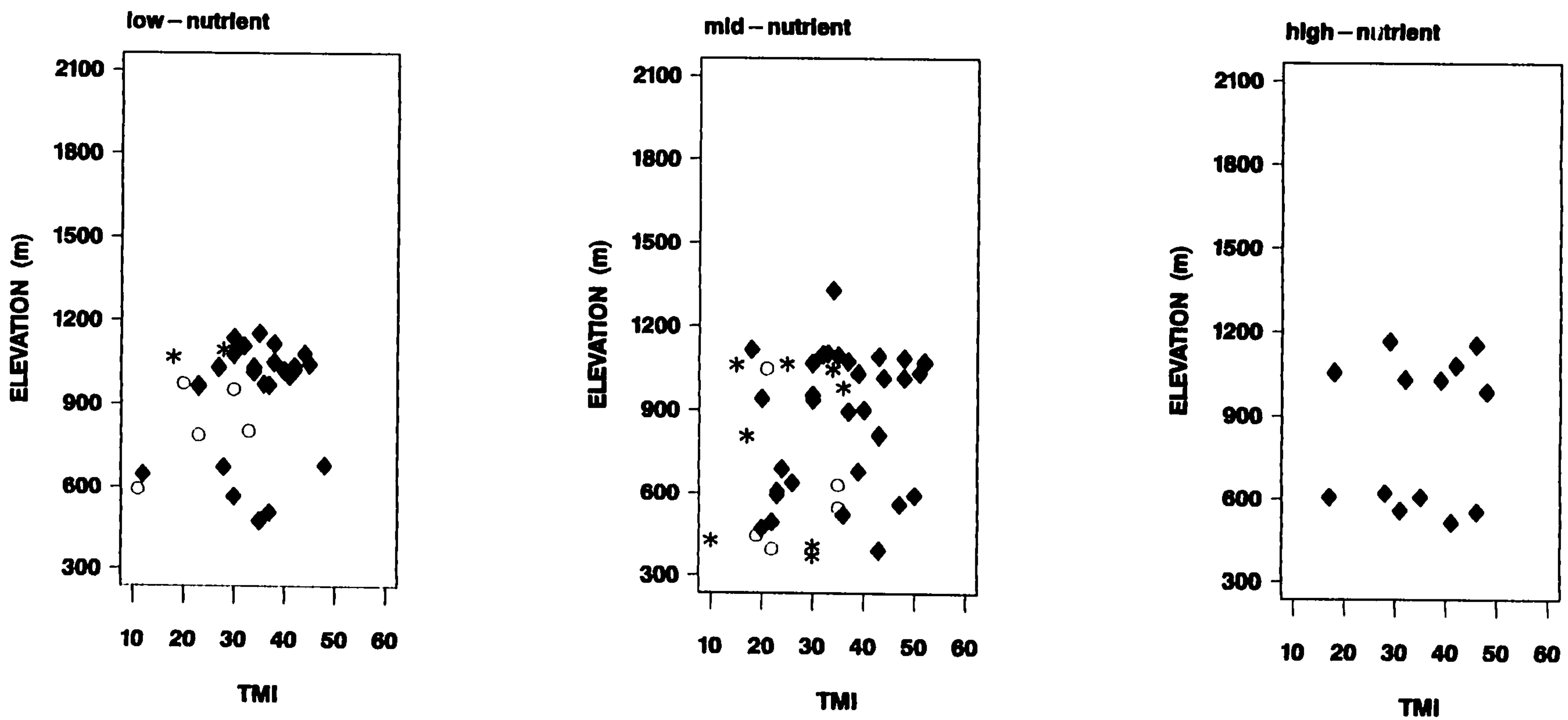


Figure 6.40. Gradient diagram of the Chattooga River Gorge (Chattooga River) showing the distribution of community types in the **Thermic Oak-Pine Forests** vegetation class identified using Ward's clustering method (see Figure 6.1). The three diagrams represent the three standard nutrient levels. Stands in this vegetation class are classified by their community type and are plotted by elevation and topographic moisture (TMI). Increasing TMI values correspond to increasingly xeric conditions. Community types are represented by the following symbols: ★= **Quercus montana/Rhododendron maximum Forest**, + = **Quercus montana-Quercus coccinea-Pinus strobus-Pinus rigida Forest**, O = **Quercus montana-Quercus coccinea/Gaylussacia ursina Forest**, # = **Quercus alba-Quercus montana-Quercus rubra/Gaylussacia ursina Forest**, ← = **Carya alba-Liriodendron-Quercus montana/Cornus florida Forest**.

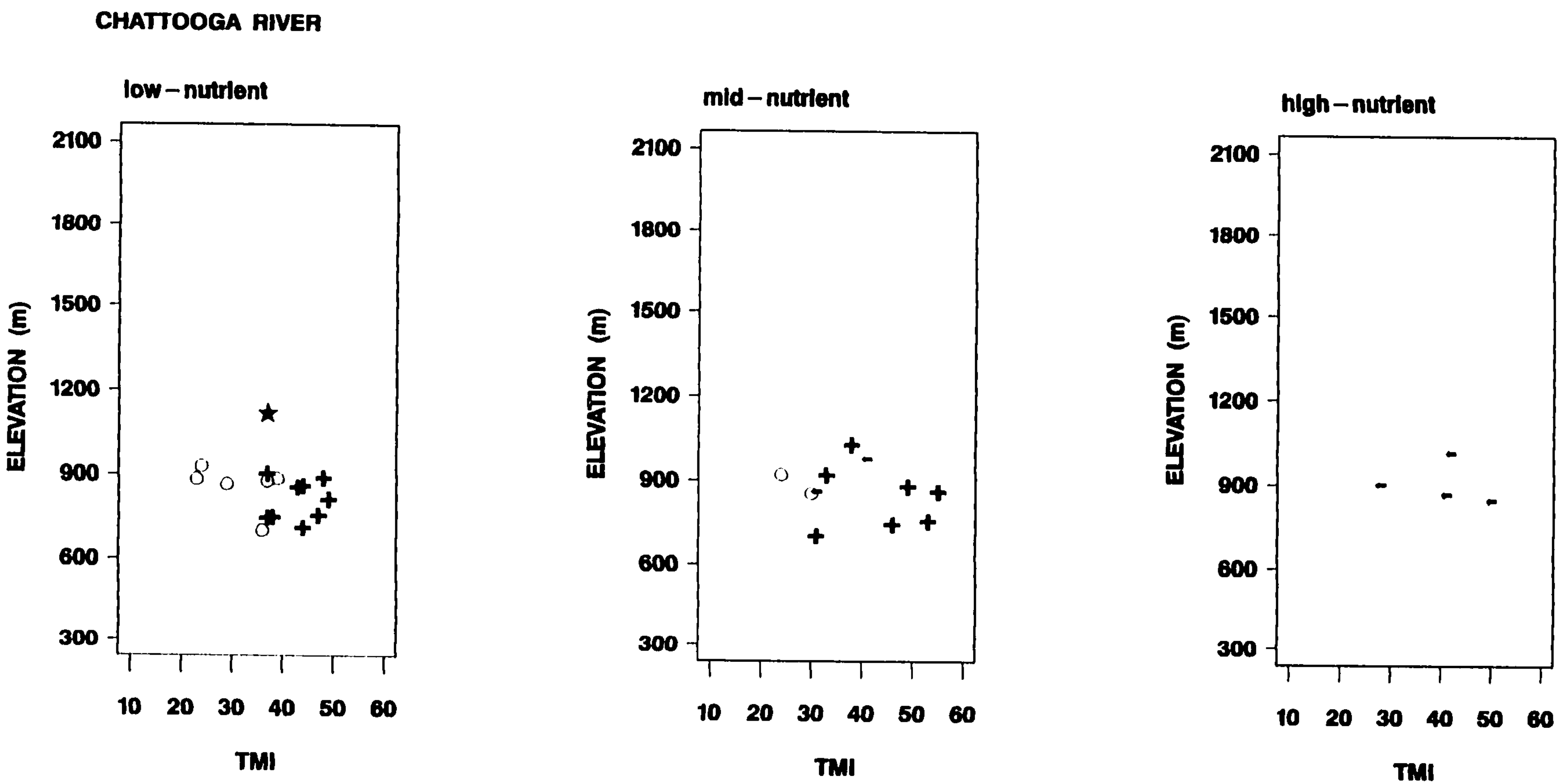

CHATTOOGA RIVER
low – nutrient
mid – nutrient
high – nutrient
ELEVATION (m)
2100
1800
1500
1200
900
600
300
TMI
10
20
30
40
50
60

Figure 6.41. Gradient diagram of the Linville Gorge Wilderness showing the distribution of community types in the **Thermic Oak-Pine Forests** vegetation class identified using Ward's clustering method (see Figure 6.1). The three diagrams represent the three standard nutrient levels. Stands in this vegetation class are classified by their community type and are plotted by elevation and topographic moisture (TMI). Increasing TMI values correspond to increasingly xeric conditions. Community types are represented by the following symbols: * = **Tsuga caroliniana Forest,** △ = **Pinus pungens-Pinus rigida-Pinus virginiana/Kalmia Forest,** ▲ = **Pinus pungens/Kalmia Forest,** □ = **Quercus montana-Pinus strobus Forest,** ★ = **Quercus montana/Rhododendron maximum Forest,** ♦ = **Quercus montana Forest,** + = **Quercus montana-Quercus coccinea-Pinus strobus-Pinus rigida Forest.**

LINVILLE GORGE WILDERNESS

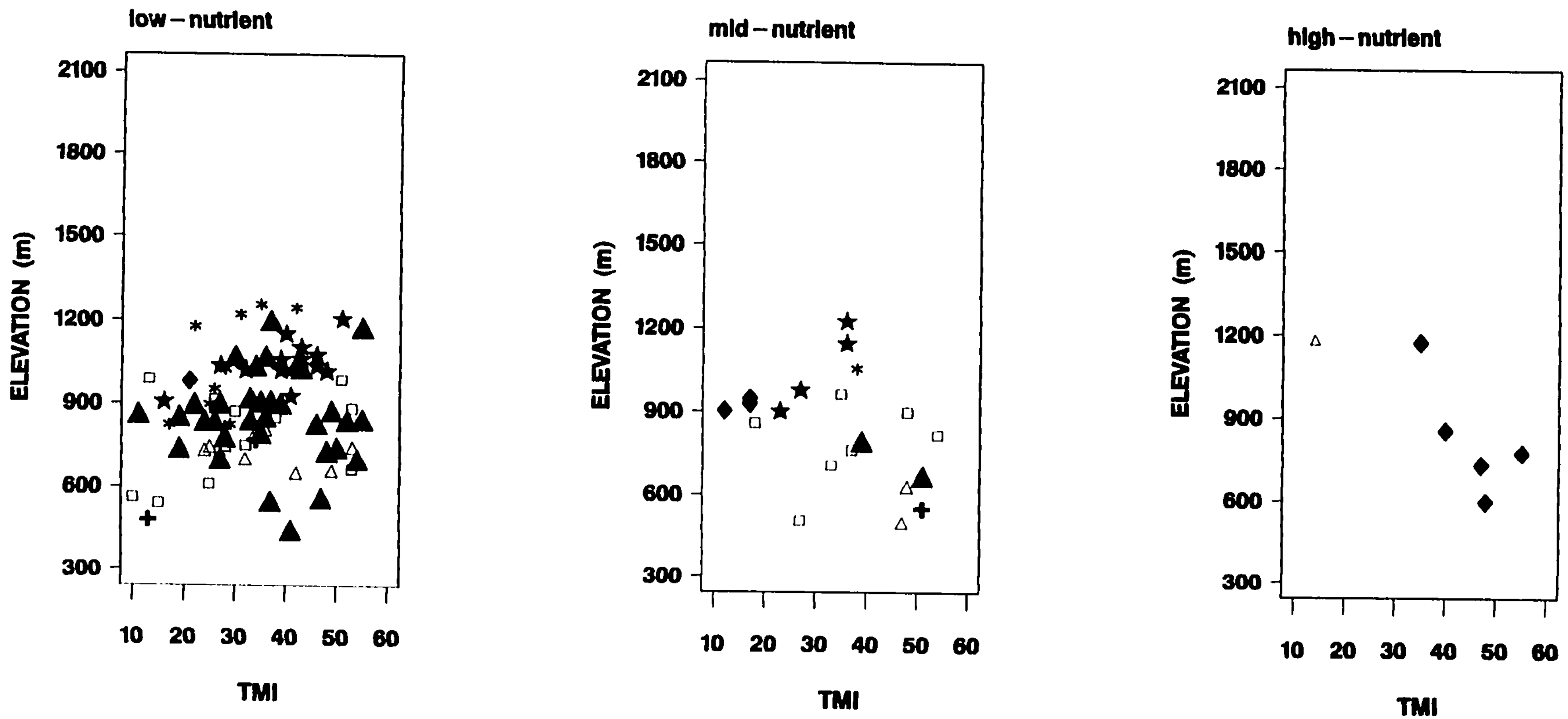
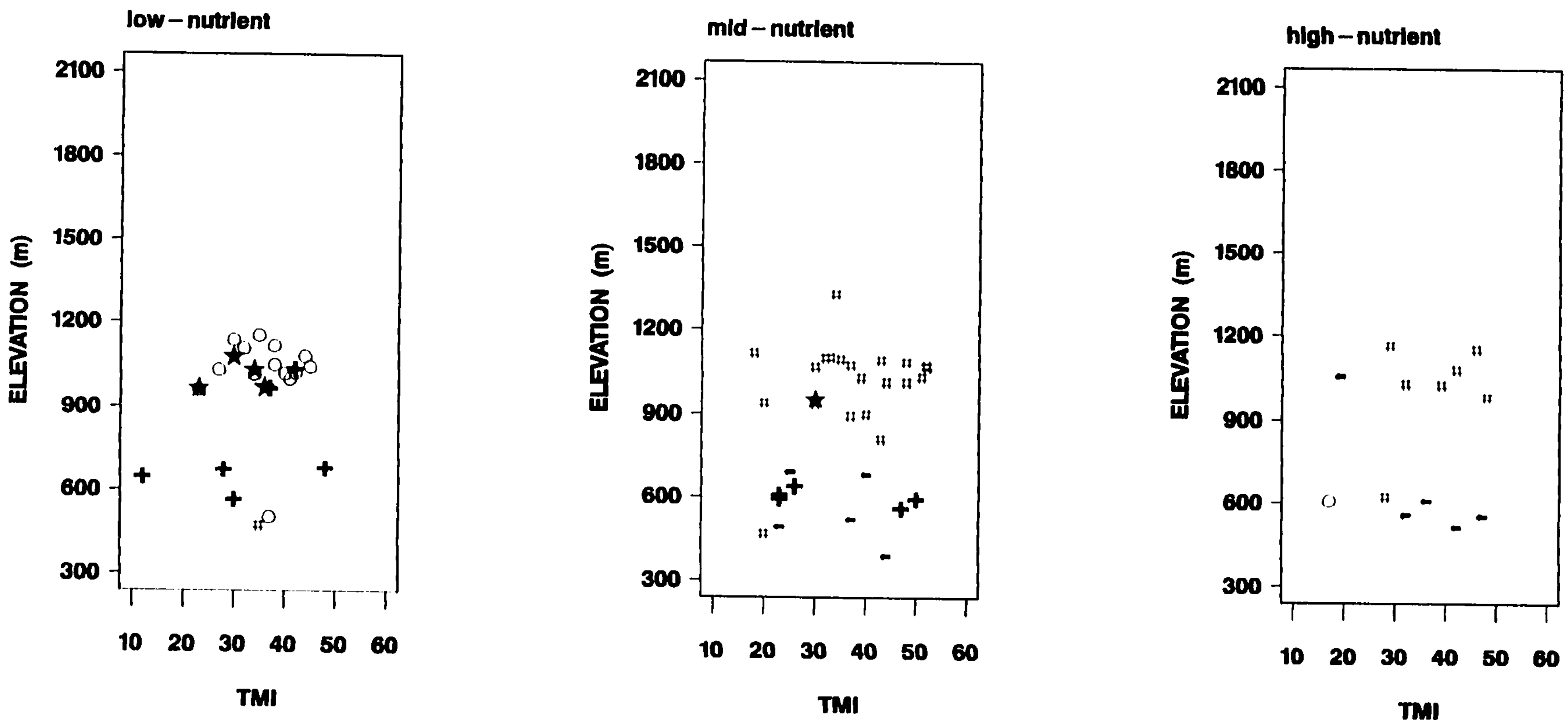


Figure 6.42. Gradient diagram of the Thompson River Gorge (Thompson River) showing the distribution of community types in the **Thermic Oak-Pine Forests** vegetation class identified using Ward's clustering method (see Figure 6.1). The three diagrams represent the three standard nutrient levels. Stands in this vegetation class are classified by their community type and are plotted by elevation and topographic moisture (TMI). Increasing TMI values correspond to increasingly xeric conditions. Community types are represented by the following symbols:★ = **Quercus montana/Rhododendron maximum Forest**, + = **Quercus montana-Quercus coccinea-Pinus strobus-Pinus rigida Forest**, O = **Quercus montana-Quercus coccinea/Gaylussacia ursina Forest**, # = **Quercus alba-Quercus montana-Quercus rubra/Gaylussacia ursina Forest**, ← = **Carya alba-Liriodendron-Quercus montana/Cornus florida Forest**.

THOMPSON RIVER



ridgelines and the xeric mid-slope areas adjacent to the bluffs rather than indistinct associations between vegetation and topography at Linville Gorge. At Linville Gorge, the broad topographic distribution of the **Pinus pungens/Kalmia Forest** on the gradient diagram is inaccurate. In comparison to other landscapes there is a limited range of canopy tree species at Linville Gorge. These are common to most community types and are dominant across a broad range of topographic positions and nutrient conditions. Accordingly, the classification based on tree species perhaps was not sufficient to separate stands into different vegetation classes. However, despite these problems, there are interpretable differences in the distribution of **Thermic Oak-Pine Forests** types at Linville Gorge with respect to soil fertility. This analysis shows that the composition of **Thermic Oak-Pine Forests** changes across the fertility gradient in Linville Gorge. Fertile sites are inhabited by the **Quercus montana Forest**. The two *Quercus montana-Rhododendron maximum*-dominated types are present on mid- and low-fertility sites, whereas the *Pinus pungens* and *Tsuga carolina* types are more-or-less restricted to infertile sites.

The community type presence and distribution of the **Thermic Oak-Pine Forests** differ between the two Escarpment landscapes with respect to soil fertility and elevation (Figures 6.40, 3.42). The **Carya alba-Liriodendron-Quercus montana/Cornus florida Forest** is present on mid- and high-nutrient sites in the Chattooga River. At the Thompson River, similar elevations under the same nutrient regimes, are dominated by the **Quercus alba-Quercus montana-Quercus rubra/Gaylussacia ursina Forest** and the latter type has a lower-elevation distribution. The **Quercus alba-Quercus montana-Quercus rubra/Gaylussacia ursina Forest** is virtually absent from the Chattooga River. Similarly, in the Chattooga River, mid-to-upper-slope sites under the mid- and low-nutrient regime are dominated by the **Quercus montana-Quercus coccinea-Pinus strobus-Pinus rigida Forest**, whereas this type is distributed across a broader range of topographic positions in the Thompson River. By contrast, the **Quercus montana-Quercus rubra/Gaylussacia ursina-Kalmia Forest**, is consistently found on infertile, lower-slopes in both landscapes.

6.5 Consistency of vegetation class distribution along the major environmental gradients in each landscape

The position of vegetation classes was also examined using the NMDS ordination analyses. This was used to validate the standard gradient diagrams and to clarify environmental differences in vegetation class distribution in the three low-elevation landscapes.

6.5.1 High-elevation landscapes

In all 3 high-elevation landscapes, vegetation classes are typically well separated along the major environmental gradients (Figures 6.2-6.7). The **Spruce-Yellow Birch Forests** and **High-Elevation Mixed Hardwood Forests** are separated from other types along the elevation gradient. The mid- and low-elevation vegetation classes are distributed along the soil nutrient gradient from the **Rich Cove and Slope Forests** on fertile sites to the **Thermic Oak-Pine Forests** on infertile sites. The latter 4 classes are also separated by topographic characteristics, with the **Rich Cove and Slope Forests** and **Acidic Cove and Slope Forests** generally having moister, lower-slope positions. In all landscapes except Shining Rock, there is clear separation of stands by vegetation class along the major environmental gradients. Indistinct patterns at Shining Rock probably relate to the intensity of past disturbances in this landscape.

6.5.2 Mid-elevation landscapes

At Joyce Kilmer, the position of vegetation classes with respect to major environmental gradients follows the pattern described in the high-elevation landscapes (Figures 6.11-6.19). The **High-Elevation Mixed Hardwood Forests** are separated from the 4 mid- and low-elevation classes by elevation, with the 4 latter vegetation classes separated by soil fertility and topographic-moisture. However, a different pattern is visible in the Nantahala Mountains. In this landscape, 3 of the 4 mid- and low-elevation vegetation classes are broadly distributed along the soil fertility gradient, with only the **Rich Cove and**

Slope Forests restricted to the fertile-end of this gradient (Figures 6.14-6.16). The presence of the **Quercus alba-Pinus rigida/Andropogon gerardii Forest** in the **Thermic Oak-Pine Forests** on serpentine sites at Buck Creek might account for this. Sites in this community type have high pH and Mn values in comparison to most community types in the **Thermic Oak-Pine Forests** class (see Table 6.7). In the Smoky Mountains, vegetation classes are well separated by elevation. There is a progression from the **High-Elevation Mixed Hardwood Forests** at high-elevations, to the **Rich Cove and Slope Forests** and **Montane Oak Forests** at mid-elevations, with the **Thermic Oak-Pine Forests** and the **Acidic Cove and Slope Forests** restricted to low-elevations (Figures 6.17-6.19). In contrast to the other two mid-elevation landscapes, the **High-Elevation Mixed Hardwood Forests** and the **Montane Oak Forests** are well distributed across the topographic-moisture gradient. There is a particularly clear restriction of the **Rich Cove and Slope Forests** and the **Acidic Cove and Slope Forests** stands to moist, lower-slope sites, with stands in the **Thermic Oak-Pine Forests** restricted to upper-slope positions.

6.5.3 Low-elevation landscapes

In Linville Gorge, vegetation classes separated more clearly along the major ordination-based environmental gradients than portrayed in the standard gradient diagrams. The separation of vegetation classes along the soil nutrient and topographic position /moisture gradients follows the patterns described in high-elevation landscapes, the Smoky Mountains and Joyce Kilmer (Figures 6.23-6.25). The two Escarpment landscapes show a different pattern (Figures 6.20-6.28). In both landscapes, the **Thermic Oak-Pine Forests** are distributed across the full length of the soil nutrient gradient and are separated from the **Acidic Cove and Slope Forests** and the **Montane Oak Forests** by site moisture and relative slope position. The breadth of **Thermic Oak-Pine Forests** distribution on the nutrient gradient the Southern Escarpment area may relate to warm site conditions across a wide range of soil nutrient regimes in these landscapes. This may be an artifact of the coarse-scale of my vegetation classification, although the composition of community types in these two landscapes (see Table 6.15) suggests that this is not the case. In such a high-rainfall environment, nutrients may leach from the soil and be unavailable for plant uptake; however, this vegetation class is broadly distributed across sites with high-nutrient status. Factors associated with land-use history and past disturbance have perhaps heightened the abundance of the **Thermic Oak-Pine Forests** and enable species associated with warm conditions to dominate a broader range of environmental conditions than they would otherwise be associated with.

6.6 Consistency of vegetation composition across the Southern Appalachian region

The 6 regional-scale vegetation classes were subdivided into community types using cluster analysis to examine the consistency of vegetation class composition and community type distribution across the region. Each vegetation class was subjected to a separate cluster analysis based on all species. Some species have localized distributions that potentially could influence final community type groupings. Environmental information was summarized for each community type by landscape to determine the consistency of site conditions across the Southern Appalachian region.

The three **Spruce-Yellow Birch Forests** community types can be distinguished from one another by topographic characteristics (site moisture, slope position and elevation; Figure 6.1, Tables 6.3-6.5). All three types are present at Black and Grandfather Mountains. The **Abies-Picea Forest**, which occurs at higher-elevations than the other two types in this class, is absent from Shining Rock. This may be the result of past logging, or reflect the fact that high-elevation areas in this landscape are below the elevational zone typically dominated by *Abies* (Ramseur 1960). This community type tends to occupy less fertile soils than the other two types (lower Ca, cation exchange capacity, Mn and P; Table 6.3). The remaining two community types dominated by *Picea* and *Betula alleghaniensis* are distinguished from each other by differences in site moisture and topographic position. High-elevation concave boulder substrates are inhabited by the **Picea-Betula alleghaniensis-Fagus/Acer spicatum Forest**. The presence of a well-developed herbaceous understory is indicative of the moist and more fertile conditions (higher Ca) of this type in comparison to the remaining community type (Table 6.3). The **Picea-Betula**

alleghaniensis Forest typically inhabits dryer slopes at lower-elevations. Community types in the classification of **Spruce-Yellow Birch Forests** were accepted at r-squared = 0.1653.

The **High-Elevation Mixed Hardwood Forests** community types separate by slope position, site moisture and soil fertility. The **Aesculus-Acer saccharum-Fagus/Cimicifuga racemosa Forest**, well represented in the Black, Grandfather and Smoky Mountains, inhabits more fertile (higher base saturation, Ca, cation exchange capacity, Mn, pH), moister, lower-slope positions than other **High-Elevation Mixed Hardwood Forests** types (Figure 6.1, Tables 6.3, 6.6, 6.8). In effect, this type is a high-elevation cove community. The remaining 4 types in this vegetation class have dryer, upper-slope positions. The **Fagus-Betula alleghaniensis-Acer saccharum/Carex pensylvanica Forest** typically occurs at higher-elevations than the remaining 3 types, which is indicated by the presence of species such as *Viburnum lantanoides* and *Acer spicatum*. The remaining three types separate geographically, with the **Quercus rubra-Betula alleghaniensis/Ageratina Forest** and the **Fagus-Halesia-Quercus rubra/Hamamelis Forest** absent from the high-elevation landscapes north of the Asheville Basin. In the classification of the **High-Elevation Mixed Hardwood Forests** class, community types were accepted at r-squared = 0.1603.

In 4 of the 5 **High-Elevation Mixed Hardwood Forests** community types, stands located at Shining Rock are situated at higher elevations and on higher slope positions than in other landscapes (Tables 6.3, 6.6, 6.7). Differences in distribution probably reflect the predominance of this class on sites once inhabited by *Picea*-dominated forests, and the ability of high-elevation hardwood species such as *Betula alleghaniensis* to establish quickly in forests opened or removed by disturbance (White *et al.* 1985).

Community types in the **Rich Cove and Slope Forests** class (accepted at r-squared = 0.1292 in the Ward's classification) differ in geographic distribution, slope position and soil substrate, with the latter probably corresponding to differences in parent material (Figure 6.1, Tables 6.3, 6.8, 6.9). The **Acer saccharum-Quercus rubra Forest** is dominant at Shining Rock, where it inhabits higher slope positions and higher elevations than other types in this class. This type has coarser-textured soils than other types. There are two boulder-substrate cove types. The **Acer saccharum-Tilia-Aesculus flava-Ostrya Forest** is present in the two high-elevation landscapes north of the Asheville Basin, with greatest representation in the Black Mountains. This type is situated at both higher relative slope positions and elevations than the second boulder-cove type. The soils of this first boulder type also have much higher Ca levels than the second boulder type, suggesting higher soil fertility. The second boulder-cove type, the **Tilia-Betula alleghaniensis-Halesia/Laportea Forest**, is found exclusively south of the Asheville Basin, with stands represented at both Joyce Kilmer and Shining Rock. The **Acer saccharum-Aesculus flava/Laportea-Cimicifuga racemosa Forest** is the major inhabitant of nutrient-rich coves with a fine-textured substrate. This type is distributed at lower-elevations than the preceding 3 types and typically has more fertile soils, with higher soil pH and cation exchange capacity levels, and particularly high Ca values. Sites also generally have higher moisture potential. High cover by herbaceous species such as *Cimicifuga racemosa* and *Laportea canadensis* are an indication of the moist, fertile conditions (Table 6.8). The **Acer saccharum-Aesculus flava/Laportea-Cimicifuga racemosa Forest** is most well-represented at Joyce Kilmer and the Nantahala Mountains.

Types within the **Acidic Cove and Slope Forests** class can be distinguished from one another by elevation, location, soil fertility and the presence/absence of a dominant ericaceous understory (Figure 6.1, Tables 6.3, 6.10, 6.11). There are two lower-slope types dominated by a canopy of *Tsuga canadensis* and a particularly dense *Rhododendron maximum* understory. The **Tsuga canadensis/Rhododendron maximum Forest** is predominantly found in the low-elevation, low-rainfall Linville Gorge landscape. This type is structurally similar to the **Tsuga canadensis-Betula alleghaniensis-Liriodendron/ Rhododendron maximum Forest**, but is dominated by a range of more xeric species (e.g., *Kalmia latifolia*, *Oxydendrum arboreum*) and smaller number of high-cover species. The latter type is prominent at mid- and low-elevations in the higher rainfall Black Mountains, Joyce Kilmer and Shining Rock landscapes. The soils of the latter type are more fertile (higher base saturation, pH), coarser-textured and less organic than those of the Linville Gorge type. The third ericaceous-community type, the **Tsuga canadensis-Pinus strobus-Oxydendrum/Rhododendron maximum-Cornus florida Forest** also inhabits low-elevations but is situated on dryer, higher-slope positions than the former two types. This type is dominant at Joyce Kilmer, Thompson River and the Black Mountains. In contrast, the remaining community type, the **Tsuga canadensis-Halesia Forest**, has an open understory and is dominated by a diverse range of herbaceous species, such as *Mitchella repens*, *Laportea canadensis* and *Polystichum acrostichoides*. The soils of this type are typically more fertile (higher pH and base saturation) and finer-textured than the previous 3 types. The **Tsuga canadensis-Halesia Forest** is mostly found at Joyce Kilmer, with some sites in the Smoky Mountains and Shining Rock.

Types within the **Montane Oak Forests** separate by elevation, soil fertility, slope position and site moisture potential (Figure 6.1, Tables 6.3, 6.12, 6.13). Most types are dominated by *Quercus rubra* and have only subtle compositional differences from one another. However, two types are compositionally distinct from the more typical types. These two types are transitional between the **Montane Oak Forests** and other vegetation classes. The **Quercus montana-Tsuga canadensis/Rhododendron maximum Forest** differs from other types by the presence of a *Rhododendron*-dominated understory. This type has some affiliations with the **Quercus montana/Rhododendron maximum Forest** in the **Thermic Oak-Pine Forests**, but inhabits moister, lower-slope positions, that have affinities with the two *Tsuga canadensis-Rhododendron maximum*-dominated types in the **Acidic Cove and Slope Forests** class. In effect, this type is intermediary between the **Thermic Oak-Pine Forests** and the **Acidic Cove and Slope Forests**. The **Liriodendron-Acer saccharum Forest** is intermediary between the **Montane Oak Forests** and the **Rich Cove and Slope Forests**. This type inhabits fertile, but dry lower-slopes and coves. The slope position gives this type affiliations with the latter class, whereas dry site conditions provide an environment more suitable for species closely associated with the **Montane Oak Forests**. This type is best developed in southern mid- and high-elevation landscapes.

The more typical **Montane Oak Forests** types have mid- to upper-slope positions. The **Quercus rubra/Ilex montana Forest** inhabits higher elevations than other **Montane Oak Forests** types and typically has less fertile soils (Tables 6.3, 6.12, 6.13). Four types occur on comparatively dry sites. Both the **Quercus rubra-Quercus montana/**

Oxydendrum Forest and the **Quercus rubra-Castanea dentata/Thelypteris Forest** occur on steep slopes, with the latter type present at higher elevations. The former type is mostly found at Joyce Kilmer and Shining Rock, whereas the latter type has greatest abundance at Joyce Kilmer and the Nantahala Mountains. The two remaining dry-slope types inhabit shallower slopes in the Black Mountains. Of these, the **Quercus rubra/ Cornus florida Forest** is situated at lower elevations than the **Quercus rubra-Quercus montana/Kalmia Forest**. The former type is also present in the high-elevation areas of the Chattooga River. The remaining type, the **Quercus rubra-Liriodendron Forest**, has a wide distribution throughout the Southern Appalachian region. This type inhabits moister and more fertile (higher Ca, base saturation), steep mid-slope sites. Community type groupings in the classification of **Montane Oak Forests** were accepted at r-squared = 0.2076.

The **Thermic Oak-Pine Forests** separate into two sections. This division reflects both differences in soil characteristics and geographic location, that at least in part correspond to differences in rainfall and geology. The six *Quercus montana-* and *Pinus pungens*-dominated community types are dominant at infertile, low-rainfall Linville Gorge and have limited distribution in other landscapes (Figure 6.1, Tables 6.3, 6.12, 6.13). The soils of these types are typically finer-textured and have lower pH and base saturation levels than the second, mixed *Quercus* group of community types. Community types within the **Thermic Oak-Pine Forests** classification were accepted at r-squared = 0.2408.

Two of the six *Quercus montana-* and *Pinus pungens*-dominated community types are dominated by *Quercus montana* and *Rhododendron maximum*, with the **Quercus montana-Pinus strobus/Rhododendron maximum Forest**, restricted to lower elevations and lower-slope positions in Linville Gorge (Tables 6.3, 6.12, 6.13). This type inhabits secondary, lower-slope ridges (Chapter 3). With the exception of Shining Rock, the two *Pinus pungens*-dominated types are absent from landscapes south of the Asheville Basin. The **Pinus pungens/Kalmia/Galax Forest** is present in all three northern landscapes. The **Pinus pungens-Pinus rigida-Pinus virginiana/Kalmia Forest** is restricted to Linville Gorge and Shining Rock. Absence of this type from the Black Mountains and Grandfather

Mountain landscapes might correspond to the lower-elevational distribution of this type in comparison to the **Pinus pungens/Kalmia/Galax Forest**. The former type may inhabit warmer site conditions than the latter. Alternatively, rainfall levels in these two high-elevation landscapes may be high. Shining Rock is the only high-elevation landscape supporting the **Pinus pungens-Pinus rigida-Pinus virginiana/Kalmia Forest** where it is restricted to the northern, low-rainfall end of this landscape, present on dry, lower-elevation slopes adjacent to the Asheville Basin (Chapter 4). *Tsuga caroliniana* dominates the canopy of the remaining type in this section and has greatest representation in Linville Gorge and the Nantahala Mountains.

The five types in the second section of the **Thermic Oak-Pine Forests** are dominated by a mixed canopies of *Quercus alba*, *Q. coccinea*, *Q. montana*, *Q. rubra* and *Carya* species (Figure 6.1, Table 6.15). The presence of evergreen ericaceous species is much lower in comparison to the former *Quercus montana-Pinus pungens* section. The three landscapes north of the Asheville Basin and Shining Rock have very low representation in this section. The **Carya alba-Liriodendron-Quercus montana/Cornus florida Forest** is well represented in 4 southern and southwest landscapes. Other types are less evenly distributed. The **Quercus alba-Pinus rigida/Andropogon gerardii Forest** is restricted to the Buck Creek olivine-derived soils in the Nantahala Mountains. Apart from the **Quercus montana-Quercus coccinea/Gaylussacia ursina Forest**, which has highest representation in Joyce Kilmer, all remaining types have greatest distribution in the Southern Escarpment landscapes. The two Escarpment gorges are dominated by different types. The **Quercus montana-Quercus coccinea-Pinus strobus-Pinus rigida Forest** is dominant in the Chattooga River and also present at nearby Thompson River. In contrast, the Thompson River is dominated by the **Quercus alba-Quercus montana-Quercus rubra/Gaylussacia ursina Forest** which is virtually absent from the Chattooga River.

6.7 Subregional and regional gradient structure

To gain greater understanding of the geographic variation in regional forest patterns, a series of regional and subregional analyses were performed to determine whether environmental gradients associated with regional- and subregional-scale gradients are

Table 6.3. Mean soil nutrient values by community type for each regional vegetation class. Values are summarized by individual landscape. See Figure 6.1 for number of stands per community type. Specific soil variables are as follows: total exchange capacity (CEC) (m.e.g/100 g), pH, easily extractable P, exchangeable cations (Ca, Mg, K, Na (ppm)), percent base saturation (Basesat), extractable micronutrients (Cu, Al, B, Fe, Mn (pm)), soluble S, percentage organic matter (Orgmat)(by loss on ignition) and bulk density (dens). Individual landscapes are listed by the following abbreviations: BM=Black Mountains, CR=Chattooga River, GM=Grandfather Mountain, JK=Joyce Kilmer, LG=Linville Gorge, NM=Nantahala Mountains, SM=Smoky Mountains, SR=Shining Rock, TR=Thompson River.

1. Spruce-Yellow Birch Forests

1.1 Abies-Picea Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	117.57	.	.	94.43	34.71	6.71	.	.	14.86	.	.	8.77	3.90	.	.	.
GM	1342.00	0.59	219.80	0.50	411.20	77.40	52.80	5.40	66.00	15.20	27.00	79.00	2.17	9.25	3.51	31.67	1.06	30.10

1.2 Picea-Betula alleghaniensis Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	245.50	.	.	98.75	58.00	6.75	.	.	22.00	.	.	12.05	3.53	.	.	.
GM	936.00	0.49	295.00	0.33	268.00	96.00	68.00	33.00	66.00	12.00	35.00	42.00	4.50	11.63	3.60	20.38	0.82	31.00
SR	1385.67	0.47	196.17	0.87	357.67	75.33	54.33	30.25	72.17	11.58	22.42	62.08	3.31	7.21	3.86	32.63	0.77	34.72

1.3 Picea-Betula alleghaniensis-Fagus/Acer spicatum Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	214.00	.	.	92.44	46.44	18.89	.	.	22.56	.	.	10.23	3.74	.	.	.
GM	1084.00	0.53	553.00	0.78	306.71	117.29	106.29	56.14	68.43	16.00	31.00	47.71	6.00	15.18	4.01	39.37	0.91	37.71
SR	978.00	0.67	237.00	0.59	638.00	55.00	43.00	9.00	75.00	10.00	40.00	95.00	1.63	7.72	3.77	27.27	0.81	32.67

2. **High-Elevation Mixed Hardwood Forests:** Table 6.7 cont.

2.1 Aesculus flava-Acer saccharum-Fagus/Cimicfuga racemosa Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	703.00	.	.	130.25	108.50	63.50	.	.	14.75	.	.	10.95	4.70	.	.	.
GM	1171.00	0.66	2141.50	1.35	246.00	115.00	136.00	99.50	69.00	12.00	32.00	40.50	14.79	29.34	4.67	22.93	0.76	48.25
JK	1158.00	0.46	651.00	1.11	231.00	57.00	75.00	93.00	61.00	14.00	28.00	45.00	6.15	11.42	4.48	9.85	2.02	44.50
NM	1221.00	0.55	1385.50	2.02	110.00	73.00	118.50	86.50	66.00	9.50	21.50	41.50	3.93	13.50	5.26	16.88	0.66	63.38
SM	1395.00	0.59	433.00	1.67	340.00	60.00	41.00	96.00	65.00	14.00	35.00	65.00	2.45	12.08	4.71	16.90	0.78	33.00
SR	1432.00	0.43	1129.00	1.00	186.00	115.50	114.00	110.00	70.00	13.50	37.00	67.00	2.83	18.58	4.53	20.07	0.76	45.50

2.2 Fagus-Betula alleghaniensis-Acer saccharum/Carex pensylvanica Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
GM	1363.13	0.55	463.00	0.81	292.00	119.63	85.38	41.25	67.88	11.75	23.13	57.88	4.25	13.39	3.93	25.07	0.79	35.25
JK	1266.50	0.52	162.67	0.67	431.33	66.67	49.00	25.17	64.83	12.33	44.50	92.17	1.86	7.31	3.58	18.51	1.82	30.88
BM	.	.	124.75	.	.	69.50	31.75	11.25	.	.	6.50	.	.	8.15	4.15	.	.	.
SM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.65	.	.	.
SR	1236.75	0.56	230.50	0.95	424.00	69.25	47.00	67.25	73.25	12.00	53.25	106.25	2.47	7.52	3.85	34.41	0.70	33.44

2.3 Quercus rubra-Betula alleghaniensis/Ageratina Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
JK	1479.00	0.35	139.00	0.46	254.00	67.00	47.00	70.00	65.00	12.00	38.00	87.00	1.93	6.23	3.63	17.60	1.94	31.25
SM	1354.00	0.53	266.67	0.63	276.67	79.00	46.33	44.67	68.33	15.67	36.33	50.67	2.57	7.59	4.44	19.03	0.66	35.67

2.4 Quercus rubra-Betula alleghaniensis/Carex pensylvanica Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	441.14	.	.	125.14	69.43	45.71	.	.	14.00	.	.	9.39	4.60	.	.	.
GM	1543.71	0.47	337.43	0.67	261.71	94.00	60.00	19.86	69.29	10.57	22.86	58.43	3.71	10.97	3.88	30.29	0.85	34.68
NM	1563.50	0.57	324.00	1.23	224.00	89.25	61.25	57.00	72.50	13.75	22.00	60.75	2.50	7.85	4.28	26.98	0.64	40.50
SR	1380.20	0.49	274.00	1.04	380.40	94.00	75.60	55.40	73.20	10.40	26.60	62.60	3.70	7.50	4.09	24.52	0.73	38.25

2.5 Fagus-Halesia-Quercus rubra/Hamamelis Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
JK	1296.33	0.44	174.33	0.56	346.00	61.67	43.67	15.33	64.67	12.67	32.67	63.00	2.23	6.85	3.69	19.28	1.74	32.08
NM	635.00	0.65	915.00	1.15	423.00	39.00	90.00	70.00	64.00	16.00	30.00	29.00	5.20	7.51	5.80	12.10	0.55	79.00
SM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.87	.	.	.
SR	1616.00	0.56	391.00	1.79	397.00	78.00	58.00	51.00	73.00	12.00	22.00	81.00	3.85	10.20	4.05	23.85	0.77	36.00

3. <u>Rich Cove</u> and <u>Slope Forests</u>: Table 6.7 cont.

3.1 Acer saccharum-Quercus rubra Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
NM	1265.50	0.53	767.25	2.16	225.75	86.25	89.25	82.50	69.75	12.75	25.75	60.25	3.60	10.65	4.52	21.15	0.59	46.56
SR	1566.56	0.42	507.56	1.03	212.89	82.44	87.89	108.67	66.56	11.44	46.11	70.67	2.60	10.83	4.28	16.61	0.79	41.00

3.2 Acer saccharum-Aesculus flava/Laportea-Cimicifuga racemosa Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
NM	1163.50	0.58	1880.83	2.07	84.17	146.00	200.83	72.50	70.00	11.67	19.67	40.17	4.03	17.88	5.31	21.30	0.64	65.85
GM	795.00	1.21	3401.33	1.50	152.33	130.00	370.00	335.00	64.00	8.67	12.33	47.00	5.13	30.15	5.99	14.35	0.95	78.50
JK	1103.43	0.46	1009.43	1.54	227.43	106.57	112.86	205.43	63.43	14.00	57.86	76.29	6.70	16.81	4.53	13.18	1.99	46.04
SM	886.00	0.82	2276.00	1.77	121.00	142.00	214.00	155.00	64.00	13.00	41.00	42.00	4.35	20.64	5.18	13.55	0.65	71.50

3.3 Tilia-Betula alleghaniensis-Halesia/Laportea Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
JK	1341.70	0.37	484.30	0.64	225.60	95.70	77.00	111.80	64.00	12.50	31.80	58.70	4.46	9.70	4.33	15.45	1.94	42.07
SM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SR	1207.73	0.54	876.91	1.53	310.91	102.27	126.36	120.91	71.64	12.64	34.73	70.18	6.85	18.50	4.14	27.71	0.63	38.73

3.4 Acer saccharum-Tilia-Aesculus flava/Ostrya Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	1049.50	.	.	139.07	153.32	58.75	.	.	6.71	.	.	11.37	5.06	.	.	.
GM	1152.25	0.56	1288.63	1.36	255.25	144.00	164.00	105.13	66.88	11.75	30.38	58.88	7.36	25.25	4.20	28.20	0.78	40.34

4. Acidic Cove and Slope Forests: Table 6.7 cont.

4.1 Tsuga canadensis-Pinus strobus-Oxydendrum/Rhododendron maximum Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	291.46	.	.	92.00	63.62	24.54	.	.	7.08	.	.	6.55	4.65	.	.	.
CR	1159.56	0.18	189.82	0.60	148.22	35.73	39.00	23.73	59.44	12.44	11.64	24.89	1.93	3.57	4.81	9.96	.	52.44
GM	835.50	0.47	271.50	0.39	217.50	58.00	65.50	19.50	53.00	9.00	14.00	28.00	2.87	6.60	4.37	6.79	1.10	42.25
JK	1355.35	0.31	184.18	0.80	199.35	67.82	51.24	68.53	60.53	11.35	18.24	46.82	2.61	4.96	4.37	12.38	2.08	42.59
LG	783.00	0.43	759.60	0.61	196.60	105.40	140.40	61.60	73.20	20.00	42.80	63.60	6.36	18.58	4.04	66.93	0.54	37.02
NM	1186.00	0.37	96.00	0.76	174.00	33.00	31.00	28.00	54.00	11.00	11.00	44.00	1.05	2.87	4.20	6.23	0.69	39.00
SM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5.15	.	.	.
TR	.	.	162.33	.	.	70.00	38.11	37.22	.	.	7.67	.	.	6.14	4.45	1.22	.	.

4.2 Tsuga canadensis/Rhododendron maximum Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
20	1082.71	2.52	224.14	0.51	193.29	41.29	45.29	13.29	60.29	13.86	20.71	32.29	3.59	6.00	4.09	19.13	0.67	39.54
CR	1084.50	0.12	135.25	0.27	173.75	35.50	39.25	3.00	65.75	12.00	11.25	47.25	2.05	3.62	4.48	17.97	.	44.75
GM	1309.00	0.45	266.00	0.26	366.00	38.00	60.00	8.00	66.00	15.00	28.00	55.00	3.68	10.44	3.48	20.55	0.77	29.75
JK	1381.00	0.37	138.50	0.23	405.00	36.50	51.50	47.50	62.50	11.00	20.00	73.00	2.25	5.38	3.85	17.25	1.93	34.38
LG	478.19	0.43	415.42	0.39	115.31	115.81	99.65	5.54	74.65	21.92	27.81	48.04	6.17	15.30	3.64	70.87	0.35	31.46
SM	1152.50	0.54	256.00	0.38	433.00	48.00	50.50	8.00	67.50	11.00	25.50	56.50	1.43	8.25	4.30	18.03	0.62	32.50
SR	682.50	0.38	241.50	0.90	273.00	105.00	72.00	8.50	75.00	12.00	37.00	61.50	2.74	10.33	3.64	46.45	0.53	31.38
TR	.	.	50.00	.	.	49.75	21.75	4.50	.	.	4.50	.	.	6.78	4.13	2.08	.	.

4.3 Tsuga canadensis-Betula alleghaniensis-Liriodendron/Rhododendron maximum Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	197.00	.	.	66.17	65.83	24.33	.	.	9.58	.	.	7.60	4.48	.	.	.
CR	1084.00	0.10	748.00	0.62	141.00	141.00	136.00	56.00	69.00	14.00	18.00	21.00	3.30	11.00	5.00	20.13	.	55.75
GM	1090.00	0.52	682.00	0.25	407.00	79.00	103.00	4.00	70.00	20.00	17.00	41.00	4.85	21.55	3.65	37.55	0.68	31.50
JK	1073.92	0.33	231.83	0.43	270.67	61.08	53.67	65.25	56.58	12.17	24.17	44.75	2.97	6.06	4.25	14.29	2.04	41.21
LG	462.00	0.51	346.00	0.61	264.00	28.00	60.00	111.00	75.00	16.00	22.00	24.00	5.90	5.79	4.75	59.50	1.34	50.00
SM	1095.00	0.65	529.00	0.52	350.00	59.00	61.00	32.00	64.00	12.00	19.00	42.00	2.40	13.60	4.78	13.75	0.85	34.50
SR	1168.89	0.53	514.56	0.79	389.89	88.78	96.89	66.89	72.33	13.22	24.78	56.89	2.59	11.75	4.11	28.76	0.71	38.64

Acidic Cove and Slope Forests cont. Table 6.7 cont.

4.4 Tsuga canadensis-Halesia Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
CR	936.00	0.10	823.00	0.49	110.00	71.00	107.00	61.00	63.00	12.00	17.00	17.00	4.40	8.92	5.35	13.48	.	65.50
GM	1405.00	0.52	323.00	0.47	409.00	90.00	111.00	16.00	70.00	15.00	15.00	48.00	8.80	15.39	3.43	41.04	0.63	29.25
JK	1351.09	0.41	326.59	0.81	264.27	68.95	61.82	61.68	63.82	11.05	26.14	63.91	2.76	7.35	4.20	16.03	1.85	40.88
LG	1073.00	0.45	1384.00	0.96	204.00	79.00	137.00	83.00	73.00	12.00	70.00	77.00	4.03	23.97	4.43	40.45	0.80	43.50
BM	.	.	785.00	.	.	117.00	129.00	100.00	.	.	5.00	.	.	9.30	5.20	.	.	.
SM	1257.00	0.64	461.00	0.89	287.50	95.50	99.00	82.50	69.50	16.50	21.50	48.50	4.00	10.04	4.18	18.80	0.78	40.50
SR	1123.60	0.44	688.60	1.28	267.60	88.00	128.40	99.00	68.40	14.00	25.80	54.40	2.88	12.73	4.52	20.67	0.65	46.60
TR	.	.	100.00	.	.	47.00	46.00	42.00	.	.	7.00	.	.	5.36	4.81	2.37	.	.

5. Montane Oak Forests: Table 6.7 cont.

5.1 Quercus montana-Tsuga canadensis/Rhododendron maximum Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
CR	1283.25	0.10	114.25	0.53	163.75	46.00	36.25	9.50	59.50	12.25	12.25	30.75	2.21	2.71	4.62	10.70	.	47.38
GM	880.75	0.39	285.25	0.46	213.00	109.25	94.00	15.50	68.25	13.50	23.25	42.00	4.32	12.54	3.64	43.27	0.62	32.13
JK	1494.00	0.24	170.00	0.64	193.80	62.60	40.80	26.60	62.20	11.40	13.80	54.60	2.20	3.91	4.47	12.04	1.86	44.30
LG	353.80	0.80	408.20	0.31	75.80	133.80	99.40	18.80	67.80	28.80	38.20	51.40	4.59	14.73	3.76	49.82	0.29	32.55
NM	1359.75	0.45	281.25	0.19	147.50	50.00	54.00	5.75	64.75	13.00	17.75	41.00	3.44	6.09	4.36	28.35	0.63	43.31
SM	1375.33	0.43	190.67	0.90	255.00	64.33	42.67	15.00	66.67	11.33	14.33	44.33	3.42	6.59	4.44	18.70	0.78	35.67
SR	1264.93	0.45	281.60	1.05	359.93	75.40	65.73	35.80	70.27	11.87	21.07	57.93	2.74	8.61	4.00	24.99	0.61	36.06
TR	.	.	56.67	.	.	52.33	21.83	17.17	.	.	5.83	.	.	5.55	4.32	1.13	.	.

5.2 Quercus rubra/Ilex montana Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	159.00	.	.	66.00	31.00	44.00	.	.	16.00	.	.	6.80	4.50	.	.	.
CR	.	.	14.00	0.33	.	36.00	11.00	2.00	.	.	3.00	.	1.21	4.80	3.80	.	.	.
GM	1309.00	0.51	171.00	0.52	338.50	87.50	68.50	8.50	69.00	11.00	25.50	42.00	5.13	8.24	3.67	34.69	0.83	31.63
JK	1302.20	0.44	242.20	0.62	361.20	94.80	49.80	17.80	66.00	12.00	25.00	50.80	3.07	8.10	3.96	24.73	1.67	36.60
NM	1276.55	0.51	219.45	1.18	264.82	66.91	53.45	43.36	72.09	12.09	32.18	70.64	2.83	6.63	4.04	24.82	0.59	36.59
SR	1403.44	0.46	297.78	1.18	319.89	81.22	66.22	60.44	71.00	12.28	22.83	57.61	3.09	8.51	4.07	24.81	0.69	37.15

5.3 Liriodendron-Acer saccharum Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
CR	1203.67	0.19	1203.33	1.01	87.33	126.00	162.00	52.33	62.00	16.67	15.67	20.33	2.91	11.60	5.66	15.01	.	73.83
GM	660.00	1.44	3096.00	2.21	92.00	149.50	401.00	315.00	61.00	11.50	10.00	43.50	34.08	25.06	6.91	10.19	1.03	95.63
JK	1366.31	0.35	653.38	0.69	183.25	101.31	92.69	95.38	63.38	11.63	22.63	42.25	3.81	10.41	4.69	14.97	1.98	49.81
NM	966.75	0.59	1503.50	1.39	117.42	100.67	181.25	99.25	57.58	12.00	22.25	36.42	3.34	14.85	5.37	10.27	0.73	67.38
SM	1086.17	0.63	1085.67	1.00	174.00	126.83	183.33	124.17	65.67	13.17	27.17	44.50	4.64	17.01	4.79	18.65	0.63	49.83
SR	1218.50	0.57	1562.00	1.76	177.00	121.00	257.50	167.50	74.00	11.00	27.50	74.50	4.33	23.07	4.74	23.82	0.71	49.88
TR	.	.	330.50	.	.	107.50	75.00	30.00	.	.	3.00	.	.	6.03	5.06	1.48	.	.

Montane Oak Forests cont. Table 6.7 cont.

5.4 Quercus montana-Quercus rubra/Oxydendrum Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
GM	1189.00	0.29	242.00	0.40	168.00	65.00	58.00	15.00	62.00	8.00	22.00	35.00	2.65	7.05	4.05	10.00	0.85	36.25
JK	1471.69	0.31	263.92	0.86	173.69	72.38	58.08	93.92	61.62	11.23	18.69	46.23	2.59	5.20	4.53	11.00	2.11	46.00
LG	775.83	0.43	700.83	0.53	191.67	89.67	143.17	68.50	73.83	14.17	56.67	64.17	5.20	16.53	3.98	48.88	0.47	36.46
SM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SR	1322.07	0.42	320.53	1.44	258.87	77.27	76.93	125.27	66.73	11.27	17.13	51.07	2.83	7.33	4.28	17.90	0.72	41.17

5.5 Quercus rubra-Quercus montana/Kalmia Foest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	163.13	.	.	87.00	47.13	36.88	.	.	4.50	.	.	5.98	4.76	.	.	.

5.6 Quercus rubra/Cornus florida Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	624.38	.	.	125.08	117.31	68.23	.	.	4.54	.	.	8.07	5.18	.	.	.
CR	.	.	15.00	0.20	.	19.00	7.00	1.00	.	.	3.00	.	0.78	4.80	3.90	.	.	.

5.7 Quercus rubra-Castanea dentata/Thelypteris Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
CR	1291.00	0.10	129.00	0.65	165.00	52.50	31.50	34.00	56.00	11.00	11.50	29.00	1.39	4.43	4.62	12.15	.	45.50
GM	1156.00	0.43	295.00	0.89	178.00	109.00	88.00	36.00	65.00	10.00	22.00	51.00	3.58	9.11	4.20	21.93	0.63	39.75
JK	1638.09	0.35	230.45	0.75	201.27	79.55	43.73	40.27	64.91	10.82	18.36	57.09	2.55	5.62	4.28	16.18	1.89	41.10
NM	1464.60	0.41	181.60	1.04	123.80	51.60	40.00	57.40	64.80	11.20	19.00	57.20	1.75	4.36	4.37	15.18	0.65	42.33
SM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.77	.	.	.
TR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

5.8 Quercus rubra-Liriodendron Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
GM	1536.00	0.36	429.50	0.38	166.50	83.50	82.50	41.50	66.50	10.00	14.50	37.00	3.68	10.52	4.33	20.88	0.87	41.50
JK	1459.83	0.31	273.00	0.77	155.33	73.67	59.17	96.17	62.67	11.17	26.67	56.83	2.50	6.51	4.31	15.40	1.99	41.58
LG	1452.38	0.30	530.13	1.07	150.50	76.00	75.25	245.00	72.38	10.75	76.88	86.13	4.64	11.62	4.20	34.64	0.70	39.41
NM	1539.86	0.33	797.71	1.39	89.29	116.71	130.00	73.71	70.29	11.00	22.29	41.43	3.21	10.93	4.92	24.90	0.71	54.46
SM	1539.00	0.48	144.00	0.96	172.00	97.00	46.00	36.00	70.00	12.00	15.00	40.00	3.40	4.35	4.75	19.60	0.73	41.00
SR	1454.79	0.43	581.00	1.57	183.00	91.57	106.07	136.00	68.64	12.07	20.93	55.07	2.52	10.24	4.51	19.01	0.71	45.61
TR	.	.	40.00	.	.	39.00	12.00	15.00	.	.	2.50	.	.	4.46	4.64	1.75	.	.

6. **Thermic Oak-Pine Forests**: Table 6.7 cont.

6.1 Tsuga caroliniana/Kalmia Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	61.00	.	.	94.00	27.00	1.00	.	.	1.00	.	.	8.00	4.30	.	.	.
GM	1147.00	0.34	175.00	0.33	272.00	23.00	27.00	11.00	58.00	10.00	30.00	49.00	1.50	5.47	3.70	7.80	1.20	32.00
LG	644.09	0.31	221.36	0.27	148.09	128.64	85.45	4.09	72.55	19.09	33.18	66.73	7.55	11.58	3.51	58.40	0.40	30.31
NM	669.67	0.31	80.40	0.23	130.00	20.00	20.80	3.00	58.00	7.00	11.20	20.33	1.10	2.65	2.33	5.22	0.70	34.64

6.2 Pinus pungens-Pinus rigida-Pinus virginiana/Kalmia Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
LG	834.64	0.25	215.27	0.22	220.00	96.36	69.64	4.55	71.73	19.00	25.64	57.09	5.20	10.09	3.53	57.91	0.45	30.48
SR	1137.25	0.52	218.25	1.44	356.00	63.75	50.25	49.25	69.25	11.75	24.00	58.25	1.70	5.92	4.23	25.05	0.70	40.75

6.3 Pinus pungens/Kalmia/Galax Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	85.50	.	.	78.25	46.25	28.50	.	.	12.50	.	.	8.33	3.78	.	.	.
GM	1170.33	0.44	253.67	0.37	210.67	81.67	59.33	5.33	61.33	12.33	10.67	43.00	4.38	9.33	3.93	30.37	0.82	35.92
LG	570.63	0.43	206.43	0.27	116.29	126.43	81.37	3.66	73.14	23.69	27.17	56.66	5.80	10.70	3.54	63.21	0.33	30.47
SR	1554.33	0.43	222.00	1.50	333.33	56.67	28.00	11.33	61.67	9.00	7.33	57.33	1.32	5.34	4.24	11.50	0.88	39.94

6.4 Quercus montana-Pinus strobus/Rhododendron maximum Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
LG	658.76	0.38	289.48	0.45	141.43	129.24	103.71	9.29	73.33	19.90	33.48	59.43	5.75	12.74	3.65	57.75	0.39	31.55

6.5 Quercus montana/Rhododendron maximum Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
CR	1352.00	0.10	115.00	0.81	132.00	32.00	29.00	3.00	55.00	10.00	12.00	38.00	2.20	2.36	4.65	10.63	.	48.00
GM	1209.67	0.44	120.33	1.42	343.33	53.67	47.33	4.00	65.33	13.00	22.67	42.00	3.10	5.54	3.73	17.40	0.95	32.33
LG	804.89	0.31	254.67	0.55	185.56	116.83	80.39	9.28	70.78	17.78	30.89	54.83	5.10	10.92	3.67	48.98	0.46	31.78
SM	792.00	0.56	199.00	0.95	334.00	100.00	73.00	11.00	75.00	16.00	27.00	43.00	5.65	9.14	4.18	41.30	0.68	30.50
SR	1023.80	0.42	284.80	1.02	326.80	97.00	70.40	17.60	68.80	11.80	21.80	47.80	3.19	9.14	3.89	35.24	0.59	34.25
TR	.	.	36.00	.	.	60.00	24.00	6.00	.	.	8.20	.	.	6.71	4.15	1.74	.	.

Thermic Oak-Pine Forests cont. Table 6.7 cont.

6.6 Quercus montana Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
LG	1099.22	0.22	884.78	0.56	316.56	118.11	115.56	61.67	71.33	16.11	34.44	70.67	5.76	21.24	3.96	46.73	0.73	36.15
NM	1015.00	0.56	101.00	0.77	406.00	54.00	61.00	8.00	70.00	13.00	11.00	40.00	2.75	4.01	4.23	22.90	0.53	39.50

6.7 Quercus alba-Pinus rigida/Andropogon gerardii Forest

NM	311.82	0.79	343.64	1.30	222.82	56.27	441.00	234.64	60.82	10.18	5.00	46.55	3.03	22.40	5.94	10.84	1.06	82.13

6.8 Quercus montana-Quercus coccinea-Pinus strobus-Pinus rigida Forest

BM	.	.	40.00	.	.	66.00	32.00	7.00	.	.	2.00	.	.	6.20	4.30	.	.	.
CR	1230.50	0.10	105.17	0.76	139.69	37.00	26.96	11.54	56.75	11.50	9.13	33.00	1.76	3.21	4.62	9.50	.	49.92
GM	1520.00	0.29	100.00	0.39	125.00	36.00	26.00	5.00	54.00	8.00	8.00	35.00	2.40	2.77	4.28	6.30	1.02	40.50
JK	1391.75	0.35	95.50	0.96	242.00	34.50	27.75	107.50	58.50	10.50	16.25	59.75	1.56	3.52	4.05	8.81	2.03	38.00
LG	417.67	0.62	264.00	0.23	100.67	118.00	83.33	7.33	61.67	23.67	32.00	45.67	4.95	10.89	3.72	34.08	0.29	32.17
NM	1044.50	0.54	123.50	0.65	314.00	36.50	27.00	8.50	54.50	9.50	12.50	40.00	1.39	3.68	4.02	7.33	0.65	35.88
SM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.73	.	.	.
SR	792.00	0.59	195.00	0.69	568.00	107.00	64.00	3.00	75.00	14.00	12.00	33.00	3.50	10.02	3.40	21.60	0.68	29.00
TR	.	.	22.50	.	.	45.44	17.00	8.31	.	.	6.38	.	.	4.61	4.26	1.21	.	.

6.9 Quercus montana-Quercus coccinea/Gaylussacia ursina Forest

CR	1194.25	0.13	137.63	0.66	149.75	39.88	32.00	6.00	58.63	12.00	11.38	35.13	2.37	2.93	4.59	10.63	.	46.84
JK	1379.75	0.27	140.29	0.51	230.50	50.38	35.67	14.67	58.42	10.92	16.13	50.46	2.09	3.92	4.21	9.21	2.18	39.34
SM	1357.00	0.46	225.00	0.72	288.00	67.00	33.00	9.00	62.00	9.00	13.00	45.00	2.90	6.37	4.58	12.65	0.68	34.50
TR	.	.	60.00	.	.	35.00	19.00	53.00	.	.	9.00	.	.	4.03	4.58	1.43	.	.

Thermic Oak-Pine Forests cont. Table 6.7 cont.

6.10 Quercus alba-Quercus montana-Quercus rubra/Gaylussacia ursina Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
BM	.	.	379.50	.	.	91.50	76.50	60.00	.	.	2.50	.	.	6.35	4.80	.	.	.
CR	.	.	160.00	1.69	.	65.00	32.00	43.00	.	.	11.00	.	2.39	5.00	4.90	.	.	.
GM	724.50	0.93	1122.00	0.88	242.00	74.00	243.00	130.50	58.50	11.00	15.00	38.00	4.44	15.03	5.30	11.34	1.09	61.00
JK	1560.60	0.25	165.40	0.61	160.20	66.20	38.60	25.40	59.60	9.40	13.60	43.00	2.19	3.54	4.66	10.16	2.08	48.15
LG	910.00	0.38	313.00	0.68	261.00	90.00	64.00	85.00	75.00	17.00	47.00	72.00	4.73	10.32	3.78	76.88	0.43	32.75
NM	1370.92	0.37	174.08	0.69	146.15	53.15	39.92	26.69	61.54	10.08	15.69	40.23	2.01	3.94	4.47	11.92	0.67	44.40
SM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.90	.	.	.
TR	.	.	47.62	.	.	51.48	21.14	24.36	.	.	7.67	.	.	5.64	4.31	1.44	.	.

6.11 Carya alba-Liriodendron-Quercus montana/Cornus florida Forest

	Al	B	Ca	Cu	Fe	K	Mg	Mn	N	Na	P	S	Zn	CEC	pH	Orgmt	dens	Basesat
CR	1229.67	0.16	585.86	1.22	83.83	61.43	72.00	43.00	62.67	10.67	13.57	23.00	2.62	5.86	5.17	11.83	.	57.92
JK	1341.86	0.28	211.14	0.82	156.00	53.86	52.71	163.43	60.00	12.14	36.57	60.00	2.06	5.18	4.27	10.55	2.17	41.04
SM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5.04	.	.	.
SR	1250.50	0.33	393.50	1.08	152.50	119.00	97.00	102.50	70.50	13.00	20.00	34.00	2.17	7.44	4.82	24.77	0.59	52.25
TR	.	.	226.46	.	.	62.77	44.62	37.15	.	.	6.46	.	.	5.69	4.63	1.24	.	.

Table 6.4. Average cover and constancy of species with a constancy of 50% or higher in the **Spruce-Yellow Birch Forests** vegetation class. Values are given for each community type. For full names see Table 6.5. 'Cov' is the mean cover class for a species for the sites it is present in. 'Con' is the constancy of a species.

Number of plots:	12	18	17
Community type:	1.1	1.2	1.3
	Cov/Con	Cov/Con	Cov/Con
Species			
ABIES FRASERI	7 100	4 83	5 76
ACER PENSYLVANICUM		2 83	5 82
ACER SACCHARUM VAR SACCHARUM			2 53
ACER SPICATUM	3 54		5 100
AGERATINA ALTISSIMA		3 61	2 76
ANGELICA TRIQUINATA			3 53
ARISAEMA TRIPHYLLUM		2 56	2 82
ASTER DIVARICATUS		3 50	4 94
ASTER ACUMINATUS VAR ACUMINATUS	3 100	4 67	3 100
ATHYRIUM ASPLENIOIDES	5 62		4 88
BETULA ALLEGHANIENSIS	5 69	5 89	7 100
CAREX INTUMESCENS	4 85		
CAREX PENSYLVANICA		3 61	5 82
CASTANEA DENTATA	5 54		
CHELONE LYONII	2 54		
DRYOPTERIS CAMPYLOPTERA	2 77		3 65
DRYOPTERIS INTERMEDIA			4 94
FAGUS GRANDIFOLIA			6 94
HUPERZIA LUCIDULA			3 65
MAIANTHEMUM CANADENSE			3 88
OXALIS MONTANA	3 85		5 82
PICEA RUBENS	6 92	7 100	8 76
PRUNUS PENSYLVANICA	3 54		
RHODODENDRON CATAWBIENSE	3 69	3 67	
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	2 100	1 72	4 71
POLYPODIUM VIRGINIANUM			2 76
PRENANTHES SP. #1		2 56	
PRUNUS SEROTINA			2 53
SAMBUCUS RACEMOSA VAR PUBENS			2 59
SAXIFRAGA MICHAUXII	1 54		
SOLIDAGO GLOMERATA	3 69		
SORBUS AMERICANA	4 100	1 67	3 82
STREPTOPUS ROSEUS VAR ROSEUS			2 82
TIARELLA CORDIFOLIA			2 65
TSUGA CANADENSIS		4 61	
VACCINIUM ERYTHROCARPUM		1 50	3 65
VIBURNUM LANTANOIDES			4 94
VIOLA BLANDA			2 53

Table 6.5. Mean values for elevation, slope, relative slope position (RSP), topographic moisture (TMI) and soil texture for each community type in the **Spruce-Yellow Birch Forests** vegetation class. Values are summarized by individual landscape. N represents the number of stands in a given landscape. High TMI values correspond with moist site conditions. High RSP values represent upper-slope positions.

1.1 Abies-Picea Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	8	1845	5	83	22	.	.	.
Grandfather Mtn:	5	1717	19	86	20	53	39	8

1.2 Picea-Betula alleghaniensis Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	4	1514	6	53	21	.	.	.
Grandfather Mtn:	2	1382	28	82	21	48	44	8
Shining Rock:	12	1671	20	64	21	50	43	7

1.3 Picea-Betula alleghaniensis-Fagus/Acer spicatum Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	9	1617	8	91	27	.	.	.
Grandfather Mtn:	7	1605	18	55	36	40	47	12
Shining Rock:	1	1824	31	98	14	76	15	9

Table 6.6. Average cover and constancy of species with a constancy of 50% or higher in the **High-Elevation Mixed Hardwood Forests** vegetation class. Values are given for each community type. For full names see Table 6.7. 'Cov' is the mean cover class for a species for the sites it is present in. 'Con' is the constancy of a species.

Number of Plots:	21	24	15	23	13
Community type:	2.1	2.2	2.3	2.4	2.5
	CovCon	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species					
ACER PENSYLVANICUM		4 75	3 80	4 96	2 82
ACER RUBRUM			2 73	4 83	5 100
ACER SACCHARUM VAR SACCHARUM	6 79	5 75	5 100	6 83	3 82
ACER SPICATUM	5 53	3 58			
AESCULUS FLAVA	7 100	3 79	4 87	3 78	
AGERATINA ALTISSIMA	3 79	3 92	4 100	3 70	2 73
AMELANCHIER ARBOREA			4 87	4 91	3 73
ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA				3 57	
ANGELICA TRIQUINATA				2 52	
ARISAEMA TRIPHYLLUM	2 79	2 75	2 73	2 83	
ASTER ACUMINATUS VAR ACUMINATUS				3 61	
ASTER DIVARICATUS	3 89	3 83	3 80	2 83	2 82
ATHYRIUM ASPLENIOIDES	2 58	3 83	3 80	3 65	
BETULA ALLEGHANIENSIS	6 95	5 88	6 100	6 87	4 73
CAULOPHYLLUM THALICTROIDES	3 63				
CAREX DEBILIS			2 53		
CAREX PENSYLVANICA		5 96		6 74	4 73
CIMICIFUGA RACEMOSA	4 79				
COLLINSONIA CANADENSIS			3 53		
CORNUS ALTERNIFOLIA			2 67	2 61	
DENNSTAEDTIA PUNCTILOBULA			4 53		3 55
DIOSCOREA VILLOSA			2 67		2 73
DRYOPTERIS INTERMEDIA	4 100	4 67	3 53		
FAGUS GRANDIFOLIA	6 89	8 100	4 93	5 65	6 100
FRAXINUS AMERICANA			3 60	4 57	
HALESIA TETRAPTERA			3 73		5 73
HAMAMELIS VIRGINIANA					4 82
HOUSTONIA SERPYLLIFOLIA			2 53		2 55
HYDRANGEA ARBORESCENS	3 58				
IMPATIENS PALLIDA	2 74				
ILEX MONTANA			2 60	3 70	2 73
LAPORTEA CANADENSIS	4 84	2 54			
MAIANTHEMUM CANADENSE		2 54			
MAIANTHEMUM RACEMOSUM					2 52
MAGNOLIA FRASERI					3 82
MEDEOLA VIRGINIANA					1 91
MITCHELLA REPENS					2 55
OSMORHIZA CLAYTONII	2 63				
OXALIS MONTANA		3 54			
POA SP. #1		2 50			
POLYGONATUM BIFLORUM		1 71	2 67	2 91	
POLYSTICHUM ACROSTICHOIDES VAR ACROSTICHOIDES	2 74				
PRENANTHES SP. #1		1 54	2 87	2 91	2 73
PROSARTES LANUGINOSA	2 63				
PRUNUS PENSYLVANICA			3 53		
PRUNUS SEROTINA			4 93	4 74	3 55
QUERCUS RUBRA			6 93	6 100	5 91
RHODODENDRON CALENDULACEUM					2 55
RHODODENDRON MAXIMUM					2 55
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS		3 71	4 67	2 78	2 91
SMILAX HERBACEA		1 58	2 60	2 65	1 55

Table 6.6. cont.

Community type:	2.1	2.2	2.3	2.4	2.5
	CovCon	Cov/Con	Cov/Con	Cov/Con	Cov/Con
SMILAX ROTUNDIFOLIA					2 91
SOLIDAGO CAESIA		2 63		2 52	2 91
SOLIDAGO SP. #1			3 53		
STELLARIA PUBERA	3 84	3 75	2 93	3 57	
THELYPTERIS NOVEBORACENSIS			4 80	3 57	3 73
TIARELLA CORDIFOLIA	3 79				
TRILLIUM ERECTUM		1 67		1 61	
TSUGA CANADENSIS					4 73
VACCINIUM ERYTHROCARPUM					2 64
VIBURNUM LANTANOIDES		4 58			
VIOLA BLANDA			2 73		
VIOLA ROTUNDIFOLIA				2 57	
VIOLA CANADENSIS VAR CANADENSIS	3 68				
VIOLA HASTATA					2 64

Table 6.7. Mean values for elevation, slope, relative slope position (RSP), topographic moisture (TMI) and soil texture for each community type in the **High-Elevation Mixed Hardwood Forests** vegetation class. Values are summarized by individual landscape. N represents the number of stands in a given landscape. High TMI values correspond with moist site conditions. High RSP values represent upper-slope positions.

2.1 Aesculus flava-Acer saccharum-Fagus/Cimicifuga racemosa Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	4	1344	8	69	32	.	.	.
Grandfather Mtn:	4	1476	23	62	38	42	45	13
Joyce Kilmer	1	1406	25	47	29	23	67	10
Nantahala Mtns:	2	1149	21	28	45	47	20	3
Smoky Mountains:	8	1372	22	63	37	38	50	11
Shining Rock	2	1538	29	41	29	84	7	9

2.2 Fagus-Betula alleghaniensis-Acer saccharum/Carex pensylvanica Forest

Black Mountains:	2	1594	5	80	29	.	.	.
Grandfather Mtn:	8	1486	21	42	28	46	47	6
Joyce Kilmer	6	1443	25	80	22	16	69	15
Smoky Mountains:	2	1449	27	90	33	19	64	18
Shining Rock	2	1764	18	92	17	52	41	8

2.3 Quercus rubra-Betula alleghaniensis/Ageratina Forest

Joyce Kilmer:	1	1406	8	95	6	17	73	10
Smoky Mountains:	14	1348	15	74	28	52	40	7

2.4 Quercus rubra-Betula alleghaniensis/Carex pensylvanica Forest

Black Mountains:	7	1371	5	74	16	.	.	.
Grandfather Mtn:	7	1409	17	79	22	45	46	9
Nantahala Mtns:	4	1453	26	83	31	40	28	2
Shining Rock:	5	1632	27	78	20	63	30	7

2.5 Fagus-Halesia-Quercus rubra/Hamamelis Forest

Joyce Kilmer:	5	1414	33	72	13	24	65	12
Nantahala Mtns:	3	1373	8	36	34	56	17	2
Smoky Mountains:	4	1308	26	55	31	38	48	14
Shining Rock:	1	1347	29	2	25	84	5	11

Table 6.8. Average cover and constancy of species with a constancy of 50% or higher in the **Rich Cove and Slope Forests** vegetation class. Values are given for each community type. For full names see Table 6.9. 'Cov' is the mean cover class for a species for the sites it is present in. 'Con' is the constancy of a species.

Number of plots:	13	19	22	39
Community type:	3.1	3.2	3.3	3.4
	CovCon	CovCon	CovCon	Cov/Con
Species				
ACER PENSYLVANICUM	3 92	2 53	3 86	3 92
ACER RUBRUM	4 77		3 68	
ACER SACCHARUM VAR SACCHARUM	5 77	7 89	5 86	7 100
AESCULUS FLAVA	5 77	5 89	5 91	5 92
AGERATINA ALTISSIMA	3 92	2 68	3 82	
AMELANCHIER ARBOREA	3 62			
AMPHICARPAEA BRACTEATA	2 54	2 58		
ARISTOLOCHIA MACROPHYLLA	2 69		3 73	3 82
ARISAEMA TRIPHYLLUM	2 85	2 68	2 82	2 97
ASTER ACUMINATUS VAR ACUMINATUS				3 56
ASTER DIVARICATUS	2 85	2 84	3 82	3 74
ATHYRIUM ASPLENIOIDES	2 54		2 68	
BETULA ALLEGHANIENSIS		4 53	6 77	4 77
BETULA LENTA			5 64	
BOTRYCHIUM VIRGINIANUM	1 62	2 63		
CARYA CORDIFORMIS		2 63		3 51
CAULOPHYLLUM THALICTROIDES	2 62	3 79	2 64	3 85
CIMICIFUGA RACEMOSA	3 69	5 74	2 64	3 85
COLLINSONIA CANADENSIS	3 54	3 53		2 54
DEPARIA ACROSTICHOIDES		2 68		2 64
DIOSCOREA VILLOSA	2 77			
DRYOPTERIS INTERMEDIA		2 58		3 72
DRYOPTERIS MARGINALIS				3 51
FAGUS GRANDIFOLIA				6 74
FESTUCA SUBVERTICILLATA	2 54			
FRAXINUS AMERICANA	4 77	4 84	2 68	4 74
GALIUM TRIFLORUM	2 62	2 74	2 64	
HALESIA TETRAPTERA			5 73	
HYDROPHYLLUM CANADENSE		3 84		2 62
IMPATIENS PALLIDA	1 54	3 63	2 50	2 64
LAPORTEA CANADENSIS		5 84	3 86	3 79
LIRIODENDRON TULIPIFERA		5 53		
MAIANTHEMUM RACEMOSUM	2 77	2 68	2 55	3 74
MONARDA CLINOPODIA	3 69			
OSMORHIZA CLAYTONII		2 68	2 59	2 64
OSTRYA VIRGINIANA VAR VIRGINIANA				5 79
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	2 58			
POLYGONATUM BIFLORUM	2 77	2 79	2 73	2 79
POLYSTICHUM ACROSTICHOIDES VAR ACROSTICHOIDES	2 77	2 89	2 91	2 100
PRENANTHES SP. #1	1 62		2 64	
PROSARTES LANUGINOSA	2 54	2 53	2 59	2 85
PRUNUS PENSYLVANICA	5 69			
PRUNUS SEROTINA		3 68		3 64
QUERCUS RUBRA	6 100	3 63	2 77	3 54
ROBINIA PSEUDOACACIA	4 77		4 59	
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	2 77		2 77	
SMILAX HERBACEA	2 77			
SOLIDAGO CAESIA	2 92	3 74	3 86	
STACHYS LATIDENS	2 77			
STELLARIA PUBERA		3 74		4 69

Table 6.8. cont.

Number of plots:	13		19		22		39	
	CovCon		CovCon		CovCon		Cov/Con	
THALICTRUM CLAVATUM	2	54						
TIARELLA CORDIFOLIA			2	63	2	64		
TILIA AMERICANA VAR HETEROPHYLLA	5	62	4	84	6	91	6	95
TRADESCANTIA SUBASPERA	2	54						
TRILLIUM ERECTUM					2	64	2	74
TSUGA CANADENSIS	2	54			4	68		
VIOLA BLANDA	2	77			3	82		
VIOLA CANADENSIS VAR CANADENSIS			3	79			4	77
VIOLA ROTUNDIFOLIA	2	54			2	64		

Table 6.9. Mean values for elevation, slope, relative slope position (RSP), topographic moisture (TMI) and soil texture for each community type in the **Rich Cove and Slope Forests** vegetation class. Values are summarized by individual landscape. N represents the number of stands in a given landscape. High TMI values correspond with moist site conditions. High RSP values represent upper-slope positions.

3.1 Acer saccharum-Quercus rubra Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Nantahala Mtns:	4	1325	16	64	33	63	20	1
Shining Rock:	9	1432	26	73	19	74	15	11

3.2 Acer saccharum-Aesculus flava/Laportea-Cimicifuga racemosa Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Grandfather Mtn:	3	961	27	79	14	39	52	9
Joyce Kilmer:	7	1065	28	42	34	38	52	11
Nantahala Mtns:	6	1091	24	36	43	69	19	2
Smoky Mountains:	3	1037	25	56	40	45	47	8

3.3 Tilia-Betula alleghaniensis-Halesia/Laportea Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Joyce Kilmer:	10	1010	21	29	35	29	57	14
Smoky Mountains:	1	869	11	4	46	73	16	11
Shining Rock:	11	1271	25	35	29	46	48	6

3.4 Acer saccharum-Tilia-Aesculus flava/Ostrya Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	31	1165	10	57	36	.	.	.
Grandfather Mtn:	8	1252	26	50	33	49	42	9

Table 6.10. Average cover and constancy of species with a constancy of 50% or higher in the **Acidic Cove and Slope Forests** vegetation class. Values are given for each community type. For full names see Table 6.11. 'Cov' is the mean cover class for a species for the sites it is present in. 'Con' is the constancy of a species.

Number of plots:	71		50		40		38	
Community type:	4.1		4.2		4.3		4.4	
	Cov/Con		Cov/Con		Cov/Con		Cov/Con	
Species								
ACER PENSYLVANICUM					3	76	4	76
ACER RUBRUM	5	92	4	96	4	80	3	79
ACER SACCHARUM VAR SACCHARUM							4	68
ARISAEMA TRIPHYLLUM					2	53	1	74
ARISTOLOCHIA MACROPHYLLA							2	58
ASTER DIVARICATUS							2	76
ATHYRIUM ASPLENIOIDES							2	50
BETULA ALLEGHANIENSIS					6	82		
BETULA LENTA	5	69	5	83	5	76	5	71
CARYA GLABRA	3	64						
CHIMAPHILA MACULATA VAR MACULATA	1	67						
CORNUS FLORIDA	4	79						
DRYOPTERIS INTERMEDIA							3	55
EUONYMUS AMERICANA	2	53						
FAGUS GRANDIFOLIA							4	55
GAYLUSSACIA URSINA	4	53						
GOODYERA PUBESCENS	1	61						
HALESIA TETRAPTERA							5	74
HAMAMELIS VIRGINIANA			3	63				
ILEX OPACA VAR OPACA	3	57						
KALMIA LATIFOLIA	4	76	4	73				
LAPORTEA CANADENSIS							3	58
LIRIODENDRON TULIPIFERA	4	86	4	65	6	53	5	63
MAGNOLIA ACUMINATA VAR ACUMINATA							3	61
MAGNOLIA FRASERI	3	65	4	79			4	50
MAIANTHEMUM RACEMOSUM							2	53
MEDEOLA VIRGINIANA	2	63					2	63
MITCHELLA REPENS	2	68					2	74
NYSSA SYLVATICA	3	69	3	60				
OXYDENDRUM ARBOREUM	5	83	4	54				
PINUS STROBUS	4	71						
PRENANTHES SP. #1							2	53
PROSARTES LANUGINOSA							2	63
POLYGONATUM BIFLORUM							2	71
POLYSTICHUM ACROSTICHOIDES VAR ACROSTICHOIDES	2	78			2	60	2	76
QUERCUS ALBA	4	67						
QUERCUS RUBRA	2	61	2	50	3	69	2	71
RHODODENDRON MAXIMUM	5	89	7	96	6	84	3	66
SMILAX GLAUCA VAR GLAUCA	2	78						
SMILAX ROTUNDIFOLIA	2	68	2	88			2	66
SOLIDAGO CAESIA							2	68
THELYPTERIS NOVEBORACENSIS	3	60					2	53
TSUGA CANADENSIS	6	86	6	94	7	91	7	84
TILIA AMERICANA VAR HETEROPHYLLA					5	51	3	58
VIOLA BLANDA							3	61
VIOLA HASTATA	2	53					2	55
VIOLA ROTUNDIFOLIA					2	51	2	58

Table 6.11. Mean values for elevation, slope, relative slope position (RSP), topographic moisture (TMI) and soil texture for each community type in the **Acidic Cove and Slope Forests** vegetation class. Values are summarized by individual landscape. N represents the number of stands in a given landscape. High TMI values correspond with moist site conditions. High RSP values represent upper-slope positions.

4.1 Tsuga canadensis-Pinus strobus-Oxydendrum/Rhododendron maximum Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	13	861	4	64	26	.	.	.
Chattooga River:	11	743	9	49	32	.	.	.
Grandfather Mtn:	2	508	15	60	32	66	28	7
Joyce Kilmer:		687	24	68	19	28	56	16
Linville Gorge:	5	477	9	39	38	14	82	4
Nantahala Mtns:	1	618	30	88	5	0	36	18
Smoky Mountains:	3	644	26	40	35	47	34	19
Thompson River:	19	642	15	35	33	.	.	.

4.2 Tsuga canadensis/Rhododendron maximum Forest

Chattooga River:	4	765	20	45	32	.	.	.
Grandfather Mtn:	1	1152	25	25	24	42	49	9
Joyce Kilmer:	2	955	37	74	28	33	57	10
Linville Gorge:	26	908	17	45	33	5	92	20
Nanatahala Mtns:	7	1170	12	50	29	88	12	0
Smoky Mountains:	4	1024	19	55	33	55	30	16
Shining Rock:	2	1184	20	62	20	19	78	3
Thompson River:	4	837	19	38	33	.	.	.

4.3 Tsuga canadensis-Betula alleghaniensis-Liriodendron/Rhododendron maximum Forest

Black Mountains:	12	1069	6	43	34	.	.	.
Chattooga River:	1	680	15	42	34	.	.	.
Grandfather Mtn.	1	1182	8	35	30	25	69	6
Joyce Kilmer:	12	810	15	38	31	43	47	10
Linville Gorge:	1	440	1	9	43	93	2	5
Smoky Mountains:	4	759	14	12	39	63	28	
Shining Rock:	9	1256	24	47	28	55	39	5

4.4 Tsuga canadensis-Halesia Forest

Black Mountains:	1	1069	6	43	34	.	.	.
Chattooga River:	1	877	12	40	46	.	.	.
Grandfather Mtn:	1	1227	18	18	45	7	85	8
Joyce Kilmer:	22	952	23	62	26	27	59	14
Linville Gorge:	1	598	13	30	47	42	53	5
Smoky Mountains:	6	1081	27	60	33	56	31	13
Shining Rock:	5	1106	21	41	28	34	62	3
Thompson River:	1	1048	20	26	39	.	.	.

Table 6.12. Average cover and constancy of species with a constancy of 50% or higher in the **Montane Oak Forests** vegetation class. Values are given for each community type. For full names see Table 6.13. 'Cov' is the mean cover class for a species for the sites it is present in. 'Con' is the constancy of a species.

Number of plots:	57	38	48	36	8	19	25	41
Community types:	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species								
ACER PENSYLVANICUM	2 54	2 80	3 65	3 81	5 92	4 60	3 87	4 76
ACER RUBRUM	6 96	5 93	4 88	7 97	7 100	4 100	6 100	5 98
ACER SACCHARUM VAR SACCHARUM			5 71		1 54	3 67	3 65	3 64
AESCULUS FLAVA			4 63			2 80		
AGERATINA ALTISSIMA		2 51	2 69				2 87	3 88
AMELANCHIER ARBOREA	2 58	4 95	2 50	2 69		2 80	3 96	2 71
AMPHICARPAEA BRACTEATA			2 54				2 61	2 67
ARISTOLOCHIA MACROPHYLLA			2 63	2 53				2 60
ARISAEMA TRIPHYLLUM			2 79			1 80		2 98
ASTER DIVARICATUS			2 79	2 81	2 62		2 78	2 88
ASTER MACROPHYLLUS					3 54			
ASTER UNDULATUS							1 57	
ATHYRIUM ASPLENIOIDES							2 70	
BETULA LENTA	4 77		4 71	4 69			3 52	4 90
BOTRYCHIUM VIRGINIANUM			2 79					1 52
CAREX DIGITALIS				1 56				1 57
CAREX PENSYLVANICA		3 54						
CARYA ALBA				3 53		4 73		
CARYA GLABRA			3 56	3 78		4 80	4 65	4 76
CASTANEA DENTATA		4 68		3 61	3 77	1 67	5 96	2 69
CAULOPHYLLUM THALICTROIDES								2 50
CHIMAPHILA MACULATA VAR MACULATA				1 83	1 62			
CIMICIFUGA RACEMOSA			3 60			2 67		
CLINTONIA UMBELLULATA							2 61	
COLLINSONIA CANADENSIS			2 54			2 80	2 78	2 67
CONOPHOLIS AMERICANA					2 62	2 67	2 52	
CORNUS ALTERNIFOLIA			2 56			1 60		
CORNUS FLORIDA			4 83	4 83	4 62	5 80		3 50
DANTHONIA COMPRESSA		2 56						
DENNSTAEDTIA PUNCTILOBULA		3 59					4 61	3 62
DESMODIUM SP. #1						1 53		
DESMODIUM NUDIFLORUM				2 50				
DIOSCOREA VILLOSA			2 77	2 75	1 62	1 87	2 100	2 90

Table 6.12. cont.

Community types:	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
EUONYMUS AMERICANA			2 50					
EUPATORIUM PURPUREUM VAR PURPUREUM							2 78	2 74
FAGUS GRANDIFOLIA			3 52			5 60	2 52	
FRAXINUS AMERICANA			3 96		1 54	2 87	2 91	3 76
GALAX URCEOLATA	3 63				5 54			
GALIUM LATIFOLIUM						1 73	2 57	
GALIUM TRIFLORUM			2 50					
GENTIANA SPECIES				1 50	2 85		1 65	
GOODYERA PUBESCENS	1 54			1 67	1 77	1 67		1 55
HALESIA TETRAPTERA			5 79	3 78			6 65	5 62
HAMAMELIS VIRGINIANA	4 53				2 77	4 67		
HIERACIUM PANICULATUM				1 56			2 70	
HOUSTONIA PURPUREA				1 61	2 77		2 87	1 50
ILEX MONTANA		4 78			2 62		3 78	
KALMIA LATIFOLIA	4 82	5 61		3 78	5 77			
LAPORTEA CANADENSIS			2 63					
LIRIODENDRON TULIPIFERA	4 51		6 92	3 78	6 77	6 100	3 61	5 74
LYSIMACHIA QUADRIFOLIA		2 59		2 56	2 92		2 100	2 71
MAGNOLIA ACUMINATA VAR ACUMINATA			3 60	3 53	3 62	3 87	3 74	3 67
MAGNOLIA FRASERI	3 68			2 58	2 54	2 67	2 52	
MAIANTHEMUM RACEMOSUM			2 73	1 58	1 62	3 93	2 91	2 88
MEDEOLA VIRGINIANA	2 54	2 56	2 50		2 54	2 87	2 91	2 74
NYSSA SYLVATICA	3 67			3 72				
OXYDENDRUM ARBOREUM	5 72			5 92	6 54			
PANICUM SP.				2 75		2 60	2 91	2 64
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA			2 81	2 53				
PEDICULARIS CANADENSIS							2 65	
PHEGOPTERIS HEXAGONOPTERA						1 53		
POA SP. #1				1 50			2 61	
POLYSTICHUM ACROSTICHOIDES VAR ACROSTICHOIDES			3 90	2 81				2 79
POLYGONATUM BIFLORUM			2 77	1 83			2 87	2 95
POTENTILLA CANADENSIS				2 56	2 54		2 70	
PRENANTHES SP. #1		2 71	2 73	2 78	2 92	2 73	2 91	2 88
PROSARTES LANUGINOSA			2 54			1 80		2 69
PRUNUS SEROTINA			3 50		2 54	1 87	2 70	2 64
PYCNANTHEMUM INCANUM						1 53		

Table 6.12. cont.

Community types:	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
QUERCUS ALBA						5 60		
QUERCUS MONTANA	6 88			6 92	8 100	4 60	4 52	
QUERCUS RUBRA	5 91	7 80	3 92	5 94	8 100	6 80	7 100	6 100
RHODODENDRON CALENDULACEUM		4 63		3 50	8 54		4 57	
RHODODENDRON CATAWBIENSE		6 51						
RHODODENDRON MAXIMUM	7 84			3 58	3 92	2 53		
ROBINIA PSEUDOACACIA	3 67			3 83	3 85	5 53	2 74	3 93
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS		2 61	2 56		1 62		2 70	2 74
SANGUINARIA CANADENSIS			2 63			1 53		
SANICULA TRIFOLIATA					1 54			
SASSAFRAS ALBIDUM	2 51			2 67	1 54		3 57	
SILENE STELLATA							2 70	
SMILAX GLAUCA VAR GLAUCA	2 58			2 81	3 62			
SMILAX HERBACEA							2 87	1 67
SMILAX ROTUNDIFOLIA	2 84		2 71	2 94		2 87	3 91	2 71
SOLIDAGO SP. #1					2 77	1 80		
SOLIDAGO CAESIA		2 63	2 73	2 75			3 83	2 88
STELLARIA PUBERA			2 69				2 61	2 50
THELYPTERIS NOVEBORACENSIS			3 56		5 69	4 53	6 100	4 83
TIARELLA CORDIFOLIA			2 69					
TILIA AMERICANA VAR HETEROPHYLLA			5 90			3 60		3 57
TOXICODENDRON RADICANS						2 67		
TSUGA CANADENSIS	5 79	2 56	4 73	3 86	3 62	2 53	3 78	
UVULARIA PUBERULA VAR PUBERULA				2 53				
VACCINIUM PALLIDUM				2 56				
VACCINIUM SIMULATUM		4 51					3 61	
VACCINIUM STAMINEUM				2 53				
VIBURNUM ACERIFOLIUM				2 72	3 69			
VIBURNUM LANTANOIDES						2 53		
VIOLA HASTATA			2 54	2 64			2 52	2 64
VIOLA SORORIA						2 60	2 65	
VITIS AESTIVALIS				2 56				
ZIZIA TRIFOLIATA				2 56	1 69			

Table 6.13. Mean values for elevation, slope, relative slope position (RSP), topographic moisture (TMI) and soil texture for each community type in the **Montane Oak Forests** vegetation class. Values are summarized by individual landscape. N represents the number of stands in a given landscape. High TMI values correspond with moist site conditions. High RSP values represent upper-slope positions.

5.1 Quercus montana-Tsuga canadensis-Oxydendrum/Rhododendron maximum Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Chattooga River:	4	1004	23	75	35	.	.	.
Grandfather Mtn:	4	1025	27	49	36	39	51	9
Joyce Kilmer:	5	816	22	47	30	19	58	23
Linville Gorge:	5	821	27	52	30	5	92	2
Nantahala Mtns:	4	1181	14	63	30	45	17	2
Smoky Mountains:	13	941	22	68	28	50	39	12
Shining Rock:	15	1223	29	63	21	44	50	6
Thompson River:	7	848	20	44	39	.	.	.

5.2 Quercus rubra/Ilex montana Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Chattooga River:	4	1004	23	75	35	.	.	.
Black Mountains:	1	1455	14	79	21	.	.	.
Chattooga River:	1	1437	27	.	.	.	.	.
Grandfather Mtn:	2	1328	14	73	16	50	43	7
Joyce Kilmer:	5	1400	21	85	13	22	62	16
Nantahala Mtns:	11	1475	12	84	22	40	19	4
Shining Rock:	18	1626	20	70	18	43	52	4

5.3 Liriodendron-Acer saccharum Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Chattooga River:	3	734	24	40	26	.	.	.
Grandfather Mtn:	2	720	39	56	15	45	44	11
Joyce Kilmer:	16	819	19	41	29	27	58	16
Nantahala Mtns:	12	826	17	57	30	29	20	8
Smoky Mountains:	11	787	23	36	39	54	36	10
Shining Rock:	2	1164	22	67	25	57	38	5
Thompson River:	2	385	31	63	30	.	.	.

5.4 Quercus montana-Quercus rubra/Oxydendrum Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Grandfather Mtn:	1	758	25	92	15	49	39	12
Joyce Kilmer:	13	884	29	60	22	28	55	17
Linville Gorge:	6	744	29	73	16	24	71	5
Smoky Mountains:	1	745	4	97	12	65	22	13
Shining Rock:	15	1148	28	65	17	45	50	5

5.5 Quercus rubra-Quercus montana/Kalmia Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	8	1089	9	65	19	.	.	.

5.6 Quercus rubra/Cornus florida Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	13	961	7	48	24	.	.	.
Chattooga River:	6	1120	4	.	.	.	.	.

Table 6.13. cont.

5.7 Quercus rubra-Castanea dentata/Thelypteris Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Chattooga River:	2	1136	16	85	2	.	.	.
Grandfather Mtn:	1	1079	23	91	29	62	22	16
Joyce Kilmer:	11	1286	24	58	19	22	63	14
Nantahala Mtns:	7	1275	19	96	25	29	17	16
Smoky Mountains:	3	1276	17	94	21	28	67	5
Thompson River	1	1256	23	91	28	.	.	.

5.8 Quercus rubra-Liriodendron Forest

Grandfather Mtn:	2	897	25	71	27	37	40	23
Joyce Kilmer:	6	972	27	68	22	24	63	13
Linville Gorge:	8	1061	24	81	26	15	78	8
Nantahala Mtns:	8	1198	23	73	33	57	25	6
Smoky Mountains:	1	1049	31	82	37	47	43	11
Shining Rock:	14	1169	20	57	19	49	45	7
Thompson River:	2	1031	26	93	30	.	.	.

Table 6.14. Average cover and constancy of species with a constancy of 50% or higher in the **Thermic Oak-Pine Forests** vegetation class. Values are given for each community type. For full names see Table 6.15. 'Cov' is the mean cover class for a species for the sites it is present in. 'Con' is the constancy of a species.

Number of plots:	18	15	45	21	34	12	8	57	39	67	37
Community type:	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	6.10	6.11
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
Species											
ACER PENSYLVANICA						3 58					
ACER RUBRUM	4 78	3 100	4 100	6 100	5 100	3 100	5 100	6 96	7 83	6 100	6 94
AMELANCHIER ARBOREA	3 67	2 53			2 83		3 100	2 50	2 60	2 63	1 59
ANDROPOGON GERARDII							5 100				
ANDROPOGON VIRGINICUS		2 53									
ASPLENIUM PLATYNEURON VAR PLATYNEURON							2 75				
ASTER LAEVIS							2 50				
ASTER PHLOGIFOLIUS							2 63				
ASTER UNDULATUS							2 63				
BETULA LENTA	2 56					2 50	3 63				
CAMPANULA DIVARICATA						2 50	2 63				
CARYA ALBA								3 53			5 78
CARYA GLABRA								3 73		4 97	4 92
CASTANEA DENTATA					2 71			2 62	2 69	4 91	2 65
CHIMAPHILA MACULATA VAR MACULATA		1 73		1 57				2 82	1 67	2 83	2 80
CLETHRA ACUMINATA	2 61										
COREOPSIS MAJOR		2 80					2 88	2 51			
CORNUS FLORIDA						2 50		4 70		4 83	5 94
DANTHONIA SERICEA		2 60									
DANTHONIA SPICATA							2 100				
DESMODIUM NUDIFLORUM										2 57	2 76
DIOSCOREA VILLOSA						1 67				2 61	2 69
DRYOPTERIS MARGINALIS						2 50					
ELYMUS TRACHYCAULUS							3 75				
EPIGAEA REPENS			1 61				2 63				
EUPATORIUM PURPUREUM VAR PURPUREUM										2 52	2 59
GALAX URCEOLATA	4 94		5 91	2 71	4 89			3 53	3 74	2 55	
GAULTHERIA PROCUMBENS			2 59								
GAYLUSSACIA BACCATA			3 80				2 50				
GAYLUSSACIA URSINA								5 61	7 83	5 79	3 51
GOODYERA PUBESCENS							1 63			2 84	2 65

Table 6.14. cont.

Number of plots:	18	15	45	21	34	12	8	57	39	67	37
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
GOODYERA REPENS	1 50										
HAMAMELIS VIRGINIANA	2 61				4 57	3 58					
HELIANTHUS MICROCEPHALUS							2 63				
HEXASTYLIS ARIFOLIA							4 100				
HOUSTONIA PURPUREA						2 50					
HOUSTONIA SERPYLLIFOLIA							2 50				
ILEX OPACA VAR OPACA											2 51
KALMIA LATIFOLIA	6 94	5 100	7 100	4 100	6 100	3 58	3 100	5 80	5 83	4 95	2 57
LEUCOTHOE RECURVA	3 83		3 78								
LIRIODENDRON TULIPIFERA										3 71	5 94
LOBELIA PUBERULA							2 50				
LYONIA LIGUSTRINA VAR LIGUSTRINA			2 70				3 50				
LYSIMACHIA QUADRIFOLIA						2 50				2 57	2 65
MAGNOLIA ACUMINATA VAR ACUMINATA							2 63				
MAGNOLIA FRASERI				3 67	2 51			2 50	2 60	2 60	2 67
MAIANTHEMUM RACEMOSUM											2 51
MEDEOLA VIRGINIANA					1 57						
MUHLENBERGIA GLOMERATA							3 50				
NYSSA SYLVATICA	4 72	3 67	5 89	3 90	4 97	2 58		5 96	5 81	4 99	4 88
OENOTHERA FRUTICOSA							2 88				
OXYPOLIS RIGIDIOR							2 88				
OXYDENDRUM ARBOREUM		4 80	3 65	4 100	5 91	3 50	3 50	5 95	5 81	5 95	4 86
PANICUM SP.		2 80				2 58	3 100	2 57		2 59	2 78
PANICUM VIRGATUM VAR VIRGATUM							2 63				
PARNASSIA GRANDIFOLIA							2 63				
PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA						2 67					
PHYSOCARPUS OPULIFOLIUS VAR OPULIFOLIUS							2 100				
PINUS PUNGENS	4 56	5 93	6 89								
PINUS RIGIDA		5 80	4 74				5 100	5 73			
PINUS STROBUS		2 73	4 70	4 81	4 69	1 67		5 84	3 74	3 84	3 76
PINUS VIRGINIANA		5 73									
POLYGALA PAUCIFOLIA							2 75				
POLYGONATUM BIFLORUM						1 75				2 52	
POLYSTICHUM ACROSTICHOIDES VAR ACROSTICHOIDES						1 67	2 50				2 82
PORTERANTHUS TRIFOLIATUS							2 50				
POTENTILLA CANADENSIS										2 52	2 55
PRENANTHES SP. #1										2 59	

Table 6.14. cont.

Number of plots:	18	15	45	21	34	12	8	57	39	67	37
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
PRUNELLA VULGARIS							2 88				
PTERIDIUM AQUILINUM VAR LATIUSCULUM							3 75	2 55			
QUERCUS ALBA					4 51		5 100	4 73		5 87	4 71
QUERCUS COCCINEA VAR COCCINEA		4 60	4 67				2 63	5 89	5 76		
QUERCUS MONTANA		5 80	4 91	5 100	5 94	5 100		5 82	6 83	5 89	5 76
QUERCUS RUBRA		3 67		2 57	4 89	2 100	2 63			5 88	4 84
QUERCUS VELUTINA								3 81	3 55	4 56	4 73
RHODODENDRON CALENDULACEUM										3 64	
RHODODENDRON CATAWBIENSE	5 78										
RHODODENDRON MAXIMUM	5 78		2 52	4 95	5 80	3 50				3 57	
RHODODENDRON MINUS	6 56	5 60				3 50					
ROBINIA PSEUDOACACIA						2 67		3 72	3 57	4 87	4 82
RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS						2 67					
SANGUISORBA CANADENSIS							3 63				
SASSAFRAS ALBIDUM	2 78				3 83		3 100	3 73	3 76	3 93	2 71
SCHIZACHYRIUM SCOPARIUM							4 75				
SENECIO ANONYMUS							2 50				
SENECIO PLATTENSIS							4 100				
SMILAX GLAUCA VAR GLAUCA	2 61	2 87	2 93	1 100	2 74	2 50	4 100	2 92	2 79	2 92	2 90
SMILAX ROTUNDIFOLIA	2 72	3 73	2 72	1 90	2 94	2 83	2 75	2 50	3 76	2 53	2 65
SOLIDAGO ARGUTA		1 67									
SOLIDAGO BICOLOR							2 100				
SOLIDAGO CAESIA										2 57	
SOLIDAGO NEMORALIS VAR NEMORALIS							2 50				
SORGHASTRUM NUTANS							3 75				
SPOROBOLUS HETEROLEPIS							4 88				
SYMPLOCOS TINCTORIA			4 80	1 86	3 60			2 55			
THALICTRUM MACROSTYLUM							2 100				
THELYPTERIS NOVEBORACENSIS										4 65	4 53
TSUGA CANADENSIS				3 71	2 77	2 92	4 63		3 71	2 65	3 67
TSUGA CAROLINIANA	4 89										
VACCINIUM CORYMBOSUM	3 72	3 53									
VACCINIUM PALLIDUM		3 67	3 87	1 52			2 63	4 91	2 74	3 67	
VACCINIUM SIMULATUM							2 63				
VACCINIUM STAMINEUM		3 73				1 50	4 100	2 61	3 60	3 87	
VIBURNUM NUDUM VAR CASSINOIDES							3 88				

Table 6.14. cont.

Number of plots:	18	15	45	21	34	12	8	57	39	67	37
	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con	Cov/Con
VIOLA SP. #1										2 51	
VIOLA HASTATA				1 57						2 53	
ZIZIA TRIFOLIATA						1 58	2 50				

Table 6.15. Mean values for elevation, slope, relative slope position (RSP), topographic moisture (TMI) and soil texture for each community type in the **Thermic Oak-Pine Forests** vegetation class. Values are summarized by individual landscape. N represents the number of stands in a given landscape. High TMI values correspond with moist site conditions. High RSP values represent upper-slope positions.

6.1 Tsuga caroliniana/Kalmia Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	13	861	4	64	26	.	.	.
Black Mountains:	1	1152	6	77	38	.	.	.
Grandfather Mtn:	1	958	14	95	34	85	12	3
Linville Gorge:	11	1027	22	82	31	6	90	4
Nantahala Mtns:	5	1313	11	90	23	1	19	3

6.2 Pinus pungens-Pinus rigida-Pinus virginiana/Kalmia Forest

Linville Gorge:	11	701	31	80	22	11	86	3
Shining Rock:	4	1120	36	78	15	54	39	7

6.3 Pinus pungens/Kalmia/Galax Forest

Black Mountains:	4	1177	4	81	24	.	.	.
Grandfather Mtn:	3	891	20	93	20	62	29	9
Linville Gorge:	35	850	17	81	23	6	91	3
Shining Rock:	3	1471	32	89	11	38	58	4

6.4 Quercus montana-Pinus strobus/Rhododendron maximum Forest

Linville Gorge:	12	797	22	62	29	8	89	3

6.5 Quercus montana/Rhododendron maximum Forest

Chattooga River:	1	1116	9	98	23	.	.	.
Grandfather Mtn:	3	1091	18	93	11	41	48	11
Linville Gorge:	18	1047	17	77	25	10	87	3
Smoky Moountains:	2	1194	16	87	25	28	52	20
Shining Rock:	5	1303	18	72	16	40	52	8
Thompson River:	5	999	7	56	29	.	.	.

6.6 Quercus montana Forest

Linville Gorge:	9	876	33	60	28	22	72	6
Nantahala Mtns:	3	1271	18	98	21	80	19	0

6.7 Quercus alba-Pinus rigida/Andropogon gerardii Forest

Nantahala Mtns:	8	1089	20	72	23	58	32	9

Table 6.15. cont.

6.8 Quercus montana-Quercus coccinea-Pinus strobus-Pinus rigida Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	1	864	6	86	26	.	.	.
Chattooga River:	26	774	16	84	17	.	.	.
Grandfather Mtn:	1	533	18	39	29	61	28	11
Joyce Kilmer:	4	608	22	83	10	18	59	23
Linville Gorge:	3	599	18	50	27	5	91	4
Nantahala Mtns:	2	931	12	95	8	1	33	12
Smoky Mountains:	3	690	14	97	21	16	52	32
Shining Rock:	1	1342	38	86	3	78	8	14
Thompson River:	16	690	19	80	23	.	.	.

6.9 Quercus montana-Quercus coccinea/Gaylussacia ursina Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Chattooga River:	8	865	22	70	30	.	.	.
Joyce Kilmer:	24	797	21	74	15	24	53	23
Smoky Mountains:	3	835	16	85	19	38	44	18
Thompson River:	16	606	30	50	43	.	.	.

6.10 Quercus alba-Quercus montana-Quercus rubra/Gaylussacia ursina Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Black Mountains:	2	861	3	91	28	.	.	.
Chattooga River:	1	1151	22	.	.	.	.	.
Grandfather Mtn:	2	758	21	100	6	26	54	20
Joyce Kilmer:	5	994	23	67	12	23	56	21
Linville Gorge:	1	1183	23	36	46	20	76	4
Nantahala Mtns:	13	1102	15	82	17	26	28	10
Smoky Mountains:	1	1101	13	98	23	27	68	6
Thompson River:	42	1000	17	77	22	.	.	.

6.11 Carya alba-Liriodendron-Quercus montana/Cornus florida Forest

Landscape	N	Elevatn	Slope	RSP	TMI	Sand	Silt	Clay
Chattooga River:	7	869	20	74	22	.	.	.
Joyce Kilmer:	7	575	20	49	22	33	54	13
Smoky Mountains:	8	643	20	64	26	27	46	27
Shining Rock:	2	1014	15	18	21	28	66	5
Thompson River:	13	600	20	77	23	.	.	.

consistent with those previously identified at the landscape-scale. These analyses also provide a framework in which to place patterns observed in individual landscapes in context with one another.

The NMDS ordination method was used to identify the major environmental gradients correlated with regional- and subregional-scale vegetation composition. The regional analysis was performed using the 1113 stands used in the Ward's cluster analysis (the 7 trimmed stands were eliminated). The ordination was based on all vascular plant species with a frequency of 3 occurrences or higher. The detailed examination of community type composition within the **Acidic Cove and Slope Forests**, **Montane Oak Forests** and **Thermic Oak-Pine Forests** in the previous section, revealed the recurring separation of types into two broad geographic categories, separated by the Asheville Basin. In attempt to quantify environmental differences between these two subregions, landscapes were grouped into those north of the Asheville Basin and those south of the Asheville Basin. An ordination was performed on each subregional group.

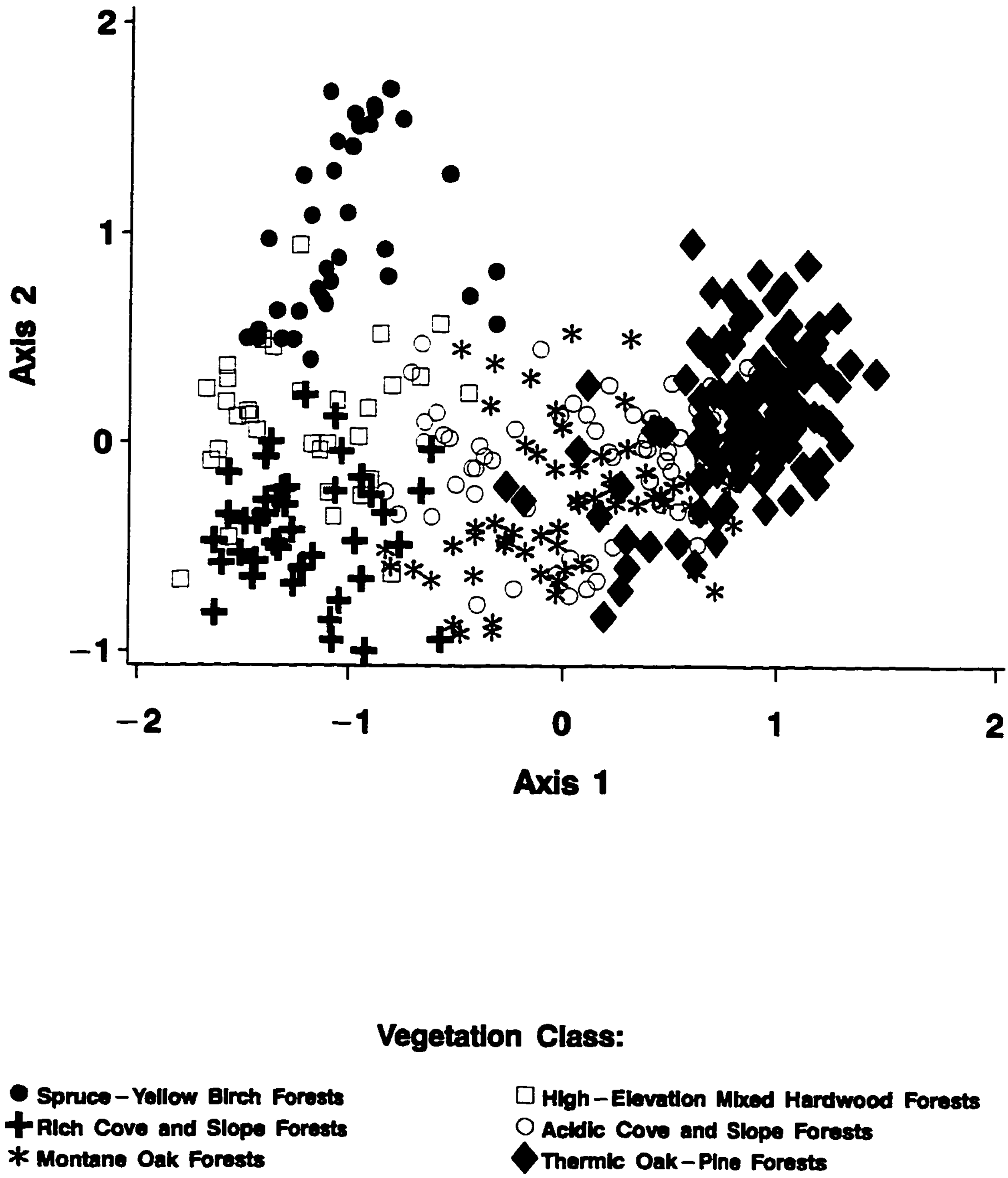
6.7.1 Subregion north of Asheville Basin

The 388 stands north of the Asheville Basin (including those from the Black Mountains, Grandfather Mountain and Linville Gorge) are distributed by elevation and soil nutrients (specifically, Cu, Mn and pH) (Figures 6.43-6.45). There are also strong correlations between vegetation, soil texture (soil density, sand, silt), rotated latitude and topographic position (TMI, solar radiation, relative slope position). Correlations with latitude correspond to the predominance of xeric stands on lower-elevations northeast of the main high-mountain chain. There is also a marked decrease in rainfall along this gradient, from the high-elevation peaks to the adjacent low-elevation mountains to the east, suggesting that latitude may also be a surrogate for rainfall (see Table 1.2).

6.7.2 Subregion south of Asheville Basin

The six landscapes south of the Asheville Basin (including the Chattooga River, Joyce Kilmer, the Nantahalas, Smoky Mountains, Shining Rock and the Thompson River, 747 plots in total) are distributed primarily along elevation and soil nutrient (represented by

Figure 6.43. Diagram for NMDS ordination of the three landscapes north of the Asheville Basin showing the distribution of stands classified by vegetation classes on the two major compositional gradients.


Axis 2
Axis 1
2
1
0
−1
−2
−1
0
1
2
Vegetation Class:
Spruce – Yellow Birch Forests
Rich Cove and Slope Forests
Montane Oak Forests
High – Elevation Mixed Hardwood Forests
Acidic Cove and Slope Forests
Thermic Oak – Pine Forests

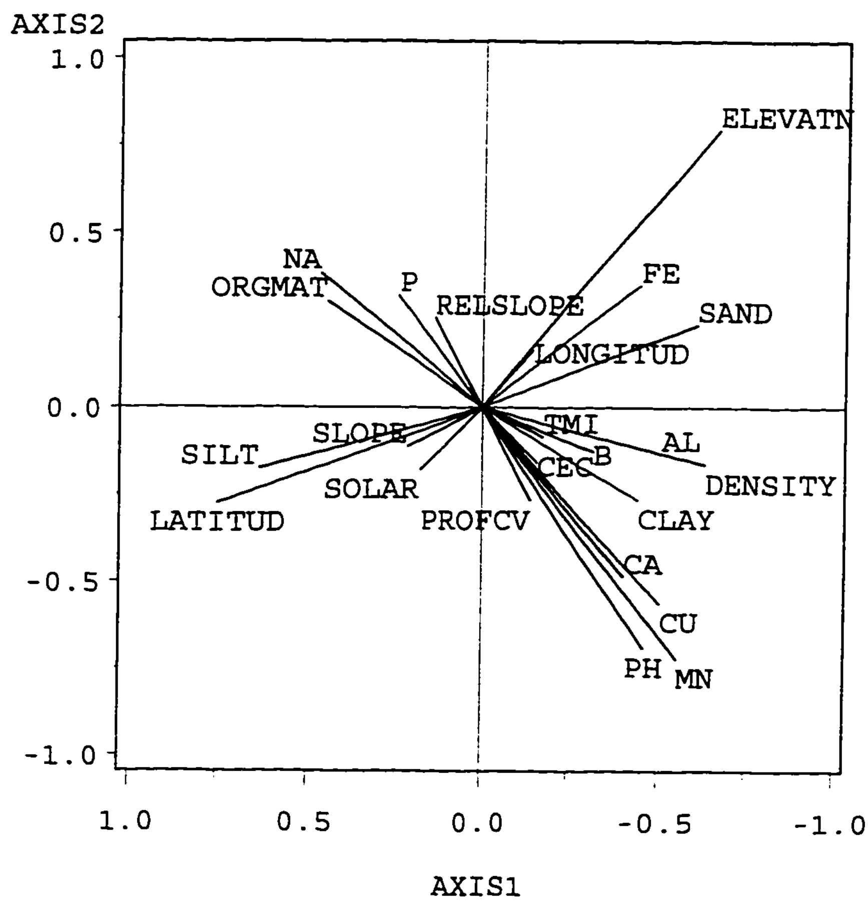


Figure 6.44. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the three landscapes north of the Asheville Basin showing association between species composition and major environmental gradients. PROFCV=profile curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

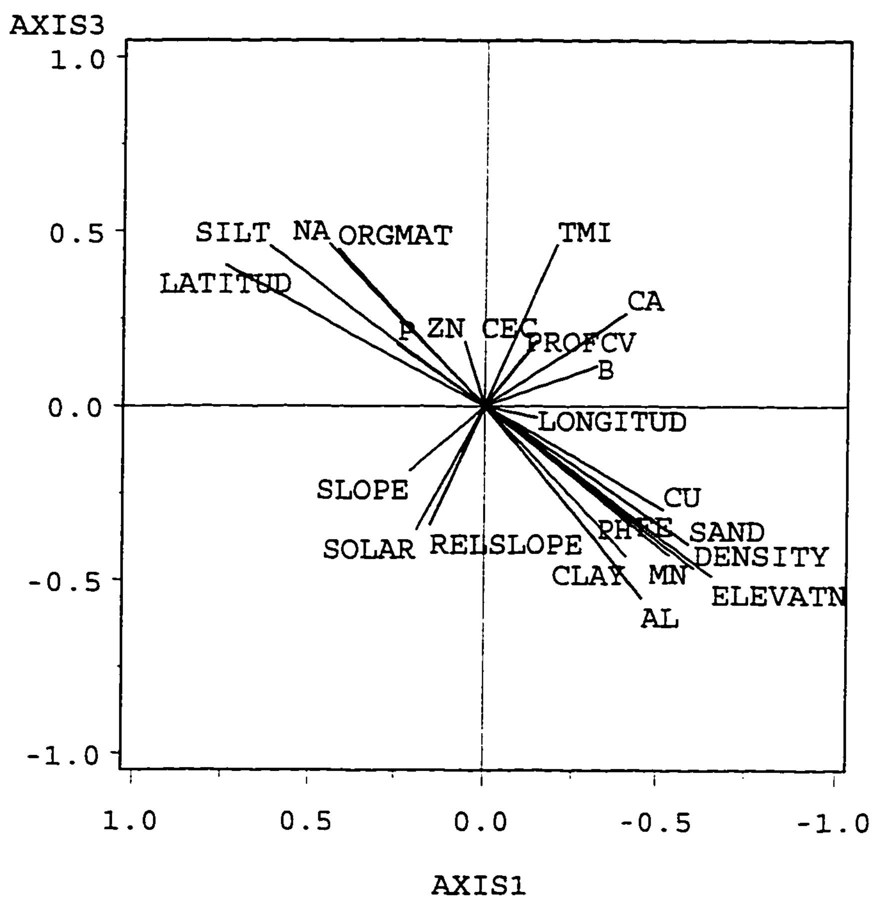
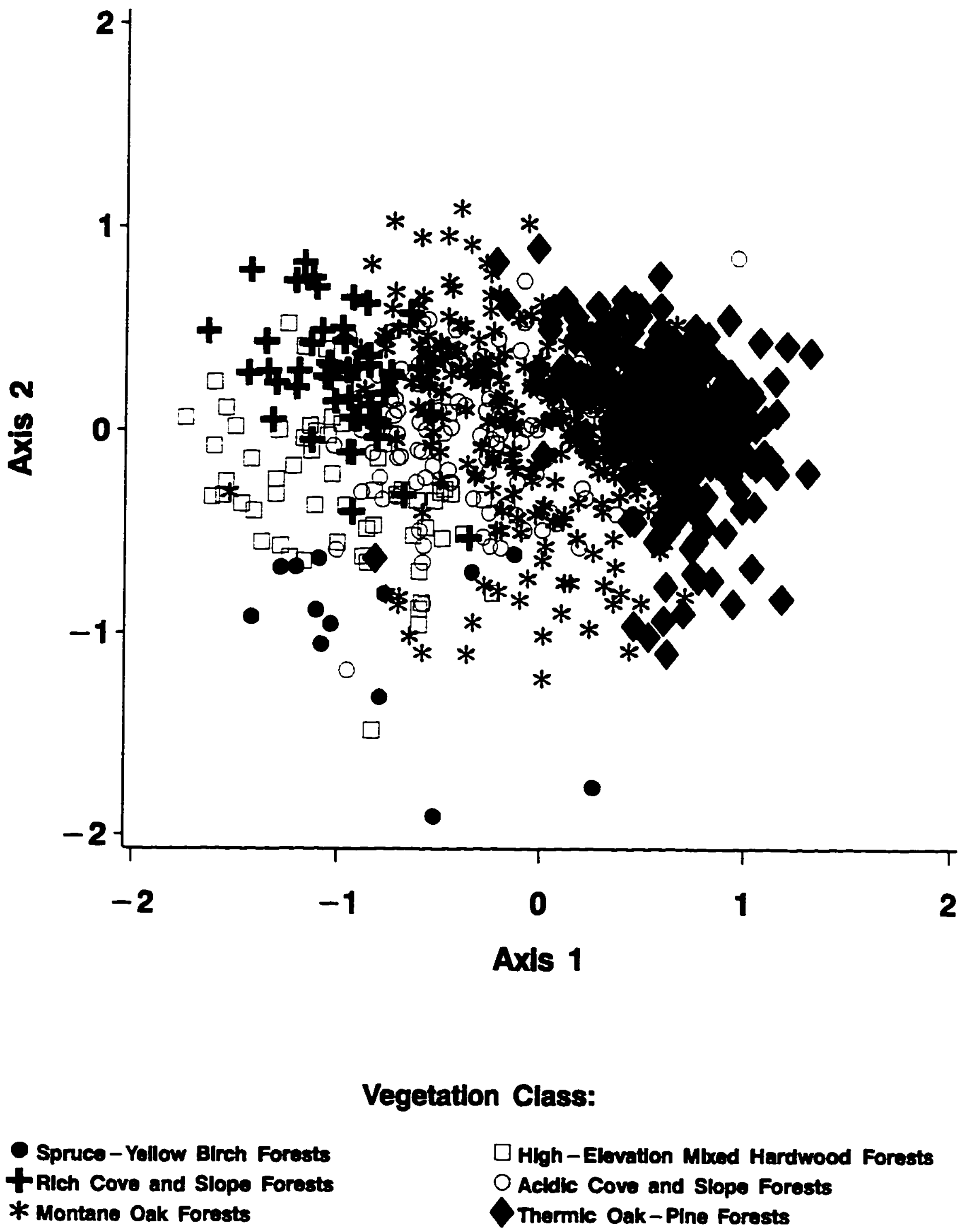


Figure 6.45. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the three landscapes north of the Asheville Basin showing association between species composition and major environmental gradients. PROFCV=profile curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.46. Diagram for NMDS ordination of the six landscapes south of the Asheville Basin showing the distribution of stands classified by vegetation classes on the two major compositional gradients.



Axis 2
Axis 1
2
1
0
−1
−2
−2
−1
0
1
2
Vegetation Class:
Spruce – Yellow Birch Forests
Rich Cove and Slope Forests
Montane Oak Forests
High – Elevation Mixed Hardwood Forests
Acidic Cove and Slope Forests
Thermic Oak – Pine Forests

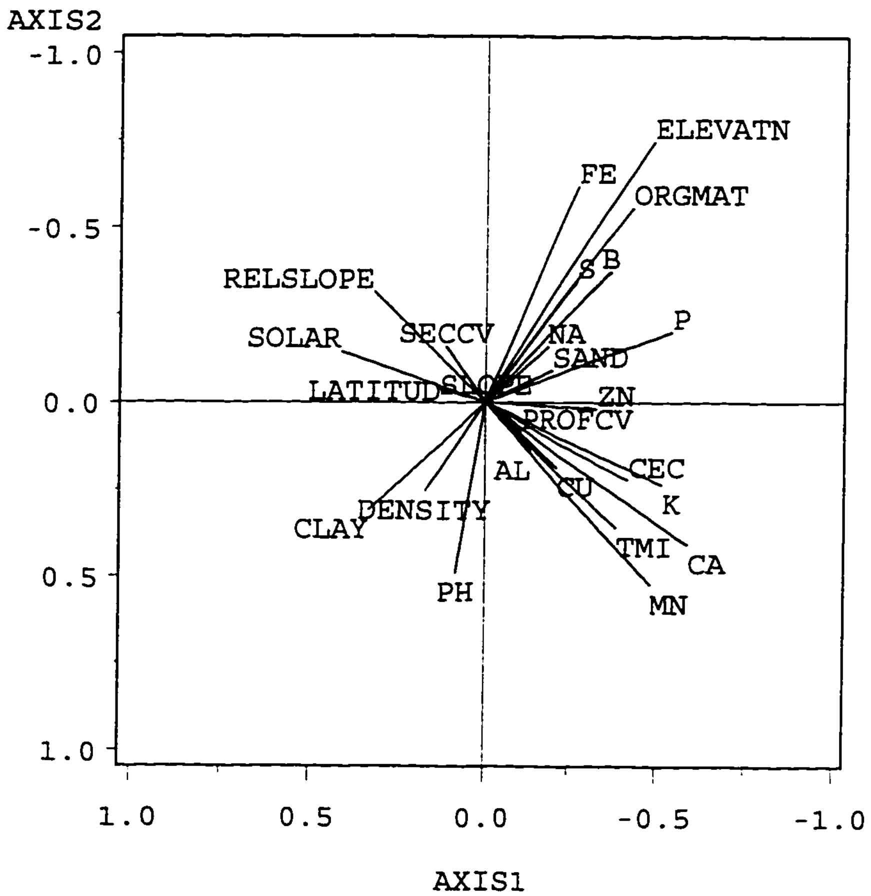


Figure 6.47. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of the six landscapes south of the Asheville Basin showing association between species composition and major environmental gradients. PROFCV=profile curvature, SECCV=section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

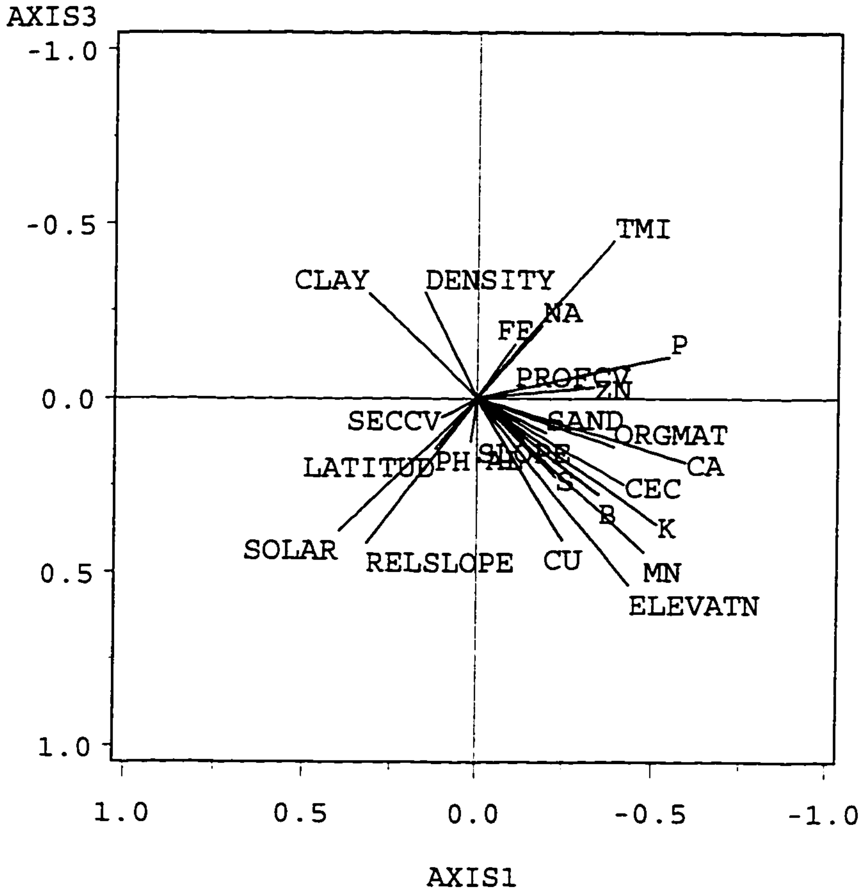
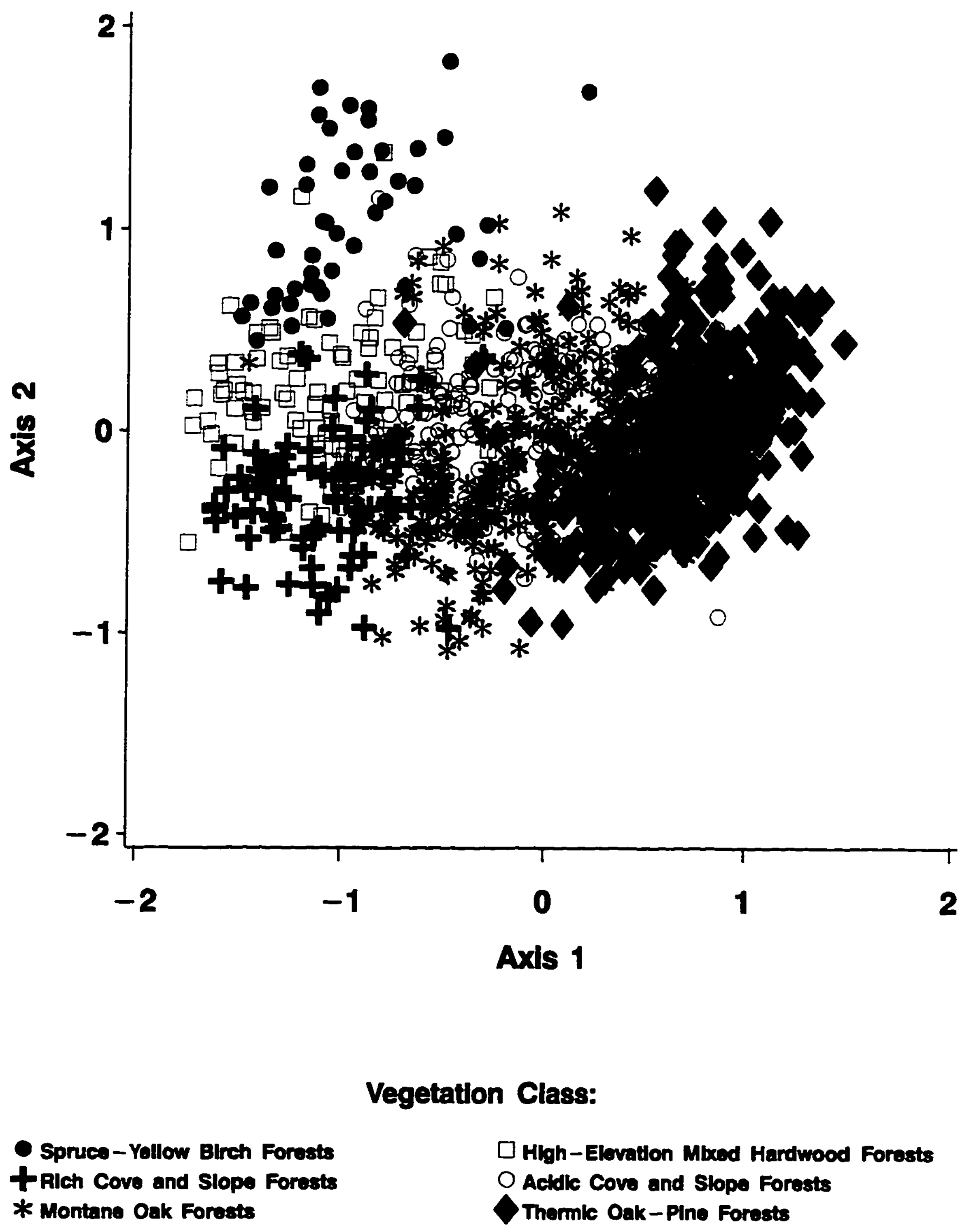


Figure 6.48. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of the six landscapes south of the Asheville Basin showing association between species composition and major environmental gradients. PROFCV=profile curvature, SECCV=section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.49. Diagram for NMDS ordination of all nine landscapes in the regional study (the 1113 stands), showing the distribution of stands classified by the six vegetation classes on the two major compositional gradients.


2
1
0
−1
−2
Axis 2
−2
−1
0
1
2
Axis 1
Vegetation Class:
Spruce−Yellow Birch Forests
Rich Cove and Slope Forests
Montane Oak Forests
High−Elevation Mixed Hardwood Forests
Acidic Cove and Slope Forests
Thermic Oak−Pine Forests

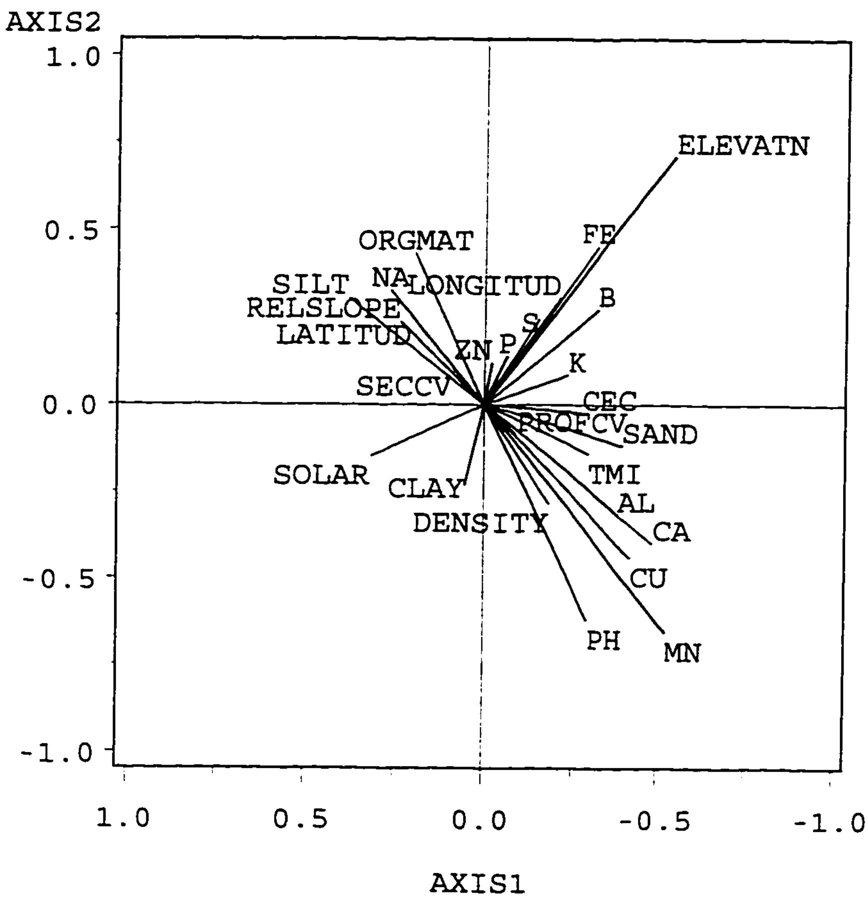


Figure 6.50. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of all nine landscapes in the regional study showing association between species composition and major environmental gradients. SECCV=section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

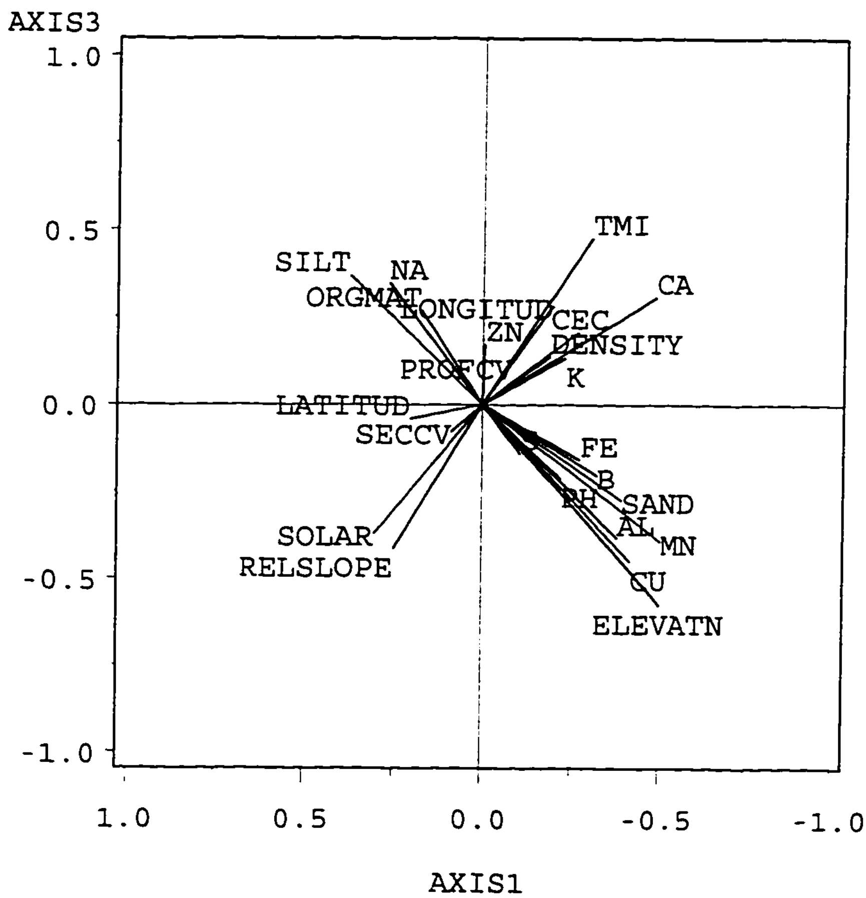
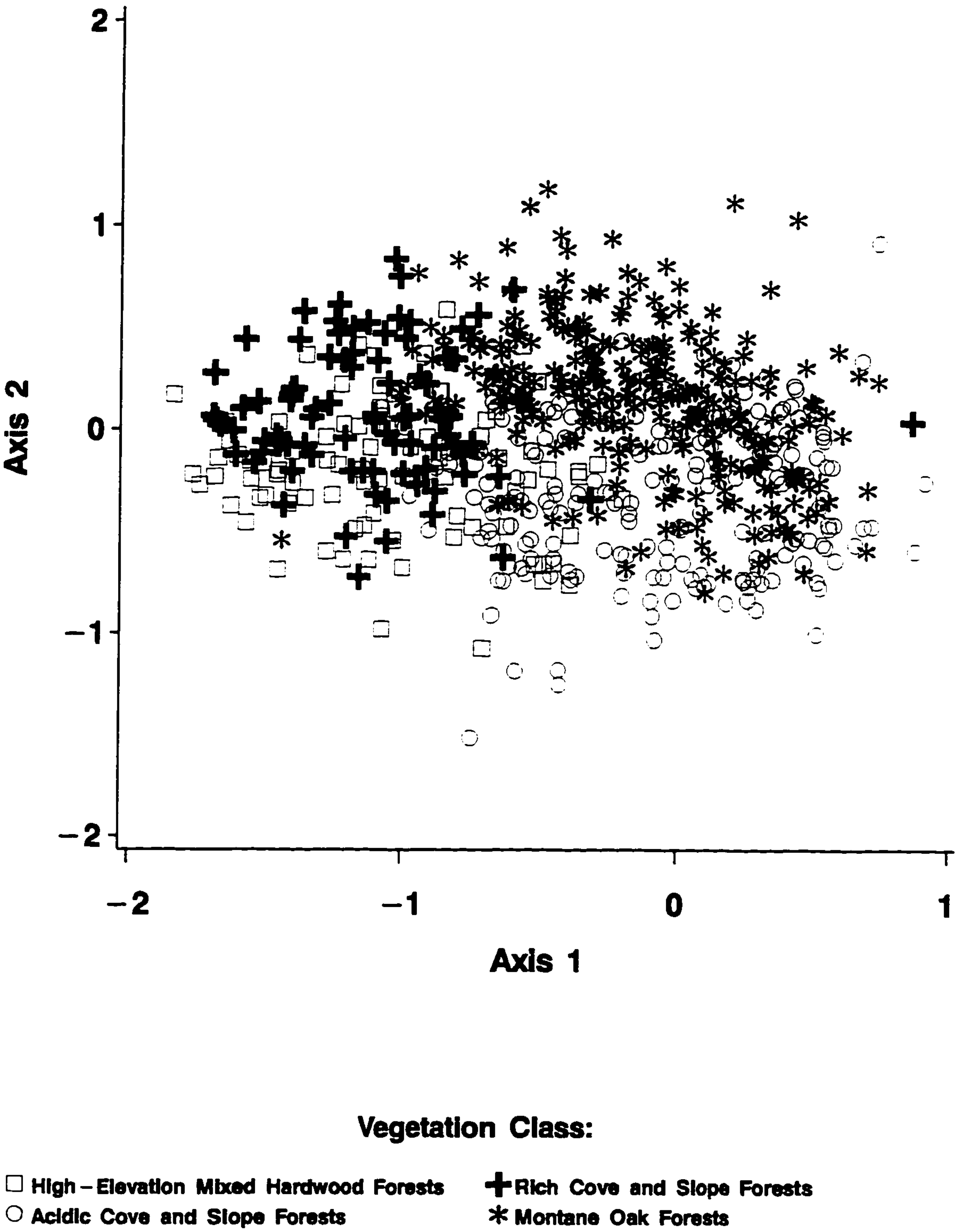


Figure 6.51. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of all nine landscapes in the regional study showing association between species composition and major environmental gradients. SECCV=section curvature. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Figure 6.52. Diagram for NMDS ordination of all nine landscapes with the **Spruce-Yellow Birch Forests** removed, showing the distribution of stands classified by five vegetation classes on the two major compositional gradients.


2
1
0
−1
−2
Axis 2
−2
−1
0
1
Axis 1
Vegetation Class:
High-Elevation Mixed Hardwood Forests
Acidic Cove and Slope Forests
Rich Cove and Slope Forests
Montane Oak Forests

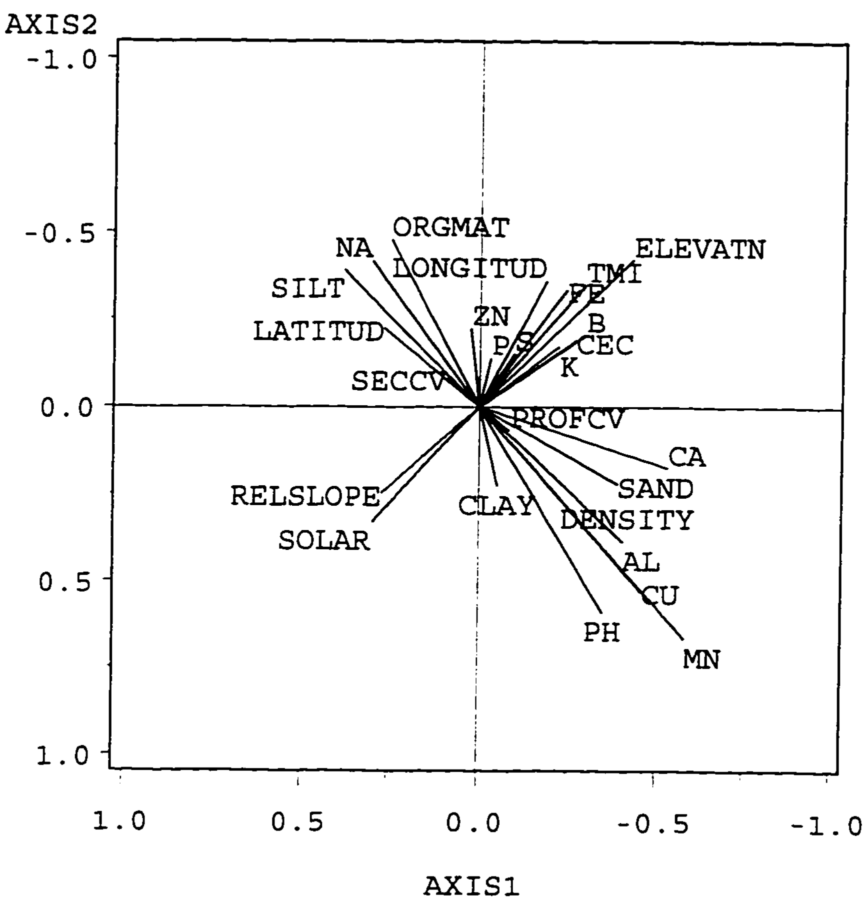


Figure 6.53. Vector diagram for Axis 1 and Axis 2 of the NMDS ordination of all nine landscapes with the **Spruce-Yellow Birch Forests** removed showing association between species composition and major environmental gradients. Low TMI values represent low site moisture potential whereas large values represent high moisture.

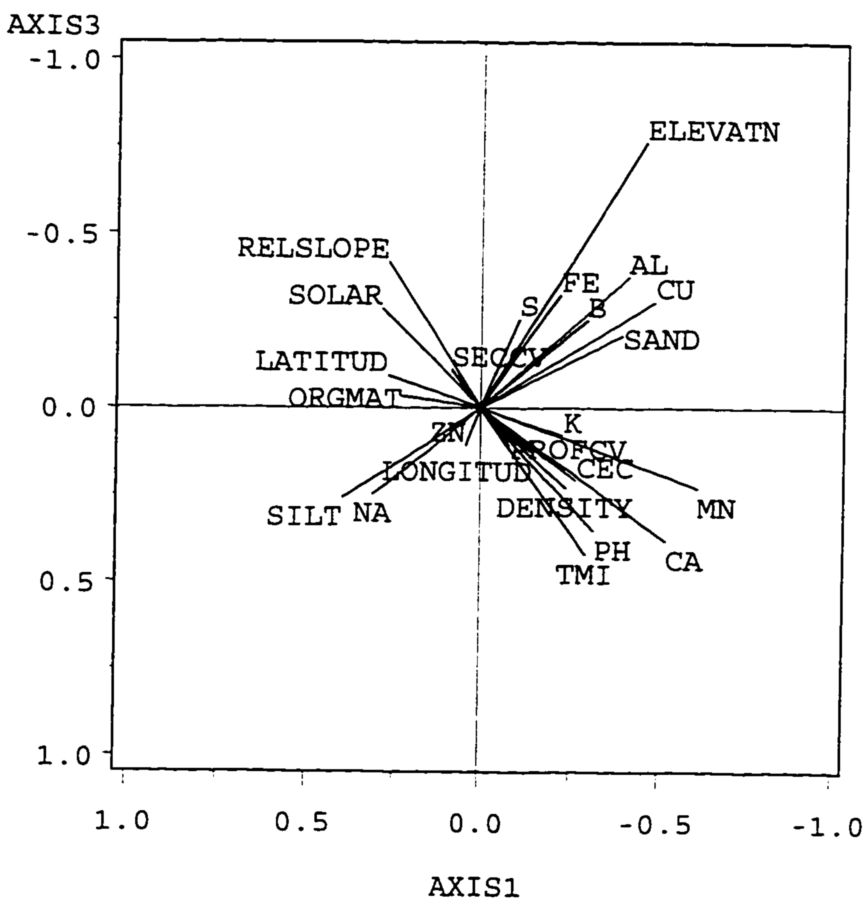


Figure 6.54. Vector diagram for Axis 1 and Axis 3 of the NMDS ordination of of all nine landscapes with the **Spruce-Yellow Birch Forests** removed showing association between species composition and major environmental gradients. Low TMI values represent low site moisture potential whereas large values represent high moisture.

Mn and Ca) gradients (Figures 6.46-6.48). Stands are also distributed by topographic position (TMI, relative slope position, solar radiation). Soil texture has a weaker association with vegetation composition than described in the northern subregion, which is probably an artifact of the lack of soil texture values for stands in the two Southern Escarpment landscapes.

6.7.3 Southern Appalachian region.

Across the whole 9 landscape-Southern Appalachian region, forest vegetation composition has strongest correlations with elevation and soil nutrients (Mn, pH) (Figures 6.49-6.51). Stands are also distributed by soil texture (silt) and topographic position (relative slope, TMI). The **Spruce-Yellow Birch Forests** are well separated from other vegetation classes along the elevation gradient, suggesting that this class might accentuate the strength of the correlation between regional vegetation patterns and elevation. A second NMDS ordination was performed with the **Spruce-Yellow Birch Forests** removed. With the **Spruce-Yellow Birch Forests** removed, vegetation is primarily distributed across the Southern Appalachian region along a soil nutrient (Cu, Mn, Na, pH)-soil texture (silt, organic matter) gradient (Figures 6.52-6.54). Elevation, Ca and topographic position (TMI, relative slope position) have stronger associations with the third compositional gradient.

6.8 Discussion

6.8.1 Whittaker's Great Smoky Mountains gradient model

In 1956 Whittaker put forward a gradient model of vegetation for the Great Smoky Mountains, suggesting that the vegetation of this area was distributed primarily along gradients of elevation and topographic moisture. Using quantified information from the central and western Smoky Mountains Golden (1981) and Callaway *et al.* (1987) reaffirmed Whittaker's model for the Smoky Mountains, showing that vegetation was primarily associated with elevation and topographic position (relative slope position Golden 1981, site protection Callaway *et al.* 1987). These authors also found that vegetation had close associations with soil pH (Golden 1981, Callaway *et al.* 1987), percentage of clay in the B-horizon (Golden 1981) and water holding capacity (Callaway *et al.* 1987).

For the Smoky Mountains dataset used in my regional study, 75 of the plots used in the Callaway study are combined with an additional 32 plots. This enables both a direct comparison with Callaway *et al.* (1987) and the ability to use this dataset as the 'standard' Whittaker model for comparisons with the other landscapes in this regional study. It must, however, be noted that Whittaker's study was undertaken in the vicinity of the central Smokies. Although the watersheds that he sampled are known, the exact locations of his plot sites will never be identified. This present study differs from the Callaway *et al.* (1987) dataset by the use a broader range of quantified topographic information and much more detailed soil information for over half the stands. Stands lacking detailed soil variables use the pH and texture values calculated by R. Callaway.

My Smoky Mountain analyses reaffirm the validity of Whittaker's (1956) gradient model, identifying elevation and topographic moisture (represented by the topographic moisture index and relative slope position) as the two environmental gradients most closely associated with vegetation composition (Figures 6.17-6.19). This study concurs with the findings of Golden (1981) and Callaway *et al.* (1987) by identifying soil characteristics as the third environmental gradient upon which vegetation is distributed. However, by using a broad range of soil nutrients, this present study has shown that vegetation in the Smoky Mountains has stronger associations with Mn, cation exchange capacity, Fe and Ca than with pH and soil texture that were identified by Golden (1981) and Callaway *et al.* (1987) as key variables.

6.8.2 Comparisons with the Great Smoky Mountains gradient model

Patterns in the three high-elevations landscapes (Black Mountains, Grandfather Mountain, Shining Rock) broadly follow Whittaker's model. In all three landscapes, elevation has strongest associations with vegetation composition (Figures 6.2-6.10). Associations between vegetation, topographic position and soil nutrients differ subtly from the 'standard' Smoky Mountain landscape. Topographic position has a stronger correspondence with vegetation composition in the Smoky Mountains than soil nutrients. However, soil nutrients have stronger correlations with vegetation than topographic characteristics in the three high-elevation landscapes.

The strength of the association between vegetation and topography in the Smoky Mountains analysis might be an artifact of the fact that only half the plots in this dataset have the full complement of soil nutrients. However, these plots are well distributed in ordination space across both the elevation and topographic position gradients. Miller (1986) suggested that the Smoky Mountains subregion is topographically more complex than other areas of the Southern Appalachian Mountain region. High topographic complexity in the Smoky Mountains might account for the stronger associations between vegetation and topographic position observed in this study in comparison to both the three high-elevation and two mid-elevation landscapes.

The two comparative mid-elevation landscapes (Joyce Kilmer, the Nantahala Mountains) broadly follow Whittaker's model. In concordance with the high-elevation landscapes used in this study, soil nutrients have a stronger association with vegetation composition than topographic characteristics. However, in these two mid-elevation landscapes the strength of the relationship between vegetation and elevation is reduced in comparison to the three high-elevation landscapes.

The three low-elevation landscapes do not follow the model described by Whittaker or the patterns observed in mid- and high-elevation landscapes in this study. In Linville Gorge, the Chattooga River and the Thompson River, vegetation composition is strongly correlated with soil nutrient and topographic position gradients. Associations between vegetation and elevation are much weaker in these landscapes than those observed in the mid- and high-elevation landscapes.

The three low-elevation landscapes have smaller elevational ranges than most other study areas (study areas have elevational ranges from 849 m at Linville Gorge to 1379 m at Grandfather Mountain), which might account for the limited association between vegetation and elevation. However, at Shining Rock, where elevation is the major environmental gradient associated with vegetation, stands are distributed across a shorter elevational range

(879 m) than the two Escarpment landscapes (975 m Chattooga River, 963 m Thompson River). Moreover, at Joyce Kilmer, which has the second broadest elevational range (1200 m), elevation is only strongly correlated with vegetation composition on the third compositional axis.

The results of this regional study suggest that the strength of associations between elevation (and the factors associated with this complex environmental gradient) and vegetation composition are dependent upon the position of a landscape on the overall regional elevation gradient. There is a general weakening of the association between vegetation and elevation with decreasing landscape position on the regional elevation gradient.

Differences in the relationship between elevation and vegetation composition in the low-elevation landscapes and those in the mid- and high-elevation landscapes are consistent with the hypothesis put forward in Chapter 3 that vegetation inhabiting mid- and lower-elevation areas is influenced more by topographic and soil gradients than vegetation of high-elevation areas. I predict that the more highly dissected topography of mid- and low-elevation landscapes is influenced by a broader range of topographic and soil conditions (e.g., a gradient from highly exposed, xeric, infertile ridges to sheltered, nutrient-rich coves) than high-elevation landscapes, where such differences will be more subtle due to less dissected topography and the more exposed conditions associated with these sites. Such sites tend to have thin soils and soils of limited development. Where such subtleties exist at high-elevations, I predict that elevation appears to override other environmental gradients and have primary influence on vegetation. This contrasts with mid- and low-elevation landscapes where more dramatic landform differences heighten topographic and soil extremes, seemingly overriding the overlying elevation gradient.

This study shows strong associations between vegetation and soil texture. This relationship previously has only been documented in a few studies of Southern Appalachian vegetation (e.g., Mowbray and Oosting 1968, Golden 1981, Chapter 3). Soil texture is associated with both regional and landscape-scale vegetation patterns. The association between vegetation and soil texture is not consistent between landscapes. In at least some landscapes, textural differences correspond with differences in the underlying bedrock (e.g., Linville Gorge, Chapter 3). Associations between vegetation and soil texture differ between the high- and mid-elevation landscapes. Strong correlations between soil texture (silt, clay, soil density) and vegetation have been documented in 2 of the 3 mid-elevation landscapes (Figures 6.25-6.30). However, the same pattern was not observed in three high-elevation landscapes where soil texture was quantified (not available for the Black Mountains). Strong correlations between vegetation and soil texture at Linville Gorge suggest that texture may be important in low-elevation landscapes. However, the generality of this relationship can not be examined because textural information was not available for the two low-elevation Escarpment landscapes. The lack of a significant relationship between soil texture and vegetation in high-elevation landscapes suggests that the textural differences between underlying geologic substrates in high-elevation landscapes are more subtle than those quantified at Linville Gorge, the Nantahalas and Joyce Kilmer. Alternatively, following on from my hypothesis in Chapter 3, broader-scale factors associated with changes in elevation may override subtle fine-scale differences in soil texture at high-elevations.

The relationship between vegetation composition and topographic position or moisture is consistent across all nine landscapes. The topographic characteristics; topographic moisture index, relative slope position and solar radiation had consistently strongest associations with vegetation composition. Strong relationships between vegetation and topographic-moisture have been well documented in past Southern Appalachian studies (e.g., Whittaker 1956, DeLapp 1978, McLeod 1988, Busing *et al.* 1993), although only a small portion of these studies used quantitative topographic information (e.g., Callaway *et al.* 1987, Fels 1994, Patterson 1994, Wilds 1996).

The association between vegetation and soil nutrients has been inferred in past Southern Appalachian Mountain studies and documented in a limited number of cases (e.g., McLeod 1988, Patterson 1994, Wiser *et al.* 1996). This present study demonstrates the consistency of this relationship in landscapes across the Southern Appalachian Mountains. My results also show the consistency of specific soil variables that are most strongly correlated with vegetation composition. Ca, cation exchange capacity, Mn and pH have strongest associations with vegetation composition in most landscapes.

The close association between pH, Ca and cation exchange capacity and their representation as predictors of soil fertility follows well-accepted patterns (e.g., Brady 1974). However, the identification of Mn as a strong predictor of soil fertility contrasts with accepted ideas. Mn is generally thought to be negatively correlated with pH. Mn, Fe and Al are known to precipitate readily in acidic soils (Collins & Buol 1970, Brady 1974, Tan 1993). In this study Fe and Al levels decrease with rising elevation, corresponding to the generally accepted pattern. Fe and Al have stronger associations with vegetation patterns in high- and mid-elevation landscapes. However, within the pH range of this study, Mn is positively correlated with pH and factors associated soil fertility. High correlations between vegetation and Mn have been documented in other Southern Appalachian forest studies (e.g., DeLapp 1978, Graves & Monk 1985, McLeod 1988, Patterson 1994, Chapters 3-5; also see Zobel 1969) and forests in the North Carolina Piedmont (Palmer 1990) and Sandhills of North and South Carolina (R.P. Duncan & R.K. Peet *unpub. data*). Correlations between the topographic moisture index, relative slope position and Mn suggest that the availability of this variable is at least partly associated with soil moisture.

6.8.3 Consistency of vegetation distribution within the standardized gradient framework

Most past vegetation studies in the Southern Appalachian Mountains have used Whittaker's (1956) two-dimensional model, with vegetation distributed by elevation and topographic moisture, as the standard framework for comparing vegetation distribution within individual landscapes in this region. However, strong correlations between vegetation composition and soil nutrients demonstrated in this study (Chapters 4-6) and recent past studies (e.g., McLeod 1988, Patterson 1994, Wiser *et al.* 1996) point to the incompleteness of Whittaker's model. The three-dimensional model used in this study, which employs Whittaker-type gradient models under three nutrient regimes, is an attempt to include soil fertility in the gradient framework.

Past discussions of vegetation patterns in the Southern Appalachian Mountains have mostly been limited to an individual landscape (but see Newell *et al. in press*). Although gradient diagrams have been used in the past individual studies, these have not used a consistent method of quantifying topographic moisture, limiting any ability to place these studies in context with one another. This present study provides a standard framework for comparing vegetation patterns in nine landscapes, which collectively represent much of the topographic, climatic and geologic complexity of this region.

This analysis uses coarser-scale vegetation groups than Whittaker's (1956) model. However, comparisons show noteworthy differences between the two studies. At the Black Mountains and Grandfather Mountain, the two high-elevation vegetation classes have greater abundance on mid- and low-nutrient sites, corresponding to the well-documented trend of decreasing soil fertility with rising elevation. In both landscapes stands with highest elevation position are present on low-nutrient sites (Figures 6.2, 6.3). The distribution of these two vegetation classes at Shining Rock deviates from the pattern described above, with the **Spruce-Yellow Birch Forests** most abundant on mid- and low-nutrient sites and the **High-Elevation Mixed Hardwood Forests** predominantly found on sites with mid- and high-nutrients. Deviations from the pattern observed in the former two studies are not obvious. The lasting effects of past intense logging and subsequent fire at Shining Rock are a plausible explanation.

This study reaffirms the position of the **Rich Cove and Slope Forests** on nutrient-rich soils. In all mid- and high-elevation landscapes, this class has highest abundance on high-nutrient soils and is virtually absent from infertile sites. This class has typically been associated with lower-slopes and coves (e.g., Whittaker 1956, Golden 1981, Schafale & Weakley 1990). In the mid-elevation landscapes and 2 of the 3 high-elevation landscapes, my results concur with the accepted distribution. However, the distribution of this class across a broad range of topographic positions in the Shining Rock landscape contrasts to the general pattern. Past anthropogenic disturbance may be a contributing factor to the broader **Rich Cove and Slope Forests** distribution at Shining Rock.

Although past landscape studies have described the presence of **<u>Rich</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** types in two of the three low-elevation landscapes (see Chapter 3, Patterson 1994), this vegetation class is conspicuously absent from these landscapes in this study. The atypical, upper-slope *Carya*-dominated stands from Linville Gorge grouped in the **<u>Montane</u> <u>Oak</u> <u>Forest</u>** class. *Liriodendron*-dominated cove and lower-slope stands in the Ellicott Rock Wilderness section of the Chattooga River grouped in the dry-cove **Liriodendron-Acer saccharum Forest** in the **<u>Montane</u> <u>Oak</u> <u>Forests</u>** class. *Tsuga canadensis*-dominated stands from both Ellicott Rock and Linville Gorge were classified in the herbaceous-dominated **Tsuga canadensis-Halesia Forest** in the **<u>Acidic</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** class. The classification of these stands in this regional study suggests that nutrient-rich coves in low-elevation landscapes are compositionally distinct from typical descriptions of **<u>Rich</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>**. This distinction has previously been suggested by Schafale and Weakley (1990) and Cooper and Hardin (1970).

The distribution of **<u>Montane</u> <u>Oak</u> <u>Forests</u>** on the nutrient gradient closely follows the pattern described for the **<u>Rich</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** in the mid- and high-elevation landscapes. In these landscapes, the **<u>Montane</u> <u>Oak</u> <u>Forests</u>** are most abundant on high-nutrient sites. This class has a consistently broad distribution on the topographic gradient in these landscapes. By contrast, this class has less consistent distribution across the three low-elevation landscapes. At Linville Gorge, the **<u>Montane</u> <u>Oak</u> <u>Forests</u>** is well distributed across the topographic gradient on both mid- and high-nutrient sites, whereas at the Thompson River, this class is mostly found in the mid-nutrient regime on sites positioned on the lower half of the topographic gradient. The **<u>Montane</u> <u>Oak</u> <u>Forests</u>** have highest, but low abundance on mid-nutrient sites in the Chattooga River.

In most landscapes the **<u>Acidic</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** are restricted to lower-slope sites with mid- and low-nutrients, corresponding to well-documented distribution patterns (e.g., Whittaker 1956, McLeod 1988, Schafale & Weakley 1990). However, in Joyce Kilmer, this class inhabits a broader range of topographic and soil fertility conditions than previous studies have documented. In this mid-elevation landscape, **<u>Acidic</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u>** stands are broadly distributed across the topographic gradient in the fertile regime. These sites are dominated by the **Tsuga canadensis-Halesia Forest**, which typically occurs on more fertile soils than other types in this vegetation class. The **Tsuga canadensis-Halesia Forest** has floristic affiliations with both the **Rich Cove and Slope Forests** and the **Montane Oak Forests**, which is suggested by its broad topographic distribution and association with fertile sites.

The **Thermic Oak-Pine Forests** show the most marked changes in distribution from mid- and high-elevation landscapes to low-elevation landscapes. In high-elevation landscapes this vegetation class is typically restricted to mid- and low-nutrient sites where it is positioned on the upper-half of the topographic moisture gradient. This class is more evenly distributed across all three nutrient regimes in the two mid-elevation landscapes, but is still typically associated with sites on the upper-half of the topographic gradient. However, in the three low-elevation landscapes, the **Thermic Oak-Pine Forests** are broadly distributed across the full topographic spectrum in all three nutrient regimes at the Thompson River and the mid- and low-nutrient regimes at Linville Gorge and the Chattooga River.

The predominance of the **Thermic Oak-Pine Forests** in the three low-elevation landscapes in part reflects the coarse-scale of my broad-scale vegetation class classification. For Linville Gorge, this also shows the limitations of a classification scheme based upon tree species. In comparison to other landscapes, Linville Gorge is dominated by a limited number of canopy species that are distributed across a wide spectrum of topographic and soil conditions. As a consequence, most stands at Linville Gorge have been lumped in the **Thermic Oak-Pine Forests** class. Dominance of the **Thermic Oak-Pine Forests** across the three low-elevation landscapes suggests the existence of a narrower vegetation gradient across each low-elevation landscape, comprising of floristically more similar stands than the vegetation gradients present in each of the mid- and high-elevation landscapes.

The **Thermic Oak-Pine Forests** have traditionally been associated with infertile, xeric ridgelines and south-facing slopes (Whittaker 1956, Racine 1966, Zobel 1969, Cooper & Hardin 1970, Schafale & Weakley 1990). These conditions correspond more closely to the Linville Gorge environment than that associated with the two high-rainfall Southern

Escarpment landscapes. Past logging may account to some extent for the dominance of this vegetation class in the latter two landscapes. However, Losche *et al.* (1970) suggest that soils on at least south-facing aspects in the Escarpment area are highly weathered, with low exchangeable cations. These authors believe that advanced soil weathering results from high soil temperatures on slopes with warm aspects. High temperatures lead to a rapid dissolution of primary minerals from the soil profile. Moreover, high precipitation levels accelerate mineral leaching from a site. Warm site conditions may play a large role in the dominance of the **Thermic Oak-Pine Forests** in the Southern Escarpment landscapes.

The study documents a broadening distribution of **Thermic Oak-Pine Forests** from high- to low-elevations. This may correspond with the changing proportion of sites within landscape with warm temperatures. In low-elevation landscapes sites with warm temperatures are found across a range of topographic positions and fertility regimes. However, in mid- and high-elevation landscapes warm conditions are restricted to ridgelines.

Few studies have documented changes in vegetation distribution across a series of landscapes (but see Allen *et al.* 1991a, Allen *et al.* 1991b). In the Rocky Mountains, changes in coarse-scale vegetation class distribution between three landscapes related to changes associated with latitude, topographic moisture and landscape differences in the soil substrate (Allen *et al.* 1991a). Similarly, in New Zealand, Allen *et al.* (1991b) documented a decline in the mean elevation position of floristically similar stands with increasing latitude. They described deviations from this pattern relating to differences in the underlying geologic substrate. Both studies span a broader latitudinal range than my Southern Appalachian study, which might account for stronger associations between vegetation composition and latitude.

6.8.4 Consistency of vegetation composition across the Southern Appalachian region

Community composition within individual landscapes across the Southern Appalachian Mountains has been quantified in detail (e.g., Golden 1981, Callaway *et al.* 1987, McLeod 1988, Patterson 1994, Chapters 3-5). However, there has been little attempt to aggregate this information and compare the composition of floristically similar vegetation classes from one landscape to another. This study provides a first attempt at such a comparison.

With the exception of the **Spruce-Yellow Birch Forests**, a proportion of community types in each vegetation class are geographically separated from each other. At the broadest scale, there is a reoccurring theme of community types, or groups of florisitically similar community types, separating by location north or south of the Asheville Basin. In the **Acidic Cove and Slope Forests** class, variation in rainfall and geology may explain subtle florisitic differences between the **Tsuga canadensis/Rhododendron maximum Forest**, restricted to Linville Gorge, and the **Tsuga canadensis-Betula alleghaniensis-Liriodendron/Rhododendron maximum Forest**, most abundant at Joyce Kilmer, the Black Mountains and Shining Rock (Table 6.12).

The **Thermic Oak-Pine Forests** divide in two sections, with the *Quercus montana-Pinus pungens* section mostly distributed north of the Asheville Basin and the mixed *Quercus* section found predominantly south of the Asheville Basin (Table 6.15). Differences in rainfall and underlying bedrock are two possible explanations for this separation. The *Quercus montana-Pinus pungens* section is mostly found in the low-rainfall, infertile Linville Gorge landscape, whereas the mixed *Quercus* section has highest abundance in the high-rainfall Southern Escarpment landscapes. It must be noted here that vegetation analogous to the **Pinus pungens/Kalmia/Galax Forest** has been described in the Escarpment area (described in most detail by Racine 1966, but also see Rodgers 1965, Zobel 1969, Cooper & Hardin 1970), however this community types has extremely restricted distribution, centered on exposed, comparatively high-elevation ridges in Horsepasture Gorge (Racine 1966, Cooper & Hardin 1970). *Pinus pungens* tends to dominate warm, dry, infertile sites with shallow soils (Zobel 1969). Racine (1966) attributes lack of *Pinus*-dominated ridges in the Escarpment region partly to lack of suitable, steep and exposed south-facing ridgelines. Losche *et al.* (1970), documented the existence of deep soils on south-facing slopes in the Thompson River (also see Cooper & Hardin 1970). The presence of deep soils on slopes with aspects typically associated *Pinus pungens* might partly explain the limited distribution of this species. In contrast, dry, infertile and thin soils are widespread across the finely dissected and steep landscape of Linville Gorge. These site differences suggest that topographic characteristics perhaps accentuate differences in *Pinus pungens* distribution that are attributable to differences in underlying geology.

Community types dominated by *Pinus rigida* have also been described in the Southern Escarpment area (see Racine 1966, Cooper & Hardin 1970, DuMond 1970). These types lack *Pinus pungens* present in the **Pinus rigida-Pinus virginiana-Pinus pungens/Kalmia Forest**, described in this study and are probably embedded in the **Quercus montana-Quercus coccinea-Pinus strobus-Pinus rigida Forest**. Racine (1966) described a broad intergrading between *Pinus rigida-*, *P. virginiana-* and *P. echinata-*dominated and *Quercus coccinea-* and *Q. montana*-dominated community types which provides evidence to support the type identified in this study. Racine (1966) contrasted the xeric *Pinus-* and *Quercus*-dominated community type in Thompson River with those in the Smoky Mountains. Excluding high-elevations, Racine suggested that in the Escarpment type, the evergreen shrub component, typically associated with the **Thermic Oak-Pine Forests** in the Southern Appalachians, is replaced by deciduous species. The results of my study suggest that this observation is more widespread in low-elevation areas of landscapes south of the Asheville Basin. Despite the presence of *Kalmia* is some types in the mixed *Quercus* section, *Rhododendron* species are virtually absent from this section and small trees such as *Cornus florida* and *Sassafras albidum* are consistent understory components (Table 6.15). The deciduous *Gaylussacia ursina* is a dominant shrub species in some types.

This study has documented closer floristic association of stands from Shining Rock with community types typically dominant in landscapes north of the Asheville Basin. The close proximity of Shining Rock to the Asheville Basin may account for this. Other landscapes south of the Asheville Basin have more southerly or southwest locations adjacent to the high-rainfall Escarpment Front or the Smoky Mountains.

Florisitic differences north and south of the Asheville Basin has been noted by other researchers (e.g., Weakley 1997, Weakley *unpub. data,* also see Radford *et al.* 1968). The dry conditions associated with the Asheville Basin may provide a barrier for plant species dispersal. Alternatively, historic events, such as post-Pleistocene warming may have isolated species in specific subsections of the Southern Appalachians (e.g., see Ramseur 1960, Wiser 1994). This hypothesis, however, probably only explains the distribution of a limited number of present-day spatially restricted species in the Southern Appalachian Mountains. There are also climatic differences between the two subregions. In the northern subregion, high-rainfall is predominantly associated with the high-elevation peaks and there is a sharp decrease along the rainfall gradient to adjacent low-elevation areas. In contrast, in the subregion south of the Asheville Basin, changes in rainfall are much more gradual, with high-rainfall more evenly distributed across landforms of all elevations.

This study has shown that a proportion of individual community types in each vegetation class are more-or-less restricted to a single landscape or to geographically close landscapes. A similar pattern was observed in the three landscape-study in the Rocky Mountains (Allen *et al.* 1991a). In that study, the restriction of community types to single localities related to latitudinal limits of specific species ranges, differences in soil conditions between individual landscapes and the loss of low-elevation community types present at lower latitudes in landscapes at higher latitudes. The smaller latitudinal range of Southern Appalachian regional study probably reduces the validity of latitude as an explanation for inconsistent species distributions. Differences in underlying geology and rainfall are probably the major contributing factors, although the position of the Escarpment landscapes coincides with the southern limits of several species (e.g., *Acer saccharum* and *Betula alleghaniensis*; see Radford *et al.* 1965, Radford *et al.* 1968) which may account in part for compositional differences between the Escarpment landscapes and other landscapes in this study. It should be noted that not all community types within a specific vegetation class are separated geographically. These types often are distributed in close proximity to one another, separated by fine-scale topographic and soil fertility differences.

Allen *et al.* (1991a) observed differences in landscape-level compositional variation between high- and lower-elevation vegetation classes and found that the subalpine forest class was the only vegetation class consistent across all three landscapes. They showed that high-elevation vegetation was floristically more similar between landscapes than lower-elevation vegetation classes. The **<u>High-Elevation Mixed Hardwoods Forests</u>** show a similar pattern across the mid- and high-elevation landscapes in this Southern Appalachian Mountains regional study. Community types in this vegetation class are more evenly distributed between the 6 landscapes than vegetation classes that dominate mid- and low-elevations. Differences in the upper elevational limits of the three high-elevation landscapes with **<u>Spruce-Yellow Birch Forests</u>** and landscape-level differences in successional stage of stands in this class make it difficult to make similar comparisons.

6.8.5 <u>Factors that account for variation in vegetation patterns across the Southern Appalachian region</u>

The results of this study show that soil nutrients and factors associated with topographic position are consistently strongly correlated with vegetation composition across the three scales (landscape, sub-regional, regional) examined in this regional study. However, elevation, which has traditionally been considered to have a close association with variation in vegetation composition, has a less consistent relationship. Elevation is strongly correlated with vegetation patterns at both the regional and sub-regional scales. However, this association varies at the landscape-scale, dependent upon the position of a respective landscape on the regional elevation gradient. This study quantifies a weakening association between vegetation and elevation with a decreasing position on the regional elevation gradient, from high-elevation landscapes to low-elevation landscapes.

Differences in subregional-scale vegetation patterns correspond with variation in broad-scale environmental gradients across the Southern Appalachian Mountains. For stands north of the Asheville Basin, associations between latitude and vegetation composition (Figures 6.43-6.45) correspond with changes in rainfall levels and distance from rainfall source areas. In this subregion, high-rainfall is predominantly associated with the high-elevation peaks, whereas it drops sharply to surrounding low-elevation areas (Table 1.2). In contrast, high-rainfall is widespread across landforms of all elevations in the area south of the Asheville Basin. In the southern subregion compositional differences correspond with subtle changes in topographic-moisture (Figures 6.46-6.48).

Regional differences in latitude also suggest that landscapes south of the Asheville Basin experience warmer temperatures than areas of the same elevation north of the Asheville Basin. However, the environmental variables used in this study were not able to quantify this probable trend. Latitudinal changes in temperature contrast with the finer-scale temperature changes associated with changes in elevation position within a landscape.

Although not quantified in this study, my results suggest that subregional differences in underlying parent material also increase geographic variation in the distribution of species. This, in part, explains compositional differences between Linville Gorge and the two Southern Escarpment landscapes, although differences in other environmental factors and disturbance history probably also greatly contribute to variation in vegetation composition. Strong correlations between regional-scale vegetation composition and soil texture perhaps correspond with broad-scale differences in underlying geologic substrate.

Geographic proximity may also account for variation in composition across the region. For example, the two Southern Escarpment landscapes support species, such as *Pinus echinata* that are typically associated with piedmont vegetation. Racine (1966) noted that the Thompson River contrasted with other Escarpment gorges by having higher elevational limits of Piedmont species such as *P. echinata*, *P. virginiana*, *Quercus stellata*, *Q. marilandica* and *Q. falcata*. He attributed this to the closer proximity of this landscape to the Piedmont and greater distance from the Blue Ridge Divide in comparison to other Southern Escarpment landscapes. The Chattooga and Thompson also contain communities that have close association with upper-Piedmont areas in South Carolina and Georgia (see The Nature Conservancy Ecology Working Group 1996). Racine (1966) noted close associations between the shortleaf pine-oak association in the Thompson River and oak-hickory forests of the upper-Piedmont. However, piedmont species are virtually absent from Linville Gorge, which also is located adjacent to the Piedmont. The abrupt topographic rise from the Piedmont to the eastern ridge of Linville Gorge contrasts with the more gentle transition through a series of rolling hills in the upper-Piedmont to the low-mountain Southern Escarpment landscapes. The gentler topographic transition most likely provides a less abrupt change in environmental conditions between piedmont and mountain landscapes and creates a broader piedmont-mountain species ecotone. However, it must also be noted that differences in the disturbance regime between the Escarpment landscapes and Linville Gorge may also account for compositional differences. This is described below.

Finer-scale, landscape-level differences in past disturbance history also influence the consistency of vegetation composition and distribution between landscapes. The presence of piedmont species in Southern Escarpment community types may partly result from disturbances associated with past logging and associated fire. Canopy opening, caused by a disturbance such as logging, leads to a drying of understory conditions (see Woods & Shanks 1959). More xeric conditions would provide suitable colonization sites for species associated with warmer temperatures. At Shining Rock less distinct vegetation class separation on the major environmental gradients, in comparison to other high-elevation landscapes, may be an artifact of the broad-scale logging and intense firing that took place in the Shining Rock landscape earlier this century.

The patterns of most vegetation classes present in Shining Rock contrast to general trends observed across the other mid- and high-elevation landscapes. Both the **Montane Oak Forests** and the **High-Elevation Mixed Hardwood Forests** occur at higher-elevations than in other landscapes. Similarly, stands within the **High-Elevation Mixed Hardwood Forests** and the **Thermic Oak-Pine Forests** inhabit soils with higher nutrient status than observed in other landscapes of similar elevation. The broad topographic range of the **Rich Cove and Slope Forests** contrasts markedly to other landscapes (Figure 6.33). The links between these aberrations and disturbance by logging and intense fire are more tenuous than those associated with broad compositional overlap between vegetation classes, however there are no other striking differences that set Shining Rock apart from other Southern Appalachian landscapes.

Landscape-scale differences in environmental conditions also account for variation in vegetation composition. Topographic characteristics, such as slope position and associated site moisture influence the distribution of specific vegetation classes and community types. Similarly, the distribution of vegetation also corresponds with fine-scale differences in soil fertility.

The environmental factors associated with regional-scale vegetation patterns in this study contrast to those observed in other studies. Contrasting results may relate in part to differences in the environmental characteristics used in these analyses and to broad variation in the topographic complexity of the regions described. Environmental factors associated with vegetation in regions of Australia dominated by subdued topography are not consistent across this continent. In southwestern Australia, Griffin *et al.* (1983) found strongest correlations between solar radiation, latitude and the composition of shrublands. This study did not include any detailed soil information. Both Fensham (1995) and Russell-Smith (1991) used pH and soil textural information in their regional analyses. For dry inland rainforests in North Queensland, Australia, Fensham (1995) identified strongest associations between vegetation composition, latitude, the coefficient of variation of monthly precipitation. These patterns were also significantly, but weakly correlated with soil rockiness, texture and pH. In contrast, for monsoon rainforests in the Northern Territories in northern Australia, Russell-Smith (1991) documented strong associations between vegetation composition, soil moisture availability, depth of the soil organic layer, texture of the subsoil, rainfall and elevation.

Mountainous regions have a complex, multidimensional structure in comparison to the comparatively simple subdued topography of landscapes such as Australia. In New Zealand researchers have shown that forest composition across the central North Island region related primarily to temperature and solar radiation, with secondary associations with rainfall, topography and drainage (Leathwick & Mitchell 1992, Leathwick 1995). However, whereas these analyses included quantified rainfall and temperature information absent from my study, they did not use detailed soil information. In a larger-scale analysis of forest vegetation across Finland, the major compositional gradients related to site fertility (subjectively measured on a 1 to 8 scale), with secondary compositional variation relating to latitude (Tonteri *et al.* 1990). In a highly mountainous, but dry region within Tibet, Chang & Gauch (1986) found that vegetation composition was most strongly associated with elevation and climatic characteristics (mean annual temperature, warmest and coldest monthly temperatures, moisture and coldness indices), with secondary compositional variation correlated with soil organic matter and pH. The results of these comparative studies demonstrate the variability of associations between vegetation and environmental factors in different regions of the world and the difficulties of comparing information from one region with another without a standard set of environmental explanatory variables.

Ecological theory has suggested that environmental processes associated with vegetation patterns change with spatial scale of observation (e.g., Allen & Starr 1982, Wiens 1989, Levin 1992). Recent studies have quantified changes in the association between specific environmental factors and vegetation composition with respect to spatial scale (e.g., Palmer 1990, Bian & Walsh 1993, Reed *et al.* 1993, Wiser *et al.* 1996). The study by Wiser *et al.* (1996) was undertaken in the Southern Appalachians and provides an interesting comparison with the results of this present study.

Wiser *et al.* (1996) found that high-elevation rock outcrops communities were distributed across the Southern Appalachian region primarily by elevation, topographic characteristics (topographic position, degree of rock fracture) and geographic location (position along the southeast-northwest axis of the mountains), with secondary correlations between vegetation, geologic substrate and soil nutrients. However, at a smaller spatial, with stands separated by individual bedrock types across this region, they found that soil nutrients typically had stronger associations with vegetation composition. Their observations contrast with those documented in the present study, where elevation, soil nutrients and topographic position have been shown to have consistently strongest association with vegetation patterns at the regional- and subregional-scales, with the latter 2 factors also consistently highly correlated with vegetation at the landscape-scale.

Rock outcrops are typically restricted to upper-slopes and infertile sites (Wiser *et al.* 1996) and persist in an environment where variation in vegetation corresponds with subtle differences in rainfall, temperature, soil fertility and topographic characteristics. By contrast, Southern Appalachian forest vegetation is distributed across much broader, coarser-scale elevational, topographic and soil nutrient gradients. The strength of environmental factors associated with vegetation gradients may be such that they have an overriding influence across a wide range of spatial scales. Alternatively, these environmental gradients may correspond with different specific environmental factors at different spatial scales. For example, at the landscape-scale, differences in soil nutrient levels probably correspond with fine-scale topographic differences in slope position, site orientation and angle, whereas at the regional-scale, variation in soil nutrients may relate to broad-scale geographic variation in underlying bedrock. My analyses of individual vegetation classes, described in Chapters 3 to 5, suggest a greater change in the factors associated with vegetation patterns at scales smaller than the landscape-scale. At the scale of an individual vegetation class, subtle compositional differences between these floristically similar stands were associated with fine-scale differences in topography, such as slope profile curvature, rather than larger-scale topography characteristics represented by relative slope position and solar radiation.

This study lacks quantified rainfall and temperature data, which are perhaps more likely to correspond with subregional- and regional-scale variation. The subregional analyses in this study suggest the presence of different rainfall regimes north and south of the Asheville Basin. However, the complexity of rainfall patterns in this mountainous region are such that the significance of this gradient may be obscured if examined at only the broader regional-scale. It is also possible that broad-scale differences in temperature may be difficult to tease apart from small-scale variation associated with changes in elevation. The complexities of regional- and subregional-scale rainfall, topographic and geologic gradients across the Southern Appalachian region may be so marked across the Southern Appalachian region that the variability within these gradients seemingly cancels out any general, large-scale patterns. If this is the case, the degree of variability within large-scale environmental processes suggests that environmental factors that have consistent and strong correlations with smaller, landscape-scale vegetation patterns, may override large-scale environmental processes and appear to have strong associations with vegetation at larger spatial scales.

6.9 Conclusions

The gradient model put forward by Whittaker (1956) provides a conceptual starting point for regional vegetation comparisons. Using vegetation information from landscapes that represent much of the climatic, elevational, geologic and topographic diversity of this region, in conjunction with quantified topographic information and soil information, I have shown that vegetation patterns across the Southern Appalachian region are more complex than suggested by Whittaker. My results reaffirm the consistency across the region of associations between topographic characteristics and vegetation composition documented by Whittaker and other researchers. This study quantifies the importance of soil nutrients as a third gradient (missing from Whittaker's two-dimensional model) and demonstrates the widespread association between soil nutrients and vegetation composition across the Southern Appalachian region. The relationship between vegetation and elevation is more complex than Whittaker and previous researchers quantifying single landscapes have perceived. My results document a decreasing association between vegetation composition and elevation from high-elevation landscapes to low-elevation landscapes. This emphasizes the importance of regional studies to place landscape studies in context with one another.

This study has also shown the importance of collectively analyzing vegetation-environment patterns at landscape-, subregional- and regional-scales. Although correlations between soil nutrients and topography are consistently strong across these three scales, there are subtle changes in the strength of associations between vegetation and specific environmental factors at different spatial scales. For example, climatic differences that correspond with subregional-scale differences in vegetation composition, are not a strongly associated with composition at the scale of an individual landscape.

This study has also shown variation in the distribution and composition of vegetation groups across the Southern Appalachian region. Coarse-scale differences in vegetation class distribution are greatest between the collective 6 mid- and high-elevation landscape group and the low-elevation landscape group. Such variation corresponds mostly with differences in the environmental conditions of landscapes with different positions on the regional elevation gradient. However, within this broad elevational framework, in landscapes with similar elevation, variation in the composition of individual vegetation classes corresponds with differences in the past disturbance regime, small-scale geologic variability and geographic position north or south of the Asheville Basin.

Variation in species composition in the Southern Appalachian region and the relationship with associated environmental gradients is complex and multidimensional. This study provides a regional framework within which individual landscapes can be placed and the complexities of this region can begin to be examined. Differences in the associations between landscape-scale vegetation patterns and environmental gradients stress the importance of placing individual landscapes within a regional context. Moreover, the variability within major environmental gradients across the Southern Appalachian region highlights the need to examine vegetation-environment relationships across a range of spatial scales to fully understand the factors associated with geographic variation in the distribution of vegetation across this region.

Appendix 1. Linville Gorge Wilderness community classification showing sample plot numbers present in each vegetation class and associated community types. Total plot site number for each group is given in parentheses. Synonymy between the Linville Gorge Wilderness classification and Alliances and Associations in The Nature Conservancy classification (TNC; The Nature Conservancy Ecology Working Group 1996) are provided. Association reference numbers are given. ** represents no synonymous Alliance in current TNC classification. *** represents no synonymous Association in current TNC classification.

1. <u>Rock Outcrops</u> (15)

1.1 Rhododendron minus/Selaginella tortipila Outcrops (11)

1.1.1 ***Rhododendron minus-Fothergilla/Leiophyllum/Selaginella tortipila sub-type***
Plots: 63, 70, 166, 167
Rhododendron carolinianum Shrubland Alliance - III.A.2.N.b.040
Rhododendron carolinianum-Fothergilla/Leiophyllum/Selaginella tortipila Shrubland ***

1.1.2 ***Rhododendron minus/Leiophyllum/Selaginella tortipila-Hypericum densiflorum sub-type***
Plots: 79, 80, 106, 107, 113
Rhododendron carolinianum Shrubland Alliance - III.A.2.N.b.040
Rhododendron carolinianum/Leiophyllum/Selaginella tortipila-Hypericum densiflorum Shrubland ***

1.1.3 ***[Selaginella tortipila-Carex umbellata sub-type]***
Plots: 18,19
Selaginella tortipila Herbaeous Alliance - V.B.2.N.b.060
Selaginella tortipila-Carex umbellata Herbaceous Vegetation ***

1.2 [Cheilanthes tomentosa-Danthonia spicata Outcrops] (1)
Plots: 118
Cheilanthes tomentosa-Danthonia spicata Alliance V.B.2.N.b.??? **

1.3 Selaginella tortipila Outcrops (3)
Plots: 179, 180, 181
Selaginella tortipila Herbacous Alliance - V.B.2.N.b.060
Selaginella tortipila Herbaceous Vegetation ***

2. **Xeric Evergreen Forests** (77)

2.1 **Pinus pungens/Gaylussacia baccata-Leiophyllum Forest** (3)

Plots: 3, 40, 105

Pinus pungens-(Pinus rigida)Woodland Alliance - II.A.4.N.a.170

Pinus pungens/Gaylussacia baccata-Vaccinium pallidum Woodland CEGL007094

2.2 **Tsuga caroliniana/Rhododendron maximum Forest** (11)

Plots: 4, 34, 38, 45, 60, 87, 96, 108, 114, 135, 148

- taller forms: Tsuga caroliniana Forest Alliance - I.A.8.N.c.080

Tsuga caroliniana/Rhododendron maximum Forest CEGL007138

- shorter forms: Tsuga caroliniana Woodland Alliance - II.A.4.N.b.040

Tsuga caroliniana Woodland CEGL003632

2.3 Pinus virginiana-Pinus pungens/Kalmia Forest (15)

Plots: 29, 30, 31, 35, 36, 37, 39, 52, 53, 111, 117, 124, 126, 172, 176

Pinus virginiana Forest Alliance - I.A.8.N.b.190

Pinus virginiana/Kalmia latifolia-Vaccinium pallidum Forest CEGL007503

2.4 Pinus pungens/Kalmia Forest (19)

2.4.1 ***Pinus pungens-Quercus coccinea/Kalmia sub-type*** (12)

Plots: 27, 28, 72, 73, 120, 122, 129, 133, 157, 171, 173, 174

Pinus (rigida, pungens)-Quercus (prinus, coccinea) Forest Alliance - I.C.3.N.a.145

Pinus pungens-Quercus prinus-Quercus coccinea/Vaccinium pallidum Forest CEGL007502

2.4.2 ***Pinus pungens-Pinus strobus/Leucothoe recurva sub-type*** (7)

Plots: 24, 25, 78, 141, 155, 168, 177

Pinus pungens-(Pinus rigida)Woodland Alliance - II.A.4.N.a.170

Pinus pungens-Pinus rigida/Kalmia latifolia-Vaccinium pallidum Forest CEGL007097

2.5. **Pinus rigida-Quercus montana/Fothergilla Forest** (10)

Plots: 41, 64, 68, 69, 115, 116, 121, 152, 161, 175

Pinus (rigida-pungens)-Quercus (prinus, coccinea) Forest Alliance - I.C.3.N.A.145

Pinus rigida-Quercus prinus-Quercus coccinea/Kalmia latifolia-Vaccinium pallidum Forest CEGL007503

2.6 Quercus alba/Kalmia Forest (3)

Plots: 46, 47, 62

Quercus alba Forest Alliance - I.B.2.N.b.070

Quercus alba/Kalmia latifolia Forest CEGL007295

2.7 Quercus alba-Pinus strobus/Kalmia Forest (5)

Plots: 2, 5, 50, 55, 110

Pinus strobus-Quercus (alba, rubra, velutina) Forest Alliance - I.C.3.N.a.150

Quercus alba-Pinus strobus/Kalmia Forest ***

2.8 Quercus montana-Quercus coccinea/Kalmia Forest (5)

Plots: 23, 26, 125, 134, 144

Quercus prinus-Quercus coccinea-(Quercus velutina) Forest Alliance - I.B.2.N.a.350

Quercus prinus-Quercus coccinea/Kalmia latifolia/Galax urceolata Forest CEGL006271

2.9 Quercus montana/Galax Forest (12)

Plots: 6, 16, 33, 59, 61, 83, 85, 91, 98, 109, 154, 165

Quercus prinus Forest Alliance - I.B.2.N.a.330

Quercus montana/Galax Forest ***

3. <u>Acidic</u> <u>Cove</u> and <u>Slope</u> <u>Forests</u> (51)

3.1 Quercus montana-Acer rubrum Forest (8)

Plots: 56, 71, 84, 93, 147, 160, 163, 170

Quercus prinus Forest Alliance - I.B.2.N.a.330

Quercus prinus-Oxydendrum arboreum/(Rhododendron maximum-Kalmia latifolia Forest ***

3.2 Quercus montana-Pinus strobus/Rhododendron maximum Forest (6)

Plots: 54, 77, 90, 94, 159, 169

Pinus strobus-Quercus(coccinea,prinus) Forest Alliance - I.C.3.N.a.160

Pinus strobus-Quercus montana/(Rhododendron maximum-Kalmia latifolia) Forest ***

3.3 **Quercus montana/Rhododendron maximum-Kalmia Forest** (6)
Plots: 1, 10, 12, 22, 75, 97, 123, 136, 151,
Quercus prinus Forest Alliance - I.B.2.N.a.330
Quercus montana/Rhododendron maximum Forest ***

3.4 **Tsuga canadensis/Rhododendron maximum Forest** (18)
Plots: 7, 9, 44, 65, 66, 67, 76, 82, 86, 89, 92, 95, 99, 101, 112, 127, 128,153
Tsuga canadensis Upland Forest - I.A.8.N.c.070
Tsuga canadensis/Rhododendron maximum Forest CEGL007136

3.5 **Tsuga canadensis-Fagus/Ilex opaca Forest** (3)
Plots: 51, 137, 140
Tsuga canadensis-Liriodendron Upland Forest Alliance - I.C.3.N.a.260
Tsuga canadensis-Fagus/Ilex opaca Forest ***

4. Montane Oak Forests (16)

4.1 **Quercus montana/Oxydendrum/Cornus florida Forest** (6)
Plots: 48, 49, 119, 150, 158, 162
Quercus prinus Forest Alliance - I.B.2.N.a.330
Quercus montana/Oxydendrum/Cornus florida Forest ***

4.2 **Quercus montana/Cornus florida Forest** (3)
Plots: 57, 58, 130,
Quercus prinus Forest Alliance - I.B.2.N.a.330
Quercus montana/Cornus florida Forest ***

4.3 **Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest** (4)
Plots: 13, 17, 20, 21
Quercus prinus Forest Alliance - I.B.2.N.a.330
Quercus montana/Acer pensylvanicum-Hamamelis virginiana Forest ***

4.4 Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest (3)

Plots: 32, 42, 156

Quercus alba Forest Alliance - I.B.2.N.b.070

Quercus alba/(Thelypteris novaboracensis-Dennstaedtia punctilobula) Forest ***

5. <u>Rich Cove</u> and <u>Slope Forests</u> (8)

5.1 Carya glabra/Ageratina Forest (6)

Plots: 11, 102, 103, 104, 131, 149

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra-Carya glabra/Ageratina altissima v. roanensis Forest ***

5.2 [Liriodendron-Carya glabra Forest] (2)

Plots: 146, 164

Tsuga canadensis-Liriodendron Upland Forest Alliance - I.C.3.N.a.260

Tsuga canadensis-Liriodendron tulipifera/Rhododendron maximum/Tiarella cordifolia Forest CEGL007543

6. <u>Alluvial Forests</u> (2)

6.1 [Liquidambar Rocky Streambed Forest] (1)

Plots: 145

Liquidambar styraciflua-(Liridendron tulipifera, Acer rubrum) Temporarily Flooded Forest Alliance - I.B.2.N.d.120

Liquidambar styraciflua-Platanus occidentalis Temporarily Flooded Forest ***

6.2 [Platanus/Asimina/Microstegium Alluvial Forest] (1)

Plots: 142

Platanus occidentalis-(Liquidambar styraciflua, Liriodendron tulipifera) Forest Alliance - I.B.2.N.d.150

Platanus occidentalis-Liquidambar styraciflua/Asimina triloba Forest CEGL007340

7. <u>Rocky Streamside Shrublands</u> (2)

7.1 **[Alnus/Xanthorhiza Rocky Stream Margin]** (2)

Plots: 81, 88

Alnus serrulata Temporarily Flooded Shrubland Alliance - III.B.2.N.d.010

Alnus serrulata-Xanthorhiza simplicissmia Shrubland CEGL003895

8. <u>**Non-Alluvial Wetlands**</u> (1)

8.1 **[Scirpus cyperinus-Dulichium Temporary Pond]** (1)

Plots: 178

Scirpus cyperinus-Dulichium arundinaceum Herbaceous Alliance - V.A.5.N.k.110

Scirpus cyperinus-Dulichium arundinaceum/Sphagnum spp. Herbaceous Vegatation CEGL004134

Appendix 2. Shining Rock Wilderness community classification showing sample plot numbers present in each vegetation class and associated community types. Total plot site number for each group is given in parentheses. Randomly chosen sites are underlined. Synonymy between the Shining Rock Wilderness classification and Alliances and Associations in The Nature Conservancy classification (TNC; The Nature Conservancy Ecology Working Group 1996) are provided. Association reference numbers are given. ** represents no synonymous Alliance in current TNC classification. *** represents no synonymous Association in current TNC classification

1. <u>Rock</u> <u>Outcrops</u> (4)

1.1 Saxifraga michauxii-Danthonia compressa-Houstonia longifolia Outcrops (4)

Plots: 310, 316, 361, 383

- [Danthonia spicata-Houstonia longifolia high-elevation outcrops] form:

Saxifraga michauxii Herbaceous Alliance - V.B.2.N.b.050

Saxifraga michauxii-Carex misera-Danthonia spicata-Krigia montana Herbaceous vegetation

- [Carex biltmoreana outcrops] form:

Carex biltmoreana Herbaceous Alliance - V.A.5.N.c.025

Carex biltmoreana-Pycnanthemum spp.-Krigia montana Herbaceous Vegetation ***

- [Saxifraga michauxii seepage] form:

Saxifraga michauxii Herbaceous Alliance - V.B.2.N.b.050

Saxifraga michauxii Herbaceous Vegetation CEGL004524

2. <u>Non-Alluvial</u> <u>Wetlands</u> (4)

2.1 [Carex gynandra Wetland] (1)

Plot: 354

Carex atlantica-Solidago patula Herbaceous Alliance - V.A.5.N.m.020

Carex gynandra Herbaceous Vegetation ***

2.2 Carex ruthii Wetland (3)

Plots: 347, 459, 460

Carex atlantica-Solidago patula Herbaceous Alliance - V.A.5.N.m.020

Carex ruthii Herbaceous Vegetation ***

3. <u>Shrub Balds</u> (7)

3.1 Picea/Rhododendron catawbiense Shrubland (5)

Plots: 357, 420, 422, 423, 424

- shrubland form: Picea rubens Woodland Alliance - II.A.4.N.b.020

Picea rubens/Rhododendron catawbiense Woodland CEGL004518

- forest form: Picea rubens upland Forest Alliance - I.A.8.N.c.030.

Picea rubens/Rhododendron catawbiense Forest CEGL006163

3.2 [Rhododendron catawbiense-Pieris Shrubland] (2)

Plots: 417, 425

Rhododendron (catawniense, carolinianum)-Kalmia latifolia Shrubland Alliance - III.A.2.N.b.050

Pieris floribunda-Rhododendron catawbiense Shrubland CEGL004516

4. <u>Grasslands</u> (6)

4.1 [Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland] (2)

Plots: 418, 419

Carex pensylvanica Herbaceous Alliance - V.A.5.N.e.030

Carex pensylvanica Herbaceous Vegetation CEGL004094

4.2 Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland (3)

Plots: 352, 358, 429

Danthonia compressa Shrub Herbaceous Alliance - V.A.7.N.l.010

Rhododendron calendulaceum/Danthonia compressa Shrub Herbaceous Vegetation CEGL004242

4.3 [Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland] (1)

Plots: 385

V.B.2.N.b.??? **

5. **<u>High-Elevation</u> <u>Mixed</u> <u>Hardwood</u> <u>Forests</u>** (36)

5.1 Fagus/Carex pensylvanica Forest (3)

Plots: 353, 359, 381

Fagus grandifolia Montane Forest Alliance - I.B.2.N.b.040.

Fagus grandifolia/Carex spp. Forest CEGL006130

5.2 Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest (8)

Plots: <u>318</u>, 329, 330, 346, 356, 427, 454, 455

- earlier successional forms:

Prunus pensylvanica Forest Alliance - I.B.2.N.b.060

Prunus pensylvanica/Rubus spp. Successional Forest CEGL007293

- later successional forms:

Betula alleghaniensis Forest Alliance - I.B.2.N.b.010

Betula alleghaniensis/Ageratina altissima v. roanensis-Aster acuminatus Forest ***

5.3 Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest (4)

Plots: 382, 384, <u>411</u>, 413

Betula alleghaniensis Forest Alliance - I.B.2.N.b.010

Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest ***

5.4 Betula alleghaniensis/Ageratina-Aster acuminatus Forest (7)

Plots: 319, 360, 396, 409, 410, 412, 426

Betula alleghaniensis Forest Alliance - I.B.2.N.b.010

Betula alleghaniensis/Ageratina altissima v. roanensis-Aster acuminatus Forest ***

5.5 Quercus rubra-Picea/Carex pensylvanica Forest (5)

Plots: 414, 416, 421, 428, <u>457</u>

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra/Carex pensylvanica-Ageratina altissima v. roanensis Forest CEGL007298

5.6 Quercus rubra/Kalmia Forest (9)

5.6.1 ***Quercus rubra/Kalmia-Rhododendron catawbiense sub-type (6)***

Plots: 340, 341, 342, 387, <u>415</u>, 456

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra/(Kalmia latifolia-Rhododendron maximum)/Galax urceolata Forest CEGL007299

5.6.2 ***Quercus rubra-Betula lenta/Rhododendron minus-Rhododendron calendulaceum sub-type (3)***

Plots: <u>375</u>, 377, 389

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra/(Vaccinium simulatum-Rhododendron calendulaceum)/(Dennstaedtia punctilobula-Thelypteris noveboracensis) Forest CEGL007300

6. <u>Spruce-Fir</u> <u>Forests</u> (2)

6.1 [Picea/Dennstaedtia Forest] (2)

Plots: 355, 408

Picea rubens Upland Forest Alliance - I.A.8.N.c.030

Picea rubens/Abies fraseri/Dennstaedtia punctilobula Forest ***

7. Acidic Cove and Slope Forests (17)

7.1 Tsuga canadensis-Betula lenta/Rhododendron maximum Forest (6)

Plots: 394, 397, 431, 432, 440, 442

Tsuga canadensis-Liriodendron tulipifera Upland Forest Alliance - I.C.3.N.a.260

Tsuga canadensis-(Quercus rubra-Betula lenta)/Rhododendron maximum Forest ***

7.2 Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest (5)

Plots: 338, 369, 370, 374, 448

Tsuga canadensis-Liriodendron tulipifera Upland Forest Alliance - I.C.3.N.a.260

Tsuga canadensis-(Quercus rubra-Betula lenta)/Rhododendron maximum Forest ***

7.3 Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest (6)

Plots: 307, 308, 311, 314, 333, 444

- Magnolia fraseri-Betula lenta/Rhododendron maximum Forest form:

Magnolia fraseri-Betula lenta/Rhododendron maximum Forest - I.C.3.N.a **

Magnolia fraseri-Betula lenta/Rhododendron maximum Forest ***

- Betula lenta/Rhododendron maximum Forest form:

Betula lenta/Rhododendron maximum Forest Alliance - I.B.2.N.b **

Betula lenta/Rhododendron maximum Forest ***

- Liriodendron-Tsuga canadensis-Betula lenta/Leucothoe Forest form:

Tsuga canadensis-Liriodendron tulipifera Upland Forest - I.C.3.N.a.260

Liriodendron tulipifera-suga canadensis-Betula lenta/Leucothoe fontanesiana Forest ***

8. <u>Xeric Evergreen Forests</u> (17)

8.1 Quercus montana-Quercus rubra/Kalmia Forest (3)

Plots: 451, 452, 453

Quercus rubra-Quercus prinus Woodland Alliance - II.B.2.N.a 150

Quercus prinus-Quercus rubra/Kalmia Forest ***

8.2 Pinus pungens-Quercus montana/Kalmia Forest (8)

Plots: 309, 313, <u>315</u>, 323, <u>362</u>, 400, 439, 450

Pinus (rigida, pungens)-Quercus (prinus, coccinea) Forest Alliance - I.C.3.N.a.145

Pinus pungens-Quercus prinus-Quercus coccinea/Vaccinium pallidum Forest CEGL007502

8.3 Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest (6)

Plots: 364, 365, 366, 401, 433, 438

Pinus (rigida, pungens, virginiana)-Quercus (prinus, coccinea) Woodland Alliance - II.C.3.N.a.100

Pinus pungens-Pinus rigida-Quercus prinus/Kalmia latifolia/Melampyrum lineare Woodland ***

9. <u>Montane Oak Forests</u> (14)

9.1 Quercus montana/Oxydendrum/Kalmia Forest (9)

Plots: 304, 306, 312, 328, 399, <u>402</u>, 430, <u>441</u>, 443

Quercus prinus-Quercus rubra Forest Alliance - I.B.2.N.a.360

Quercus prinus/Oxydendrum arboreum/(Rhododendron maximum-Kalmia latifolia Forest ***

9.2 Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest (5)

Plots: 320, <u>334</u>, 405, <u>446</u>, 447

Quercus prinus-Quercus rubra Forest Alliance - I.B.2.N.a.360

Quercus prinus-Quercus rubra/Rhododendron calendulaceum Forest ***

10. Rich Cove and Slope Forests (52)

10.1 Quercus rubra-Carya glabra/Cornus florida Forest (17)

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra-Carya glabra/Cornus florida Forest ***

10.1.1 ***Quercus rubra-Liriodendron-Carya glabra/Hamamelis-Cornus florida sub-type (7)***

Plots: 301, 305, 322, 331, 332, 339, 343

10.1.2 ***Quercus rubra-Carya glabra/Cornus florida-Acer pensylvanicum sub-type (10)***

Plots: 303, 321, 327, 335, 336, 367, 372, 404, 437, 449

10.2 Liriodendron/Halesia Forest (8)

Plots: 302, 337, 344, 345, 371, 403, 406, 407

Liriodendron tulipifera-Tilia americana v. heterophylla-Aesculus flava-Acer saccharum Forest Alliance - I.B.2.N.b.050

Liriodendron tulipifera/Halesia tetraptera/Thelypteris novaboracensis Forest ***

10.3 Quercus rubra-Halesia/Acer saccharum Forest (5)

Plots: 351, 393, 395, 434, 435

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra-Halesia tetraptera/Acer saccharum Forest ***

10.4 Betula lenta-Robinia pseudo-acacia/Ageratina Forest (6)

Plots: 317, 324, 326, 348, 398, 436

Tsuga canadensis-Liriodendron Upland Forest Alliance - I.C.3.N.a.260

Betula (alleghaniensis,lenta)/Ageratina altimissima v. roanensis Forest ***

10.5 Tilia-Betula lenta Forest (10)

Plots: 325, 349, 363, 368, 373, 390, 391, 392, 445, 458

Liriodendron tulipifera-Tilia americana v. heterophylla-Aesculus flava-Acer saccharum Forest Alliance - I.B.2.N.b.050

Tilia americana v. heterophylla-Betula lenta/ Ageratina altimissima v. roanensis Forest ***

10.6 Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest (6)

Plots: 376, 378, 379, 380, 386, 388

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra-Aesculus flava/Ageratina altimissima v. roanensis Forest ***

11. Alluvial Forests (1)

11.1 [Betula alleghaniensis/Salix nigra Alluvial Forest] (1)

Plots: 350

Salix nigra Shrubland Alliance- III.B.2.N.d.060

Betula alleghaniensis/Salix nigra Forest (new association)

Appendix 3. Joyce Kilmer/Slickrock Wilderness community classification showing sample plot numbers present in each vegetation class and associated community types. Total plot site number for each group is given in parentheses. Randomly chosen sites are underlined. Synonymy between the Joyce Kilmer/Slickrock Wilderness classification and Alliances and Associations in The Nature Conservancy classification (TNC; The Nature Conservancy Ecology Working Group 1996) are provided. Association reference numbers are given. ** represents no synonymous Alliance in current TNC classification. *** represents no synonymous Association in current TNC classification

1. Rock Outcrops (1)

1.1 [Aronia melanocarpa/Danthonia compressa Outcrop] (1)

Plot: 625

Danthonia compressa Shrub *Herbaceous Alliance* V.A.7.N.c.010

2. Non-Alluvial Wetlands (1)

2.1 [Liriodendron-Quercus rubra/Carex ruthii Wetland] (1)

Plot: 595

I.B.2.N.d.??? **

3. Grasslands (2)

3.1 [Crategus flabellata/Frageria virginiana/Phlox carolina Grassland] (2)

Plots: 648, 649

V.B.2.N.b.??? **

4. Shrub Balds (2)

4.1 [Rhododendron catawbiense-Kalmia Shrubland] (2)

Plots: 609, 626

Rhododendron (catawniense, carolinianum)-Kalmia latifolia Shrubland Alliance - III.A.2.N.b.050

Kalmia latifolia-(Rhododendron catawbiense) Shrubland CEGL003814

5. <u>High-Elevation</u> <u>Mixed</u> <u>Hardwood</u> <u>Forests</u> (26)

5.1 Betula alleghaniensis-Fagus/Rhododendron maximum Forest (4)

Plots: 512, 628, 664, 681

Betula alleghaniensis Forest Alliance I.B.2.N.b.0.10

Betula alleghaniensis-Fagus/Rhododendron maximum Forest (new association)

5.2 Quercus rubra/Thelypteris Forest (13)

Plots: 511, 536, <u>607</u>, <u>608</u>, 644, 647, 659, 660, 668, 669, 670, 671, 677

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra/Carex pensylvanica-Ageratina altissima v. roanensis Forest CEGL007298

5.3 Fagus-Betula alleghaniensis/Dryopteris intermedia Forest (7)

Plots: <u>547</u>, 548, <u>554</u>, 555, <u>611</u>, 640, 676

Fagus grandifolia Montane Forest Alliance - I.B.2.N.b.040.

Fagus grandifolia/Ageratina altissima var. roanensis Forest CEGL006246

5.4 Fagus/Carex pensylvanica Forest (2)

Plots: 627, <u>680</u>

Fagus grandifolia Montane Forest Alliance - I.B.2.N.b.040.

Fagus grandifolia/Carex spp. Forest CEGL006130

6. <u>Xeric</u> <u>Evergreen</u> <u>Forests</u> (29)

6.1 Quercus montana-Pinus rigida/Vaccinium pallidum Forest (10)

Plots: 537, 539, <u>543</u>, 572, 599, <u>602</u>, 610, <u>632</u>, 635, <u>638</u>

Pinus (rigida-pungens)-Quercus (prinus, coccinea) Forest Alliance - I.C.3.N.a.145

Pinus rigida-Quercus prinus-Quercus coccinea/Kalmia latifolia-Vaccinium pallidum Forest CEGL007503

6.2 Quercus montana-Quercus coccinea/Galax Forest (19)

Plots: 506, 507, 518, 523, 538, 540, 549, 550, 556, 557, 562, 571, 577, <u>594</u>, <u>617</u>, <u>618</u>, 619, 623, <u>639</u>

Quercus prinus-Quercus coccinea-(Quercus velutina) Forest Alliance - I.B.2.N.a.350

Quercus prinus-Quercus coccinea/Kalmia latifolia/Galax urceolata Forest CEGL006271

7. <u>Montane</u> <u>Oak</u> <u>Forests</u> (36)

7.1 Quercus montana-Quercus velutina/Oxydendrum Forest (5)

Plots: 505, 530, 531, 534, 675

Quercus prinus-(Quercus coccinea-Quercus velutina) Forest Alliance I.B.2.N.a.350

Quercus montana-Quercus velutina/Oxydendrum arboreum Forest ***

7.2 Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest (4)

Plots: 508, <u>593</u>, 601, 622

Quercus alba-Quercus rubra(Carya ovata, glabra, alba) Forest Alliance I.B.2.N.a.270

Quercus rubra-Acer rubrum-(Carya spp.)/Thelypteris novaeboracensis Forest CEGL007242

7.3 Quercus montana-Quercus rubra/Cornus florida Forest (7)

Plots: 532, <u>542</u>, <u>546</u>, 563, 575, 643, 674

Quercus prinus-Quercus rubra Forest Alliance - I.B.2.N.a.360

Quercus prinus-Acer rubrum-(Carya spp.)/Oxydendrum arboreum-Cornus florida Forest CEGL007267

7.4 Carya alba-Quercus alba/Cornus florida/Polystichum Forest (5)

Plots: 561, 573, 631, 634, 637

Quercus alba-Quercus rubra(Carya ovata, glabra, alba) Forest Alliance I.B.2.N.a.270

Quercus alba-Quercus rubra-Carya (alba, ovata) Forest CEGL007235

7.5 Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest (6)

Plots: 502, 503, 504, 509, 541, 597

Quercus alba-Quercus rubra(Carya ovata, glabra, alba) Forest Alliance I.B.2.N.a.270

Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest (new association)

7.6 Quercus rubra-Halesia/Thelypteris Forest (9)

Plots: 553, 558, 590, 613, 624, 656, 658, 662, 679

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra/(Vaccinium simulatum-Rhododendron calendulaceum)/(Dennstaedtia punctilobula-Thelypteris noveboracensis) Forest CEGL007300

8. Acidic Cove and Slope Forests (47)

8.1 Acer rubrum/Rhododendron maximum Forest (7)

Plots: 510, 519, 520, 600, 603, 612, 615

Quercus rubra Forest Alliance - I.B.2.N.b.080.

Quercus rubra/(Kalmia latifolia-Rhododendron maximum/Galax urecolata Forest CEGL007543

8.2 Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest (5)

Plots: 579, 581, 606, 636, 645

Tsuga canadensis-Liriodendron tulipifera Upland Forest Alliance - I.C.3.N.a.260

Tsuga canadensis-Liriodendron tulipifera/Rhododendron maximum/Tiarella cordifolia Forest CEGL007543

8.3 Tsuga canadensis-Liriodendron/Thelypteris Forest (12)

Tsuga canadensis-Liriodendron tulipifera Upland Forest Alliance - I.C.3.N.a.260

Tsuga canadensis-Liriodendron/Thelypteris Forest ***

8.3.1 ***Tsuga canadensis-Liriodendron/Mitchella sub-type*** (5)

Plots: 525, 574, 651, 653, 654

8.3.2 ***Liriodendron-Quercus rubra-Tsuga canadensis/Cornus florida sub-type*** (7)

Plots: 501, 513, 514, 517, 522, 533, 578

8.4 Tsuga canadensis-Halesia/Dryopteris intermedia Forest (8)

Plots: 566, 567, 570, 583, 587, 604, 641, 642

I.C.3.N.a.??? **

8.5 Tsuga canadensis-Magnolia fraseri Forest (6)
I.C.3.N.a.??? **

8.5.1 ***Magnolia fraseri/Acer pensylvanicum sub-type*** (3)
Plots: 586, 591, 605

8.5.2 ***Tsuga canadensis-Fagus-Halesia sub-type*** (3)
Plots: 516, 588, 663

8.6 Tsuga canadensis/Rhododendron maximum Forest (4)
Plots: 564, 568, 576, 652
Tsuga canadensis Upland Forest - I.A.8.N.c.070
Tsuga canadensis/Rhododendron maximum Forest CEGL007136

8.7 Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest (5)
Plots: 521, 545, 569, 585, 630

Tsuga canadensis-Liriodendron tulipifera Upland Forest Alliance - I.C.3.N.a.260

Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest ***

9. Rich Cove and Slope Forests (34)
9.1 Liriodendron/Cornus florida Forest (3)
Plots: 528, 529, 580
Liriodendron tulipifera Forest Alliance - I.B.2.N.a.220
Liriodendron tulipifera Forest CEGL007218

9.2 Acer saccharum-Halesia/Cimicifuga racemosa Forest (10)
Liriodendron tulipifera-Tilia americana var. heterophylla-Aesculus flava-Acer saccharum Forest Alliance - I.B.2.N.b.050
Liriodendron tulipifera-Tilia americana var. heterophylla (-Aesculus flava)/Cimicifuga racemosa Forest CEGL007291

9.2.1 ***Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type*** (3)
Plots: 524, 526, 527

9.2.2 *Halesia-Acer saccharum-Tilia/Viola blanda sub-type* (7)
Plots: 515, 552, 592, 655, 657, 672, 673

9.3 Tsuga canadensis-Halesia/Laportea Forest (3)
Plots: 629, 682, 683
I.C.3.N.a.??? **

9.4 Acer saccharum-Fagus/Viola blanda Forest (5)
Plots: 614, 661, 665, 666, 667
Betula alleghaniensis-Fagus grandifolia-Aesculua flava-(Acer saccharum) Forest Alliance - 1.B.N.b.020
Acer saccharum-Fagus grandifolia/Viola blanda Forest ***

9.5 Liriodendron-Tilia/Asarum canadense Forest (4)
Plots: 559, 560, 584, 678
Liriodendron tulipifera-Tilia americana var. heterophylla-Aesculus flava-Acer saccharum Forest Alliance - 1.B.2.N.b.050
Liriodendron tulipifera-Tilia americana var. heterophylla /Asarum canadense Forest ***

9.6 [Acer saccharum-Halesia/Cladrastis/Solidago curtisii Forest] (2)
Plots: 616, 646
Betula alleghaniensis-Fagus grandifolia-Aesculua flava-(Acer saccharum) Forest Alliance - 1.B.N.b.020
Acer saccharum-Halesia tetraptera/Cladrastis kentukiensis/Solidago curtisii Forest ***

9.7 Aesculus-Acer saccharum/Solidago curtisii Forest (5)
Plots: 535, 551, 565, 582, 589
Betula alleghaniensis-Fagus grandifolia-Aesculua flava-(Acer saccharum) Forest Alliance - 1.B.N.b.020
Aesculus flava-Acer saccharum/Solidago curtisii Forest ***

9.8 [Aesculus/Rudbeckia lacinata Forest] (2)
Plots: 620, 621
Betula alleghaniensis-Fagus grandifolia-Aesculua flava-(Acer saccharum) Forest Alliance - 1.B.N.b.020
Aesculus flava/Rudbeckia lacinata Forest **

10. Alluvial Forests (4)

10.1 [Liriodendron-Platanus/Amphicarpaea Alluvial Forest] (1)

Plot: 544

Platanus occidentalis-(Liquidambar stryaciflua-Liriodendron tulipifera) Temporarily Flooded Forest I.B.2.N.d.150

Liriodendron tulipifera-Platanus occidentalis/Amphicarpaea Forest ***

10.2 Platanus-Betula alleghaniensis Alluvial Forest (3)

Plots: 596, 598, 633

I.B.2.N.d.??? ***

Appendix 4: Vegetation map of Linville Gorge Wilderness showing distribution of community types. See Chapter 3 for detailed descriptions of each community type.

Linville Gorge Wilderness Community Types

Rock Outcrops

1.1.1: Rhododendron minus-Fothergilla/Leiophyllum/Selaginella tortipila sub-type
■ 1.1.2: Rhododendron minus/Leiophyllum/Selaginella tortipila-Hypericum densiflorum sub-type
■ 1.1.3: [Selaginella tortipila-Carex umbellata sub-type
■ 1.2: [Cheilanthes tomentosa-Danthonia spicata Outcrops]

Xeric Evergreen Forests

■ 2.2: Tsuga caroliniana/Rhododendron maximum Forest
■ 2.3: Pinus virginiana-Pinus pungens/Kalmia Forest
■ 2.4: Pinus pungens/Kalmia Forest
■ 2.5: Pinus rigida-Quercus montana/Fothergilla Forest
■ 2.6: Quercus alba/Kalmia Forest
2.7: Quercus alba-Pinus strobus/Kalmia Forest
■ 2.8: Quercus montana-Quercus coccinea/Kalmia Forest
2.9: Quercus montana/Galax Forest

Acidic Cove and Slope Forests

■ 3.1: Quercus montana-Acer rubrum Forest
■ 3.2: Quercus montana-Pinus strobus/Rhododendron maximum Forest
■ 3.3: Quercus montana/Rhododendron maximum Forest
■ 3.4: Tsuga canadensis/Rhododendron maximum Forest
■ 3.5: Tsuga canadensis-Fagus/Ilex opaca Forest

Montane Oak Forests

■ 4.1: Quercus montana-Oxydendrum/Cornus florida Forest
■ 4.2: Quercus montana/Cornus florida Forest
■ 4.3: Quercus montana-Tilia/Acer pensylvanicum-Hamamelis Forest
■ 4.4: Quercus alba-Acer rubrum/Thelypteris-Dennstaedtia Forest

Rich Cove and Slope Forests

5.1: Carya glabra/Ageratina Forest
■ 5.2: [Liriodendron-Carya glabra Forest]

Alluvial Forests

6.2: [Platanus/Asimina/Microstegium Alluvial Forest]

□ Linville River


N
0 km
1
2
3

Appendix 5: Vegetation map of Shining Rock Wilderness showing distribution of community types. See Chapter 4 for detailed descriptions of each community type.

Shining Rock Wilderness Community Types

Non-Alluvial Wetlands

2: Non-Alluvial Wetlands

Shrub Balds

3.1: Picea/Rhododendron catawbiense Shrubland

3.2: [Rhododendron catawbiense-Pieris Shrubland]

Grasslands

4.1: [Rhododendron catawbiense/Carex pensylvanica-Dennstaedtia Grassland]

4.2: Vaccinium corymbosum/Danthonia compressa-Carex pensylvanica Grassland

4.3: [Phlox carolina-Schizachyrium-Vaccinium stamineum Grassland]

High-Elevation Mixed Hardwood Forests

5.1: Fagus/Carex pensylvanica Forest

5.2: Betula alleghaniensis-Prunus pensylvanica/Rhododendron catawbiense-Vaccinium simulatum Forest

5.3: Betula alleghaniensis/Acer spicatum-Rhododendron catawbiense Forest

5.4: Betula alleghaniensis/Ageratina-Aster acuminatus Forest

5.5: Quercus rubra-Picea/Carex pensylvanica Forest

5.6: Quercus rubra/Kalmia Forest

Spruce-Fir Forests

6.1: [Picea/Dennstaedtia Forest]

Acidic Cove and Slope Forests

7.1: Tsuga canadensis-Betula lenta/Rhododendron maximum Forest

7.2: Tsuga canadensis-Quercus rubra/Rhododendron maximum Forest

7.3: Betula lenta-Magnolia fraseri/Rhododendron maximum-Hamamelis Forest

Xeric Evergreen Forests

8.1: Quercus montana-Quercus rubra/Kalmia Forest

8.2: Pinus pungens-Quercus montana/Kalmia Forest

8.3: Pinus pungens-Pinus rigida-Quercus montana/Kalmia Forest

Montane Oak Forests

9.1: Quercus montana/Oxydendrum/Kalmia Forest

9.2: Quercus montana-Quercus rubra/Rhododendron calendulaceum Forest

Rich Cove and Slope Forests

10.1: Quercus rubra-Carya glabra/Cornus florida Forest

10.2: Liriodendron/Halesia Forest

10.3: Quercus rubra-Halesia/Acer saccharum Forest

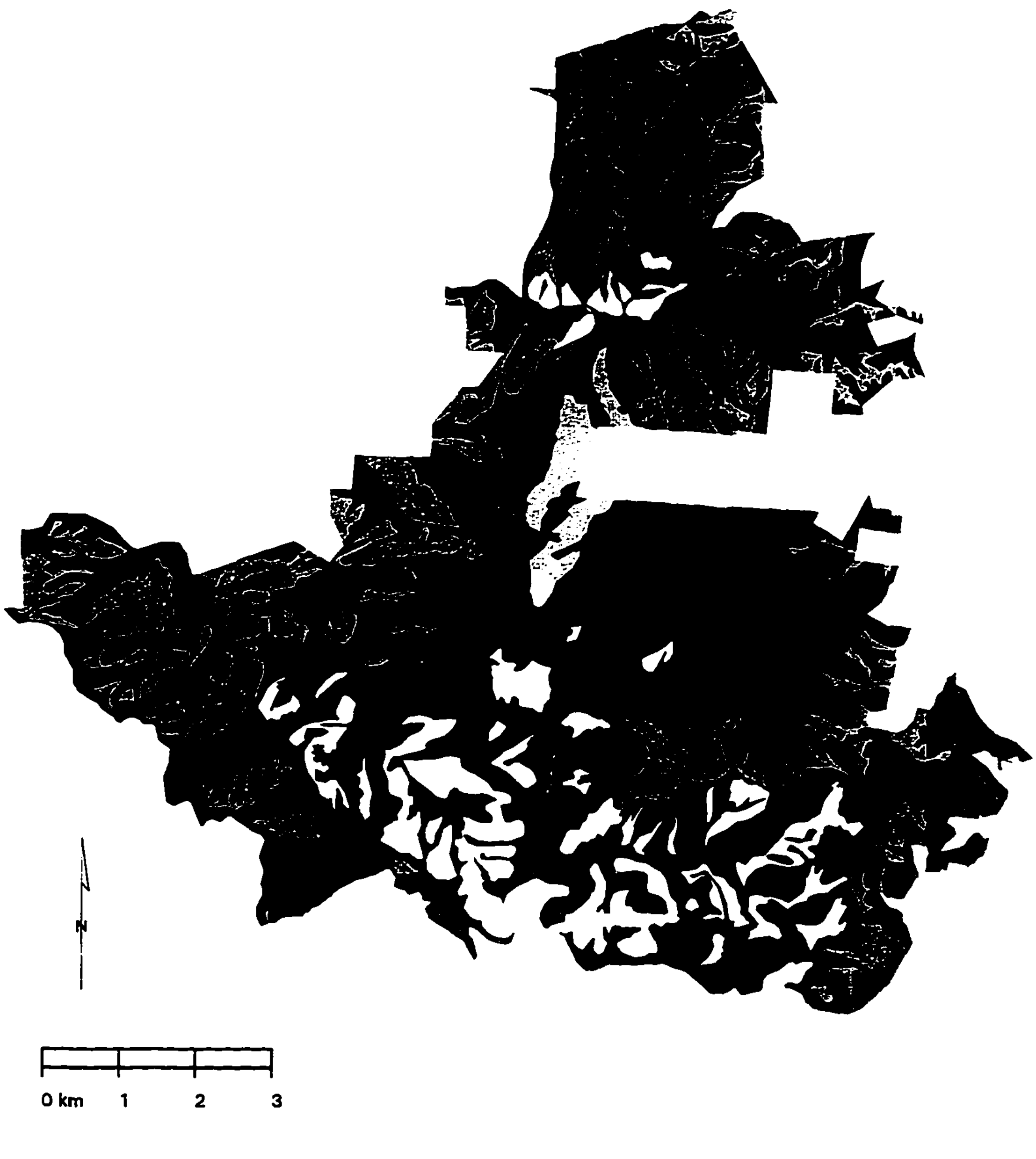
10.4: Betula lenta-Robinia pseudo-acacia/Ageratina Forest

10.5: Tilia-Betula lenta Forest

10.6: Quercus rubra-Aesculus-Robinia pseudo-acacia/Ageratina Forest

Alluvial Forests

11.1: [Betula alleghaniensis/Salix nigra Alluvial Forest]


N
0 km
1
2
3

Appendix 6: Vegetation map of Joyce Kilmer/Slickrock Wilderness showing distribution of community types. See Chapter 5 for detailed descriptions of each community type.


0
1
2
kilometers
scale 1:56000

Non-Alluvial Wetlands

- 2.1 [Liriodendron-Acer rubrum/Carex ruthii Wetland

Grasslands

- 3.1 [Crategus macrosperma/Fragaria virginiana/Phlox carolina Grassland]

Shrub Balds

- 4.1 [Rhododendron catawbiense-Kalmia Shrubland]

High-Elevation Mixed Hardwood Forests

- 5.1 Betula alleghaniensis-Fagus/Rhododendron maximum Forest
- 5.2 Quercus rubra/Thelypteris Forest
- 5.3 Fagus-Betula alleghaniensis/Dryopteris intermedia Forest
- 5.4 Fagus/Carex pensylvanica Forest

Xeric Evergreen Forests

- 6.1 Quercus montana-Pinus rigida/Vaccinium pallidum Forest
- 6.2 Quercus montana-Quercus coccinea/Galax Forest

Montane Oak Forests

- 7.1 Quercus montana-Quercus velutina/Oxydendrum Forest
- 7.2 Quercus rubra/Acer pensylvanicum/Gaylussacia ursina/Thelypteris Forest
- 7.3 Quercus montana-Quercus rubra/Cornus florida Forest
- 7.4 Carya alba-Quercus alba/Cornus florida/Polystichum Forest
- 7.5 Quercus coccinea-Carya glabra/Kalmia-Gaylussacia ursina Forest
- 7.6 Quercus rubra-Halesia/Thelypteris Forest

Acidic Cove and Slope Forests

- 8.1 Acer rubrum/Rhododendron maximum Forest
- 8.2 Liriodendron-Betula lenta-Tsuga canadensis/Polystichum Forest
- 8.3 Tsuga canadensis-Liriodendron/Thelypteris Forest
- 8.4 Tsuga canadensis-Halesia/Dryopteris intermedia Forest
- 8.5 Tsuga canadensis-Magnolia fraseri Forest
- 8.6 Tsuga canadensis/Rhododendron maximum Forest
- 8.7 Tsuga canadensis-Betula alleghaniensis/Rhododendron maximum Forest

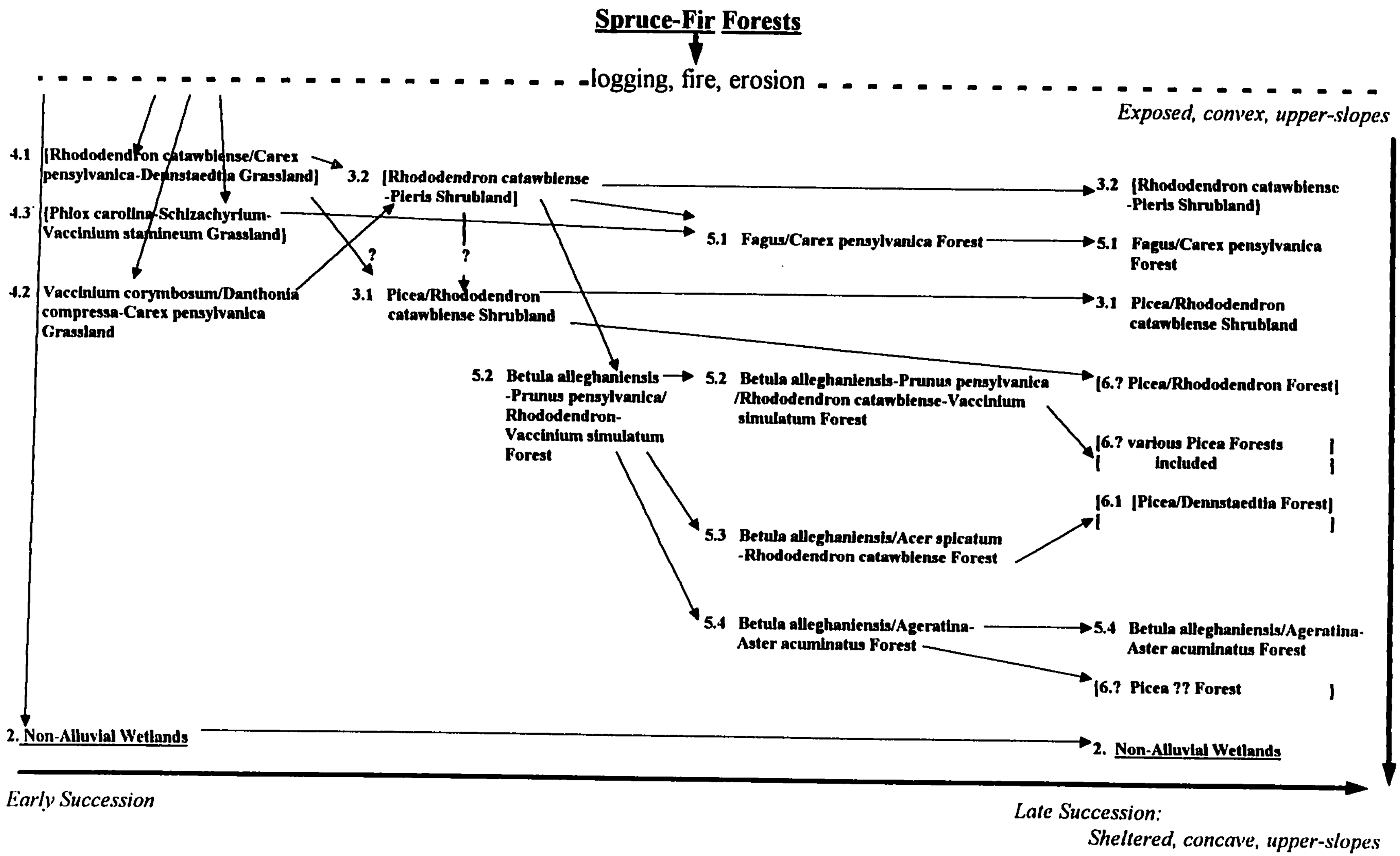
Rich Cove and Slope Forests

- 9.1 Liriodendron/Cornus florida Forest
- 9.2.1 Liriodendron-Tilia-Halesia/Cimicifuga racemosa sub-type
- 9.2.2 Halesia-Acer saccharum-Tilia/Viola blanda sub-type
- 9.3 Tsuga canadensis-Halesia/Laportea Forest
- 9.4 Acer saccharum-Fagus/Viola blanda Forest
- 9.5 Liriodendron-Tilia/Asarum canadense Forest
- 9.6 [Acer saccharum-Halesia/Cladrastris/Solidago curtisii Forest]
- 9.7 Aesculus-Acer saccharum/Solidago curtisii Forest
- 9.8 [Aesculus/Rudbeckia lacinata Forest]

Alluvial Forests

- 10.1 [Liriodendron-Platanus/Amphicarpaea Alluvial Forest]
- 10.2 Platanus-Betula alleghaniensis Alluvial Forest

Appendix 7: Successional trajectory of high-elevation Shining Rock Wilderness community types. Modified from Ramseur (1960) and McLeod (1988).



Appendix 8: Steps taken to standardize species nomenclature across all datasets used in the regional analysis.

1. The following taxa were deleted due to low resolution status and ambiguity in identification;

a: Taxa identified at Genus level:
Acer species, *Agrimonia* species, *Agrostis* species, *Amelanchier* species, *Andropogon* species, *Aralia* species, *Aristolochia* species, *Asclepias* species, *Betula* species, *Botrychium* species, *Calystegia* species, *Carex* species, *Carex* species #1 to #9, *Carya* species, *Chelone* species, *Dryopteris* species, *Geum* species, *Heuchera* species, *Hydrangea* species, *Hypericum* species, *Impatiens* species, *Leucothoe* species, *Lilium* species, *Luzula* species, *Muhlenbergia* species, *Oenothera* species, *Osmorhiza* species, *Osmunda* species, *Quercus* species, *Pinus* species, *Phacelia* species, *Platanthera* species, *Polygala* species, *Polygonatum* species, *Potentilla* species, *Prosartes* species, *Prunus* species, *Ranunculus* species, *Ribes* species, *Saccharum* species, *Sisyrinchium* species, *Smilax* species, *Stellaria* species, *Trillium* species #2, *Vaccinium* species, *Vicia* species, *Viola* species #2, *Uvularia* species.

b: Taxa identified at family level
Apiaceae species, Asteraceae species, Cyperaceae species, Fabaceae species, Orchidaceae species, Poaceae species #1, Poaceae species #2, Rosaceae species, Saxifragaceae species

c: Low resolution taxa
Dicot #1, Dicot #2, Dicot #3, Unknown species #1,

2. The following taxa were deleted as not all workers had recorded their presence
a: Non-vascular taxa
Lichens, Mosses, Sphagnum, *Vittaria appalachiana*

b: Species visible only in spring
Dicentra canadensis, *Dicentra cucullaria*

3. Species and/or subspecies were lumped to the following genera:

ACALYPHA species: (includes; *Acalypha virginica*)

CRATAEGUS species: (includes; *Crataegus flabellata*, *C. flava*, *C. macrosperma*, *C. phaenopyrum*, *C. punctata* and all *Crataegus* taxa identified at genus level)

CUSCUTA species: (includes; *Cuscuta campestris*, *C. gronovii* var. *gronovii*, *C. rostrata*)

GENTIANA species: (includes; *Gentiana austromontana*, *G clausa*, *G. decora*, *G. saponaria*, *G. villosa*)

LESPEDEZA species: (includes; *Lespedeza cuneata, L. hirta* ssp. *hirta, L. intermedia, L. repens*)

HYPERICUM species: (includes; *Hypericum graveolens, H. mitchellianum, H. punctatum*)

PANICUM species: (includes; *Dichanthelium* species, *D. acuminatum* var. *acuminatum, D. acuminatum* var. *lindheimeri, D. acuminatum* var. *fasciulatum, D. angustifolium, D. boscii, D. sabulorum, D. clandestinum, D. commutatum, D. commutatum* x. *latifolium, D. depauperatum, D. dichotomum* var. 3 (=*lucidum*), *D. dichotomum* var. 4 (= *ramulosum*), *D. dichotomum* var. 5 (=*yadkinense*), *D. dichotomum* var. *dichotomum, D. latifolium, D. laxiflorum, D. meridionale, D. sphaerocarpon, D. sphaerocarpon* var. *isophyllum, Dichanthelium* species 7 (=*tenue*), *D. villosissimum* var. *villosissimum*, all *Panicum* taxa identified at the genus level)

POA species: (includes; *Poa alsodes, P. autumnalis, P. compressa, P. cuspidata, P. pratensis, P. saltuensis, P. trivialis*)

PRENANTHES species: (includes; *Prenanthes altissima, P. roanensis, P. serpentaria, P. trifoliata*)

SPIRANTHES species: (includes; *Spiranthes cernua*)

4. Subspecies were lumped to the following species:

ACER RUBRUM: (includes *Acer rubrum* var. *rubrum, A. rubrum* var. *trilobum*)

ACONITUM UNCINATUM: (includes; *Aconitum uncinatum* ssp. *muticum, A. uncinatum* ssp. *uncinatum*)

AGERATINA ALTISSIMA: (includes; *Ageratina altissima* var. *altissima, A. altissima* var. *roanensis*)

AGERATINA AROMATICA: (includes; *Ageratina aromatica* var. *aromatica*)

ALLIUM TRICOCCUM: (includes; *Allium burdickii*)

AMELANCHIER ARBOREA: (includes; *Amelanchier laevis*)

ANDROPOGON VIRGINICUS: (includes; *Andropogon virginicus* var. *virginicus*)

ARABIS LAEVIGATA: (includes; *Arabis laevigata* var. *laevigata*)

ASCLEPIAS INCARNATA: (includes; *Asclepias incarnata* var. *pulchra*)

ASTER DIVARICATUS: (includes; *Aster chlorolepis*)

ASTER LAEVIS: (includes; *Aster laevis* var. *concinnus*)

ARISAEMA TRIPHYLLUM: (includes; *Arisaema triphyllum* var. *triphyllum*, *Arisaema triphyllum* var. *quinatum*, *Arisaema triphyllum* var. *pusillum*, *Arisaema dracontium*)

BRACHYELYTUM ERECTUM: (includes; *Brachyelytrum septentrionale*)

BOTRYCHIUM DISSECTUM: (includes; *Botrychium biternatum*)

CAREX LAXIFLORA VAR. LAXIFLORA: (includes; *Carex blanda*)

CAREX DEBILIS: (includes; *Carex flexuosa*)

CAREX INTUMESCENS: (includes; *Carex intumescens* var. *fernaldii*)

CARYA GLABRA: (includes; *Carya ovalis*)

COREOPSIS MAJOR: (includes; *Coreopsis major* var. *major*, *C. major* var. *rigida*)

DIOSCOREA VILLOSA: (includes; *Dioscorea quaternata*, *D. villosa* var. *villosa*)

EUPATORIUM PURPUREUM VAR. PUPUREUM: (includes; *Eupatorium steelii*)

ERYNGIUM YUCCIFOLIUM: (includes; *Eryngium yuccifolium* var. *yuccifolium*)

FRAXINUS AMERICANA: (includes; *Fraxinus americana* var. *americana*)

GALIUM CIRCAEZANS: (includes; *Galium circaezans* var. *circaezans*, *G. circaezans* var. *hypomalacum*)

GALIUM PILOSUM: (includes; *Galium pilosum* var. *pilosum*)

HALESIA TETRAPTERA: (includes; *Halesia tetraptera* var. *monticola*, *Halesia tetraptera* var. *tetraptera*)

HEXASTYLIS ARIFOLIA: (includes; *Hexastylis arifolia* var. *ruthii*)

HOUSTONIA PURPUREA: (includes; *Houstonia purpurea* var. *calycosa*, *H. purpurea* var. *purpurea*)

HYDROPHYLLUM VIRGINIANUM: (includes; *Hydrophyllum virginianum* var. *virginianum*)

HYPERICUM DENSIFLORUM: (includes; *Hypericum densiflorum* var. 1)

ILEX MONTANA: (includes; *Ilex ambigua, I. beadlei*)

LINDERA BENZOIN: (includes; *Lindera benzoin* var. *benzoin*)

LUZULA ACUMINATA: (includes; *Luzula acuminata* var. *acuminata*)

LYCOPODIUM OBSCURUM: (includes; *Lycopodium dendroideum*)

MELAMPYRUM LINEARE: (includes; *Melampyrum lineare* var. *lineare*)

MONARDA FISTULOSA: (includes; *Monarda fistulosa* var. *brevis, M. fistulosa* var. *fistulosa, M. fistulosa* var. *mollis*)

MUHLENBERGIA TENUIFLORA: (includes: *Muhlenbergia tenuiflora* var. *tenuiflora, M. tenuiflora* var. *variabilis*)

PARTHENIUM INTEGRIFOLIUM: (includes; *Parthenium integrifolium* var. *integrifolium*)

PEDICULARIS CANADENSIS: (includes; *Pedicularis canadensis* var. *canadensis*)

PHLOX CAROLINA: (includes; *Phlox carolina* var. *carolina*)

POLYGONATUM BIFLORUM: (includes; *Polygonatum biflorum* var. *biflorum*, *P. pubescens*)

POLYPODIUM VIRGINIANUM: (includes; *Polypodium appalachianum*)

POTENTILLA CANADENSIS: (includes; *Potentilla canadensis* var. *canadensis, P. simplex*)

PYCNANTHEMUM INCANUM: (includes; *Pycnanthemum beadlei, P. incanum* var. *incanum*)

RHODODENDRON MINUS: (includes; *Rhododendron caroliniamum*)

RHUS COPALLINUM: (includes; *Rhus copallinum* var. *copallinum*)

ROBINIA HISPIDA: (includes; *Robinia hispida* var. *fertilis, R. hispida* var. *hispida*)

RUBUS IDAEUS: (includes; *Rubus idaeus* var. *strigosus*)

RUBUS ALLEGHENIENSIS: (includes; *Rubus argutus, R. canadensis*)

RUDBECKIA LACINATA: (includes; *Rudbeckia lacinata* var. *humilis*, *R. lacinata* var. *lacinata*)

SCLERIA PAUCIFLORA: (includes; *Scleria pauciflora* var. *pauciflora*)

SCUTELLARIA ELLIPTICA: (includes; *Scutellaria elliptica* var. *elliptica*)

SCUTELLARIA OVATA: (includes; *Scutellaria ovata* var. *bracteata*)

SILPHIUM COMPOSITUM: (includes; *Silphium compositum* var. *compositum*)

SMILAX HERBACEA: (includes; *Smilax biltmoreana*, *S. hugeri*, *S. pulverulenta*)

SOLIDAGO ARGUTA: (includes; *Solidago arguta* spp. *caroliniana*)

SOLIDAGO CAESIA: (includes; *Solidago curtisii*)

SOLIDAGO PATULA: (includes; *Solidago patula* var. *patula*)

SOLIDAGO SPECIOSA: (includes; *Solidago erecta*, *S. speciosa* var. *erecta*)

STELLARIA PUBERULA: (includes; *Stellaria corei*)

THALICTRUM PUBESCENS: (includes; *Thalictrum pubescens* var. *pubescens*)

THASPIUM TRIFOLIATUM: (includes; *Thaspium trifoliatum* var. *trifoliatum*)

TIARELLA CORDIFOLIA: (includes; *Tiarella cordifolia* var. *collina*, *T. cordifolia* var. *cordifolia*)

TOXICODENDRON RADICANS: (includes; *Toxicodendron radicans* var. *radicans*)

VACCINIUM STAMINIUM: (includes; *Vaccinium staminium* var. *candicans*)

VITIS AESTIVALIS: (includes; *Vitis aestivalis* var. *aestivalis*, *V. aestivalis* var. *bicolor*)

VIOLA BLANDA: (includes; *Viola macloskeyi* ssp. *pallens*)

VIOLA PALMATA: (includes; *Viola palmata* var. *palmata*, *Viola palmata* var *triloba*)

VIOLA PUBESCENS: (includes; *Viola pubsecens* var. *leiocarpon*, *V. pubescens* var. *pubescens*)

5. Taxa were updated to the following names:

HOUSTONIA LONGIFOLIA VAR. GLABRA: (includes; *Houstonia longifolia*)

MAGNOLIA ACUMINATA VAR. ACUMINATA: (includes; *Magnolia acuminata*)

6. Hybrid species were merged with the following species:

QUERCUS ALBA: (includes; *Quercus* x *saulii*)

QUERCUS COCCINEA VAR. COCCINEA: (includes; *Quercus* x *fontana*)

QUERCUS FALCATA: (includes; *Quercus falcata* x *coccinea*)

QUERCUS RUBRA: (includes; *Quercus* x *hawkinsiae*)

QUERCUS VELUTINA: (includes; *Quercus* x *bushii*, *Quercus laevis* x *velutina*)

Appendix 9: 904 taxa recognized across the 1113 plots used in the regional analysis. The code, scientific name, family number (as used by Radford *et al.* 1968) and the frequency of occurances by study area. The folowing abbreviations for each study areas were used: BM=Black and Craggy Mountains, CR=Chattooga River Gorge, GR=Grandfather and Roan Mountains, JK=Joyce Kilmer/Slickrock Wilderness, LG=Linville Gorge Wilderness, NM = Nantahala Mountains, SM=Smoky Mountains, SR= Shining Rock Wilderness, TR=Thompson River Gorge. N=number sample plots in each study area.

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
N			137	72	70	177	161	100	107	140	150
EQUIARV	2	EQUISETUM ARVENSE	.	.	.	.	.	1	.	.	.
DIPHDIG	3	DIPHASIASTRUM DIGITATUM	4	1	.	.	.	1	.	3	.
DIPHTRI	3	DIPHASIASTRUM TRISTACHYUM	1	.	.	.	.	.	.	.	.
HUPELUC	3	HUPERZIA LUCIDULA	33	5	24	31	.	7	12	9	3
LYCOCLAC	3	LYCOPODIUM CLAVATUM VAR CLAVATUM	1	.	.	.	.	.	.	2	.
LYCOOBS	3	LYCOPODIUM OBSCURUM	1	.	2	1	.	2	1	6	.
SELAAPO	4	SELAGINELLA APODA	.	.	.	.	.	.	.	.	1
SELATOR	4	SELAGINELLA TORTIPILA	.	.	1	.	10	3	.	.	1
BOTRDIS	6	BOTRYCHIUM DISSECTUM	2	8	.	2	.	1	2	12	8
BOTRONE	6	BOTRYCHIUM ONEIDENSE	.	2	.	.	.	.	.	.	.
BOTRVIR	6	BOTRYCHIUM VIRGINIANUM	32	7	10	35	5	26	13	31	4
COMAUMBU	6	COMANDRA UMBELLATA VAR UMBELLATA	.	.	1	2	.	.	.	.	.
PYRUPUB	6	PYRULARIA PUBERA	11	23	1	60	24	20	32	19	41
OSMUCINC	7	OSMUNDA CINNAMOMEA VAR CINNAMOMEA	8	8	1	13	6	11	6	18	10
OSMUCLA	7	OSMUNDA CLAYTONIANA	.	3	1	.	1	2	3	.	3
OSMUREGS	7	OSMUNDA REGALIS VAR SPECTABILIS	1	1	.	1	.	.	.	.	1
ADIAPEDP	10	ADIANTUM PEDATUM VAR PEDATUM	11	7	1	19	1	17	8	7	9
DENNPUN	10	DENNSTAEDTIA PUNCTILOBULA	15	10	12	29	20	25	27	50	36
PELLATR	10	PELLAEA ATROPURPUREA	.	.	5	.	.	.	.	.	.
PTERAQUL	10	PTERIDIUM AQUILINUM VAR LATIUSCULUM	5	17	6	12	20	19	4	19	42
ASPLMNT	13	ASPLENIUM MONTANUM	.	.	1	.	6	.	.	1	.
ASPLPLAP	13	ASPLENIUM PLATYNEURON VAR PLATYNEURON	.	1	2	2	12	16	1	2	3
ASPLRES	13	ASPLENIUM RESILIENS	.	.	5	.	.	.	.	.	.
ASPLRHI	13	ASPLENIUM RHIZOPHYLLUM	.	.	.	1	.	.	.	.	.
ASPLRUTC	13	ASPLENIUM RUTA-MURARIA VAR CRYPTOLEPIS	.	.	3	.	.	.	.	.	.
ATHYASP	13	ATHYRIUM ASPLENIOIDES	37	21	23	96	10	34	30	56	44

Code	Family number	Scientific name	Study Areas BM	CR	GR	JK	LG	NM	SM	SR	TH
CYSTBUL	13	CYSTOPTERIS BULBIFERA	.	.	2	.	.	.	.	.	.
CYSTPRO	13	CYSTOPTERIS PROTRUSA	5	1	8	12	.	10	4	1	1
DEPAACR	13	DEPARIA ACROSTICHOIDES	27	3	12	13	1	15	17	4	.
DIPLPYC	13	DIPLAZIUM PYCNOCARPON	.	.	1	1	.	1	.	.	.
DRYOCAM	13	DRYOPTERIS CAMPYLOPTERA	13	.	20	.	.	1	.	4	.
DRYOCAR	13	DRYOPTERIS CARTHUSIANA	.	.	.	.	.	.	1	.	.
DRYOGOL	13	DRYOPTERIS GOLDIANA	3	.	.	3	.	5	2	.	.
DRYOINT	13	DRYOPTERIS INTERMEDIA	52	3	30	61	6	19	45	14	.
DRYOMAR	13	DRYOPTERIS MARGINALIS	17	2	11	38	19	30	6	13	8
PHEGCON	13	PHEGOPTERIS CONNECTILIS	.	.	.	.	.	.	.	1	.
PHEGHEX	13	PHEGOPTERIS HEXAGONOPTERA	14	7	1	20	2	12	13	6	8
POLYACRA	13	POLYSTICHUM ACROSTICHOIDES VAR ACROSTICHOIDES	66	36	34	115	29	44	48	76	67
THELNOV	13	THELYPTERIS NOVEBORACENSIS	49	34	8	101	18	46	48	33	86
PLEOPOLM	14	PLEOPELTIS POLYPODIOIDES SSP MICHAUXIANA	5	7	1	.	.	2	.	.	10
POLYVRG	14	POLYPODIUM VIRGINIANUM	26	2	32	19	32	15	6	23	4
ABIEFRA	16	ABIES FRASERI	21	.	24	.	.	.	.	22	.
PICERUB	16	PICEA RUBENS	39	.	33	.	.	.	.	30	.
PINUECH	16	PINUS ECHINATA	.	7	1	3	.	3	.	.	11
PINUPUN	16	PINUS PUNGENS	6	1	7	1	50	3	10	9	1
PINURIG	16	PINUS RIGIDA	6	19	5	23	51	14	8	4	38
PINUSTR	16	PINUS STROBUS	7	61	11	63	123	22	28	9	123
PINUVIR	16	PINUS VIRGINIANA	.	6	1	10	31	3	9	1	20
TSUGCAN	16	TSUGA CANADENSIS	75	53	35	163	107	44	82	84	87
TSUGCAR	16	TSUGA CAROLINIANA	18	.	3	.	80	6	.	4	.
JUNIVIRV	18	JUNIPERUS VIRGINIANA VAR VIRGINIANA	.	1	2	.	.	3	.	.	.
AGROCAP	29	AGROSTIS CAPILLARIS	.	.	.	.	1	.	.	.	.
AGROHYE	29	AGROSTIS HYEMALIS	.	.	3	.	1	1	.	.	.
AGROPER	29	AGROSTIS PERENNANS	5	1	5	26	9	7	.	26	10
AGROSTO	29	AGROSTIS STOLONIFERA	1	.	1	.	1	1	.	3	.
ANDRGER	29	ANDROPOGON GERARDII	.	.	.	.	.	9	.	.	.
ANDRGYRG	29	ANDROPOGON GYRANS VAR GYRANS	.	.	.	.	.	2	.	.	.
ANDRTER	29	ANDROPOGON TERNARIUS	.	.	.	.	.	2	.	.	.
ANDRVIR	29	ANDROPOGON VIRGINICUS	.	3	.	.	11	1	.	6	31
ARISPURP	29	ARISTIDA PURPURASCENS VAR PURPURASCENS	.	.	.	.	.	1	.	.	.
ARISSTR	29	ARISTIDA STRICTA	.	1	.	.	.	.	.	.	.

Code	Family number	Scientific name	BM	CR	GR	JK	LG	NM	SM	SR	TH
			Study Areas								
ARUNGSS	29	ARUNDINARIA GIGANTEA	.	22	.	.	2	6	.	.	51
BRACERE	29	BRACHYELYTRUM ERECTUM	.	6	14	33	1	12	4	23	18
BROMLAT	29	BROMUS LATIGLUMIS	.	.	.	.	.	2	.	.	.
BROMPUB	29	BROMUS PUBESCENS	.	.	3	.	.	3	.	13	.
CHASLAT	29	CHASMANTHIUM LATIFOLIUM	.	.	3	.	.	1	.	.	.
CHASLAX	29	CHASMANTHIUM LAXUM	.	.	.	.	1	.	.	.	.
CHASSES	29	CHASMANTHIUM SESSILIFLORUM	.	.	.	.	.	.	.	.	3
CINNARU	29	CINNA ARUNDINACEA	.	2	.	.	.	.	.	.	.
CINNLAT	29	CINNA LATIFOLIA	19	.	3	.	.	.	5	1	.
DANTCOM	29	DANTHONIA COMPRESSA	2	5	4	12	1	20	9	44	3
DANTSER	29	DANTHONIA SERICEA	.	2	.	2	10	1	.	3	.
DANTSPI	29	DANTHONIA SPICATA	.	2	3	2	9	12	.	.	8
DESCCESG	29	DESCHAMPSIA CESPITOSA VAR GLAUCA	.	.	.	.	.	2	.	.	.
DESCFLEF	29	DESCHAMPSIA FLEXUOSA VAR FLEXUOSA	7	.	1	.	1	4	.	19	.
ELYMHYSH	29	ELYMUS HYSTRIX VAR HYSTRIX	.	1	3	1	.	.	.	1	.
ELYMTRA	29	ELYMUS TRACHYCAULUS	.	.	.	.	.	6	.	.	.
ELYMVIL	29	ELYMUS VILLOSUS	.	.	.	.	.	1	.	.	.
FESTOVI	29	FESTUCA OVINA	.	.	.	.	.	4	.	.	.
FESTPRA	29	FESTUCA PRATENSIS	.	.	1	.	.	.	.	.	.
FESTSUB	29	FESTUCA SUBVERTICILLATA	.	1	18	9	2	9	1	22	.
GLYCMEL	29	GLYCERIA MELICARIA	4	.	2	.	.	.	.	1	.
GLYCSTRS	29	GLYCERIA STRIATA VAR STRIATA	1	.	.	.	.	1	.	.	.
MELIMUT	29	MELICA MUTICA	.	.	.	.	.	1	.	.	.
MICRVIM	29	MICROSTEGIUM VIMINEUM	.	1	2	2	1	3	.	.	1
MUHLGLO	29	MUHLENBERGIA GLOMERATA	.	.	.	.	.	4	.	.	.
MUHLTEN	29	MUHLENBERGIA TENUIFLORA	.	2	6	9	9	11	2	15	1
PANIRIG	29	PANICUM RIGIDULUM	.	.	.	.	.	2	.	.	.
PANI1S1	29	PANICUM SP.	24	31	11	68	44	42	18	42	80
PANIVIRV	29	PANICUM VIRGATUM VAR VIRGATUM	.	.	.	.	.	5	.	.	.
PIPTAVE	29	PIPTOCHAETIUM AVENACEUM	.	4	.	.	1	1	.	.	.
POA_1S1	29	POA SP. #1	12	.	19	54	12	19	10	45	.
SACCBREC	29	SACCHARUM BREVIBARBE VAR CONCORTUM	.	.	.	.	.	1	.	.	.
SACCCON	29	SACCHARUM CONTORTUM	.	.	.	.	.	.	.	.	2
SCHISCO	29	SCHIZACHYRIUM SCOPARIUM	1	.	4	12	17	13	3	.	.
SORGNUT	29	SORGHASTRUM NUTANS	.	.	.	4	1	8	1	2	.

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
SPHENIT	29	SPHENOPHOLIS NITIDA	.	.	.	.	.	.	.	1	.
SPHEPEN	29	SPHENOPHOLIS PENSYLVANICA	.	.	.	1	.	.	.	.	.
SPORHET	29	SPOROBOLUS HETEROLEPIS	.	.	.	.	.	7	.	.	.
CAREAES	30	CAREX AESTIVALIS	2	.	13	25	.	14	3	41	.
CAREALT	30	CAREX ALBOLUTESCENS	.	.	.	.	.	.	1	.	.
CAREALS	30	CAREX ALBURSINA	.	.	1	.	.	2	.	.	.
CAREALG	30	CAREX ALLEGHENIENSIS	.	.	.	1	.	.	.	.	.
CAREAPP	30	CAREX APPALACHICA	.	.	12	13	1	9	.	15	.
CAREATLC	30	CAREX ATLANTICA VAR CAPILLACEA	1	.	.	.	.	.	.	.	.
CAREAUS	30	CAREX AUSTROCAROLINIANA	.	.	.	10	.	3	.	1	.
CAREBROB	30	CAREX BROMOIDES VAR BROMOIDES	.	.	1	.	.	.	.	.	.
CAREBRUS	30	CAREX BRUNNESCENS VAR SPHAEROSTACHYA	13	.	2	.	.	.	.	2	.
CARECEP	30	CAREX CEPHALOPHORA	.	.	.	1	1	.	.	.	.
CARECMM	30	CAREX COMMUNIS	.	.	1	.	4	5	.	26	.
CARECRE	30	CAREX CREBRIFLORA	.	.	.	.	.	1	.	.	.
CAREDEB	30	CAREX DEBILIS	1	.	19	16	2	4	10	26	.
CAREDIG	30	CAREX DIGITALIS	.	4	4	35	13	12	6	43	.
CAREECHE	30	CAREX ECHINATA VAR ECHINATA	.	.	.	.	.	3	.	.	.
CAREEMM	30	CAREX EMMONSII	.	.	.	.	.	.	3	.	.
CAREGRC	30	CAREX GRACILLIMA	.	.	1	.	.	1	.	.	.
CAREGYN	30	CAREX GYNANDRA	12	.	.	1	.	1	.	.	.
CAREHRS	30	CAREX HIRSUTELLA	.	1	.	.	.	.	.	.	.
CAREHIT	30	CAREX HITCHCOCKIANA	.	.	.	.	.	2	.	.	.
CAREINT	30	CAREX INTUMESCENS	11	.	8	5	.	1	1	5	.
CARELXCL	30	CAREX LAXICULMIS VAR LAXICULMIS	.	.	1	.	.	2	.	.	.
CARELXFL	30	CAREX LAXIFLORA VAR LAXIFLORA	.	1	12	20	11	12	2	19	.
CARELPO	30	CAREX LEPTONERVIA	.	.	10	4	.	.	.	8	.
CARELUCA	30	CAREX LUCORUM VAR AUSTROLUCORUM	.	.	.	9	1	.	.	13	.
CARELUR	30	CAREX LURIDA	.	.	.	1	.	.	.	.	.
CAREMAN	30	CAREX MANHARTII	.	.	.	28	.	14	1	9	.
CAREMIS	30	CAREX MISERA	.	.	1	.	.	.	.	.	.
CARENIG	30	CAREX NIGROMARGINATA	.	.	.	16	1	.	.	2	.
CARENOR	30	CAREX NORMALIS	.	.	.	.	.	3	.	.	.
CAREOLC	30	CAREX OLIGOCARPA	.	.	1	.	.	.	.	.	.
CAREPEN	30	CAREX PENSYLVANICA	47	8	29	35	5	35	10	45	6

Code	Family number	Scientific name	Study Areas BM	CR	GR	JK	LG	NM	SM	SR	TH
CAREPLN	30	CAREX PLANTAGINEA	6	.	1	10	.	4	4	1	.
CAREPLT	30	CAREX PLATYPHYLLA	.	.	.	8	.	1	.	1	.
CAREPUR	30	CAREX PURPURIFERA	.	.	.	.	.	5	.	.	.
CAREROS	30	CAREX ROSEA	.	.	.	.	.	2	.	.	.
CARERUT	30	CAREX RUTHII	.	.	.	3	.	1	1	4	.
CARESCA	30	CAREX SCABRATA	.	.	1	1	.	1	.	.	.
CARESCOS	30	CAREX SCOPARIA VAR SCOPARIA	1	.	.	.	.	.	.	1	.
CARESTY	30	CAREX STYLOFLEXA	.	1	.	.	.	.	.	.	.
CARESWA	30	CAREX SWANII	.	.	2	13	6	1	.	6	.
CARETOR	30	CAREX TORTA	.	.	.	2	1	.	.	.	.
CAREUMB	30	CAREX UMBELLATA	.	.	.	1	7	2	.	9	.
CAREVIR	30	CAREX VIRESCENS	.	4	4	5	7	7	1	17	.
CAREWOO	30	CAREX WOODII	.	.	.	.	.	1	.	1	.
CARERFB	30	CAREX--RED FIBROUS BASE	.	.	3	.	.	1	.	.	.
CYMOFRA	30	CYMOPHYLLUS FRASERI	.	.	1	8	.	1	.	.	.
SCIRPOL	30	SCIRPUS POLYPHYLLUS	.	.	.	.	.	1	.	.	.
SCLEPAU	30	SCLERIA PAUCIFLORA	.	.	.	.	.	2	.	.	.
SCLETRI	30	SCLERIA TRIGLOMERATA	.	.	.	.	.	2	.	.	.
ARISTRI	32	ARISAEMA TRIPHYLLUM	75	20	48	87	25	44	41	77	39
COMMCOML	38	COMMELINA COMMUNIS VAR LUDENS	.	1	.	.	.	2	.	.	.
COMMVIR	38	COMMELINA VIRGINICA	.	.	.	.	.	.	1	.	.
TRADOHI	38	TRADESCANTIA OHIENSIS	.	.	.	.	.	1	.	.	.
TRADSUB	38	TRADESCANTIA SUBASPERA	8	3	4	2	6	15	2	16	3
JUNCEFFS	40	JUNCUS EFFUSUS VAR SOLUTUS	.	.	.	.	.	.	.	.	1
JUNCGYM	40	JUNCUS GYMNOCARPUS	1	.	.	2	.	1	.	.	.
JUNCSUBS	40	JUNCUS SUBCAUDATUS VAR SUBCAUDATUS	1	.	.	.	.	.	.	.	.
JUNCTENT	40	JUNCUS TENUIS VAR TENUIS	.	.	.	.	.	.	.	1	.
LUZUACU	40	LUZULA ACUMINATA	25	4	4	10	.	3	1	21	.
LUZUECH	40	LUZULA ECHINATA	.	.	7	.	.	3	.	.	.
LUZUMULC	40	LUZULA MULTIFLORA VAR CONGESTA	.	.	.	22	4	2	.	24	.
ALLICERC	41	ALLIUM CERNUUM VAR CERNUUM	.	.	3	.	1	.	.	.	.
ALLITRI	41	ALLIUM TRICOCCUM	25	.	10	3	.	9	3	6	.
AMIAMUS	41	AMIANTHIUM MUSCAETOXICUM	2	10	2	12	11	6	.	12	1
CHAMLUT	41	CHAMAELIRIUM LUTEUM	1	26	4	36	48	7	1	21	51
CLINBOR	41	CLINTONIA BOREALIS	8	.	13	1	.	.	2	.	.

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
CLINUMB	41	CLINTONIA UMBELLULATA	30	6	10	37	15	18	12	29	13
CONVMON	41	CONVALLARIA MONTANA	.	.	.	.	1	.	.	.	.
ERYTAMEA	41	ERYTHRONIUM AMERICANUM VAR AMERICANUM	1	.	.	.	.	.	.	.	.
HYPOHIR	41	HYPOXIS HIRSUTA	.	6	2	11	4	6	2	1	16
LILIMIC	41	LILIUM MICHAUXII	3	4	6	18	10	11	6	23	6
LILISUP	41	LILIUM SUPERBUM	40	.	6	7	.	14	3	.	.
MAIACAN	41	MAIANTHEMUM CANADENSE	22	.	19	9	4	3	1	10	.
MAIARAC	41	MAIANTHEMUM RACEMOSUM	64	28	25	83	23	44	36	63	46
MEDEVIR	41	MEDEOLA VIRGINIANA	62	38	14	105	32	41	51	48	49
MELALAT	41	MELANTHIUM LATIFOLIUM	.	.	2	.	.	4	.	.	1
MELAPAR	41	MELANTHIUM PARVIFLORUM	22	8	18	41	11	24	4	11	14
MELAVIR	41	MELANTHIUM VIRGINICUM	.	.	2	4	.	.	.	7	.
POLYBIF	41	POLYGONATUM BIFLORUM	56	32	41	112	34	62	31	72	43
PROSLAN	41	PROSARTES LANUGINOSA	59	5	20	62	5	19	24	47	9
PROSMAC	41	PROSARTES MACULATUM	9	.	.	.	.	5	1	.	.
SMILBON	41	SMILAX BONA-NOX	.	.	.	.	1	.	.	.	53
SMILGLAG	41	SMILAX GLAUCA VAR GLAUCA	37	65	20	97	132	56	34	35	129
SMILHER	41	SMILAX HERBACEA	24	7	20	35	6	40	17	55	60
SMILROT	41	SMILAX ROTUNDIFOLIA	40	53	29	149	138	64	77	67	60
SMILTAM	41	SMILAX TAMNOIDES	.	1	7	.	.	6	7	.	.
STENGRAM	41	STENANTHIUM GRAMINEUM VAR MICRANTHUM	2	15	1	11	.	9	2	5	17
STREROSR	41	STREPTOPUS ROSEUS VAR ROSEUS	15	.	18	7	.	3	2	3	.
TRILCAT	41	TRILLIUM CATESBAEI	2	31	.	.	.	14	11	.	41
TRILCER	41	TRILLIUM CERNUUM	1	.	.	.	.	1	.	.	.
TRILCUN	41	TRILLIUM CUNEATUM	.	.	.	2	.	.	.	.	.
TRILERE	41	TRILLIUM ERECTUM	46	6	21	44	1	18	11	46	6
TRILGRA	41	TRILLIUM GRANDIFLORUM	13	1	3	10	.	8	.	.	.
TRILLUT	41	TRILLIUM LUTEUM	.	.	.	16	.	.	.	.	.
TRILRUG	41	TRILLIUM RUGELII	.	.	1	.	.	3	.	.	.
TRIL1S1	41	TRILLIUM SPECIES #1	.	.	2	.	.	1	15	.	5
TRILUND	41	TRILLIUM UNDULATUM	9	.	6	44	17	17	11	11	4
TRILVAS	41	TRILLIUM VASEYI	.	1	.	16	.	16	2	.	.
UVULGRA	41	UVULARIA GRANDIFLORA	15	1	6	2	.	10	3	1	.
UVULPER	41	UVULARIA PERFOLIATA	11	4	4	49	.	12	9	23	22
UVULPUBP	41	UVULARIA PUBERULA VAR PUBERULA	14	17	6	6	36	19	10	31	51

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
UVULSES	41	UVULARIA SESSILIFOLIA	1	9	3	.	.	6	11	.	42
VERAVIRV	41	VERATRUM VIRIDE VAR VIRIDE	8	1	3	.	.	5	2	.	.
XEROASP	41	XEROPHYLLUM ASPHODELOIDES	1	.	3	.	34	1	.	.	1
ZIGAELEG	41	ZIGADENUS ELEGANS VAR GLAUCUS	.	.	1	.	.	.	.	.	.
ZIGAGLA	41	ZIGADENUS GLABERRIMUS	.	.	1	.	.	.	.	.	.
DIOSOPP	43	DIOSCOREA OPPOSITIFOLIA	.	1	.	.	.	2	.	.	.
DIOSVIL	43	DIOSCOREA VILLOSA	37	26	13	88	36	51	43	70	78
IRISCRI	46	IRIS CRISTATA	9	1	3	22	5	5	4	.	1
IRIS1S1	46	IRIS SP. #1	.	.	.	.	.	.	.	.	37
IRISVER	46	IRIS VERNA	1	17	1	1	21	1	.	.	23
SISYANG	46	SISYRINCHIUM ANGUSTIFOLIUM	1	.	.	.	.	.	.	2	.
SISYMUC	46	SISYRINCHIUM MUCRONATUM	.	.	.	.	.	1	.	.	.
APLEHYE	49	APLECTRUM HYEMALE	6	.	2	1	.	4	.	.	.
CLEIBIF	49	CLEISTES BIFARA	.	.	.	.	.	1	.	.	.
CLEIDIV	49	CLEISTES DIVARICATA	.	1	.	.	.	.	.	.	.
CORAMAC	49	CORALLORHIZA MACULATA	4	.	.	.	.	.	.	.	.
CORAODOO	49	CORALLORHIZA ODONTORHIZA VAR ODONTORHIZA	2	.	.	1	.	.	.	.	12
CYPRACA	49	CYPRIPEDIUM ACAULE	6	9	5	9	6	3	1	5	7
CYPRPARB	49	CYPRIPEDIUM PARVIFLORUM VAR PUBESCENS	3	2	.	5	2	4	.	3	4
GALESPE	49	GALEARIS SPECTABILIS	8	5	3	11	2	11	4	8	.
GOODPUB	49	GOODYERA PUBESCENS	50	57	9	83	42	47	34	45	95
GOODREP	49	GOODYERA REPENS	6	.	2	.	23	5	.	.	.
ISOTVER	49	ISOTRIA VERTICILLATA	3	2	2	12	.	2	.	.	.
LIPALIL	49	LIPARIS LILIIFOLIA	.	1	.	4	1	1	.	2	1
LISTSMA	49	LISTERA SMALLII	6	4	3	2	11	5	1	12	.
MALAUNI	49	MALAXIS UNIFOLIA	1	1	.	.	1	.	.	.	2
PLATCIL	49	PLATANTHERA CILIARIS	.	.	.	.	.	3	.	.	2
PLATCLA	49	PLATANTHERA CLAVELLATA	1	.	.	8	.	.	1	5	1
PLATLACL	49	PLATANTHERA LACERA VAR LACERA	1	.	.	.	.	.	.	.	.
PLATORBO	49	PLATANTHERA ORBICULATA VAR ORBICULATA	1	.	3	.	1	.	.	.	.
PLATPSY	49	PLATANTHERA PSYCODES	1	.	1	.	.	.	.	.	.
SPIR1S1	49	SPIRANTHES SP.	1	.	.	.	8	.	.	.	.
TIPUDIS	49	TIPULARIA DISCOLOR	.	3	.	4	4	.	1	.	.
TRIPTRI	49	TRIPHORA TRIANTHOPHORA	2	1	.	.	.	.	.	.	1
COMPPER	52	COMPTONIA PEREGRINA	1	.	.	.	1	.	.	.	.

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
CARYALB	53	CARYA ALBA	18	37	4	40	15	19	12	32	57
CARYCOR	53	CARYA CORDIFORMIS	25	3	13	25	1	30	17	7	1
CARYGLA	53	CARYA GLABRA	24	48	9	71	33	46	27	41	132
CARYOVT	53	CARYA OVATA	10	6	2	18	11	2	1	4	1
CARYPAL	53	CARYA PALLIDA	.	7	.	5	7	1	.	.	.
JUGLCIN	53	JUGLANS CINEREA	2	.	2	2	.	5	1	.	2
JUGLNIG	53	JUGLANS NIGRA	1	1	5	2	1	8	.	3	.
ALNUSER	54	ALNUS SERRULATA	2	1	.	2	.	.	.	.	3
BETUALL	54	BETULA ALLEGHANIENSIS	77	.	42	65	7	34	52	56	.
BETULEN	54	BETULA LENTA	48	28	18	115	70	51	44	84	59
BETUNIG	54	BETULA NIGRA	.	.	.	.	.	.	.	.	1
BETUPAPC	54	BETULA PAPYRIFERA VAR CORDIFOLIA	4	.	.	.	.	.	.	.	.
CARPCARV	54	CARPINUS CAROLINIANA VAR VIRGINIANA	14	4	3	5	2	12	.	1	6
CORYAME	54	CORYLUS AMERICANA	.	.	1	.	.	2	.	.	.
CORYCORC	54	CORYLUS CORNUTA VAR CORNUTA	10	.	2	.	.	1	.	3	1
OSTRVIRV	54	OSTRYA VIRGINIANA VAR VIRGINIANA	50	.	9	6	1	10	.	11	.
CASTDEN	55	CASTANEA DENTATA	57	46	11	73	37	56	47	52	104
CASTPUMP	55	CASTANEA PUMILA VAR PUMILA	2	25	2	.	18	10	.	2	23
FAGUGRA	55	FAGUS GRANDIFOLIA	71	5	29	98	13	37	54	39	22
QUERALB	55	QUERCUS ALBA	29	56	9	42	42	55	15	14	113
QUERCOCC	55	QUERCUS COCCINEA VAR COCCINEA	20	46	8	44	52	28	21	13	60
QUERFAL	55	QUERCUS FALCATA	.	5	2	9	.	4	.	.	3
QUERIMB	55	QUERCUS IMBRICARIA	.	.	.	.	.	1	.	.	.
QUERMRL	55	QUERCUS MARILANDICA	.	4	1	1	4	.	.	.	8
QUERMON	55	QUERCUS MONTANA	39	44	17	75	119	32	46	65	120
QUERMUH	55	QUERCUS MUHLENBERGII	.	.	2	.	.	1	.	.	.
QUERRUB	55	QUERCUS RUBRA	72	43	36	130	86	87	82	110	133
QUERSTE	55	QUERCUS STELLATA	.	3	.	.	.	2	.	.	3
QUERVEL	55	QUERCUS VELUTINA	12	47	4	62	10	28	19	14	79
CELTOCC	56	CELTIS OCCIDENTALIS	.	.	3	.	.	.	.	.	.
ULMURUB	56	ULMUS RUBRA	.	1	4	.	.	7	.	.	.
MORURUBR	57	MORUS RUBRA VAR RUBRA	.	.	1	.	.	4	.	.	3
BOEHCYL	59	BOEHMERIA CYLINDRICA	.	2	1	.	1	.	1	.	3
LAPOCAN	59	LAPORTEA CANADENSIS	39	4	22	58	4	22	35	30	4
PILEPUMP	59	PILEA PUMILA VAR PUMILA	.	1	.	.	.	.	2	.	.

Code	Family number	Scientific name	BM	CR	GR	JK	LG	NM	SM	SR	TH
			Study Areas								
PHORSER	61	PHORADENDRON SEROTINUM	.	2	.	.	1	.	.	.	.
ARISMAC	62	ARISTOLOCHIA MACROPHYLLA	46	4	18	67	7	21	14	61	1
ARISSER	62	ARISTOLOCHIA SERPENTARIA	.	8	2	3	1	5	.	1	10
ASARCAN	62	ASARUM CANADENSE	20	.	1	9	.	5	2	2	.
HEXAARI	62	HEXASTYLIS ARIFOLIA	.	1	.	1	.	8	3	.	.
HEXAHET	62	HEXASTYLIS HETEROPHYLLA	.	.	.	.	.	.	.	.	5
HEXASHUS	62	HEXASTYLIS SHUTTLEWORTHII VAR SHUTTLEWORTHII	1	11	1	.	29	7	1	.	5
HEXA1S1	62	HEXASTYLIS SPECIES	.	1	.	.	.	.	.	.	22
HEXAVIR	62	HEXASTYLIS VIRGINICA	.	.	1	.	45	.	.	.	.
POLYCIL	63	POLYGONUM CILINODE	3	.	.	.	.	.	.	.	.
POLYCONC	63	POLYGONUM CONVOLVULUS VAR CONVOLVULUS	.	.	.	.	6	.	.	6	.
POLYPER	63	POLYGONUM PERSICARIA	1	.	.	1	.	.	.	.	.
POLYSCA	63	POLYGONUM SCANDENS	.	.	.	.	.	2	.	.	.
POLYVGN	63	POLYGONUM VIRGINIANUM	.	1	1	7	.	6	5	.	2
RUMEACE	63	RUMEX ACETOSELLA	.	.	.	.	1	2	.	.	.
RUMECRI	63	RUMEX CRISPUS	.	.	1	.	.	.	.	1	.
RUMEOBT	63	RUMEX OBTUSIFOLIUS	.	.	.	.	1	.	.	.	.
PHYTAME	68	PHYTOLACCA AMERICANA	.	2	.	.	2	2	2	1	.
CLAYCARC	70	CLAYTONIA CAROLINIANA VAR CAROLINIANA	6	.	.	.	.	.	.	.	.
CLAYVIR	70	CLAYTONIA VIRGINICA	.	.	.	.	.	3	.	.	.
DIANARM	71	DIANTHUS ARMERIA	.	.	.	.	.	1	.	.	.
SILESTE	71	SILENE STELLATA	4	1	3	15	3	10	8	9	3
SILEVIRV	71	SILENE VIRGINICA VAR VIRGINICA	1	.	2	13	6	2	.	13	.
STELMED	71	STELLARIA MEDIA	.	.	2	.	.	.	.	.	.
STELPUB	71	STELLARIA PUBERA	50	9	25	96	15	25	48	11	.
CERADEM	72	CERATOPHYLLUM DEMERSUM	.	1	.	.	.	.	.	.	.
ACONREC	76	ACONITUM RECLINATUM	3	.	2	.	.	.	.	.	.
ACONUNC	76	ACONITUM UNCINATUM	1	.	.	.	.	5	.	.	.
ACTAPAC	76	ACTAEA PACHYPODA	26	5	9	19	.	16	11	10	9
ANEMQUIQ	76	ANEMONE QUINQUEFOLIA VAR QUINQUEFOLIA	45	4	8	34	.	19	6	21	.
ANEMVIRV	76	ANEMONE VIRGINIANA VAR VIRGINIANA	.	.	2	.	.	4	.	.	.
ANEMTHA	76	ANEMONELLA THALICTROIDES	1	1	.	20	.	6	14	1	.
AQUICAN	76	AQUILEGIA CANADENSIS	.	.	5	1	1	.	.	4	.
CIMIAME	76	CIMICIFUGA AMERICANA	20	.	13	4	2	8	3	1	.
CIMIRAC	76	CIMICIFUGA RACEMOSA	57	.	10	45	6	24	21	31	1

Code	Family number	Scientific name	BM	CR	GR	JK	LG	NM	SM	SR	TH
			Study Areas								
CLEMCAT	76	CLEMATIS CATESBYANA	.	.	4	.	.	.	.	.	.
CLEMVIO	76	CLEMATIS VIORNA	1	.	1	.	.	5	.	15	.
CLEMVIR	76	CLEMATIS VIRGINIANA	7	4	3	.	3	8	.	6	2
DELPEXA	76	DELPHINIUM EXALTATUM	.	.	1	.	.	.	.	.	.
DELPTRI	76	DELPHINIUM TRICORNE	5	.	.	.	.	.	.	.	.
HEPAACU	76	HEPATICA ACUTILOBA	18	.	.	14	.	5	2	.	2
HYDRCND	76	HYDRASTIS CANADENSIS	.	.	.	.	.	1	.	.	.
RANUABOA	76	RANUNCULUS ABORTIVUS VAR ABORTIVUS	.	.	1	.	.	3	.	1	.
RANUACRA	76	RANUNCULUS ACRIS VAR ACRIS	2	.	.	.	.	.	.	.	.
RANUARV	76	RANUNCULUS ARVENSIS	.	1	.	.	.	.	.	.	.
RANUHIS	76	RANUNCULUS HISPIDUS	7	3	.	19	1	13	.	9	3
RANUREC	76	RANUNCULUS RECURVATUS	.	.	6	2	3	14	6	11	.
RANUREP	76	RANUNCULUS REPENS	.	.	.	.	2	.	.	.	.
THALCLA	76	THALICTRUM CLAVATUM	8	2	9	13	1	5	4	27	2
THALCOR	76	THALICTRUM CORIACEUM	.	.	4	10	1	.	.	1	.
THALDIO	76	THALICTRUM DIOICUM	29	3	.	18	1	13	3	1	1
THALMAC	76	THALICTRUM MACROSTYLUM	.	.	.	.	.	8	.	.	.
THALPUB	76	THALICTRUM PUBESCENS	.	1	1	.	2	.	1	3	.
THALREV	76	THALICTRUM REVOLUTUM	.	.	2	4	1	9	.	1	.
THAL1S1	76	THALICTRUM SP.	.	.	3	.	.	1	10	.	12
TRAUCARC	76	TRAUTVETTERIA CAROLINIENSIS VAR CAROLINIENSIS	.	.	5	5	1	7	3	.	.
XANTSIM	76	XANTHORHIZA SIMPLICISSIMA	.	3	.	.	1	1	.	2	4
BERBTHU	77	BERBERIS THUNBERGII	.	.	.	.	.	1	.	.	.
CAULTHA	77	CAULOPHYLLUM THALICTROIDES	48	3	15	34	1	27	21	36	1
DIPHCYM	77	DIPHYLLEIA CYMOSA	14	2	3	7	.	7	4	6	1
PODOPEL	77	PODOPHYLLUM PELTATUM	11	2	3	14	1	19	4	6	.
COCCCAR	79	COCCULUS CAROLINUS	.	.	1	.	.	.	.	.	.
MENICAN	79	MENISPERMUM CANADENSE	.	.	2	1	.	.	.	.	8
LIRITUL	80	LIRIODENDRON TULIPIFERA	62	52	19	117	54	45	60	34	110
MAGNACUA	80	MAGNOLIA ACUMINATA VAR ACUMINATA	43	10	12	69	.	40	40	51	2
MAGNFRA	80	MAGNOLIA FRASERI	36	54	22	106	74	33	60	32	93
MAGNTRI	80	MAGNOLIA TRIPETALA	.	.	2	2	.	.	.	.	.
ASIMTRI	81	ASIMINA TRILOBA	.	3	.	5	2	1	.	.	4
CALYFLOG	83	CALYCANTHUS FLORIDUS VAR GLAUCUS	2	9	2	34	4	7	32	4	40
LINDBEN	84	LINDERA BENZOIN	10	10	3	20	.	15	5	3	5

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
SASSALB	84	SASSAFRAS ALBIDUM	21	45	20	91	69	52	50	24	110
SANGCND	85	SANGUINARIA CANADENSIS	26	5	7	18	4	25	10	19	3
CORYSEM	86	CORYDALIS SEMPERVIRENS	.	.	.	.	1	1	.	.	.
ARABCAN	88	ARABIS CANADENSIS	.	.	.	.	2	2	.	5	.
ARABLAE	88	ARABIS LAEVIGATA	17	.	8	.	9	7	.	15	.
BRASNAP	88	BRASSICA NAPUS	.	.	.	.	.	1	.	.	.
CARDANGA	88	CARDAMINE ANGUSTATA VAR ANGUSTATA	.	.	.	.	.	1	.	.	.
CARDCLE	88	CARDAMINE CLEMATITIS	.	.	6	.	.	.	.	2	.
CARDCON	88	CARDAMINE CONCATENATA	.	.	.	.	.	.	1	2	.
CARDDIP	88	CARDAMINE DIPHYLLA	.	.	2	41	4	11	18	1	.
CARDFLA	88	CARDAMINE FLAGELLIFERA	.	.	1	.	2	12	.	.	.
SEDUTLD	91	SEDUM TELEPHIOIDES	2	.	.	.	.	.	.	.	.
SEDUTER	91	SEDUM TERNATUM	19	.	6	1	.	4	.	16	.
ASTIBIT	94	ASTILBE BITERNATA	10	.	3	4	.	14	3	.	.
CHRYAME	94	CHRYSOSPLENIUM AMERICANUM	.	.	.	.	.	.	2	.	.
DECUBAR	94	DECUMARIA BARBARA	.	.	.	.	.	.	.	.	6
HEUCASS	94	HEUCHERA AMERICANA	3	.	1	2	3	3	.	5	.
HEUCVILV	94	HEUCHERA VILLOSA VAR VILLOSA	14	2	9	15	6	13	1	3	10
HYDRARB	94	HYDRANGEA ARBORESCENS	32	6	18	63	2	24	19	10	59
HYDRCIN	94	HYDRANGEA CINEREA	.	1	.	.	.	.	.	.	.
HYDRRAD	94	HYDRANGEA RADIATA	.	11	1	.	.	.	.	.	.
MITEDIP	94	MITELLA DIPHYLLA	2	.	2	1	.	.	1	.	.
PARNASA	94	PARNASSIA ASARIFOLIA	.	.	.	.	.	2	.	.	.
PARNGRA	94	PARNASSIA GRANDIFOLIA	.	.	.	.	.	5	.	.	.
RIBECYN	94	RIBES CYNOSBATI	3	.	17	7	.	7	.	8	.
RIBEGLA	94	RIBES GLANDULOSUM	.	.	2	.	.	.	.	1	.
RIBEROT	94	RIBES ROTUNDIFOLIUM	18	.	3	.	.	.	.	6	.
SAXICRY	94	SAXIFRAGA CAREYANA	1	.	2	.	.	.	.	.	.
SAXIMCH	94	SAXIFRAGA MICHAUXII	7	.	4	1	3	1	2	.	.
SAXIMCR	94	SAXIFRAGA MICRANTHIDIFOLIA	.	.	7	5	.	3	1	1	1
SAXIVIR	94	SAXIFRAGA VIRGINIENSIS	.	.	.	.	.	1	.	.	.
TIARCOR	94	TIARELLA CORDIFOLIA	34	5	14	60	2	30	34	30	4
FOTHMAJ	95	FOTHERGILLA MAJOR	.	.	.	.	15	.	.	.	.
HAMAVIR	95	HAMAMELIS VIRGINIANA	64	27	23	47	83	36	42	26	51
LIQUSTY	95	LIQUIDAMBAR STYRACIFLUA	.	.	.	6	11	.	.	.	18

Code	Family number	Scientific name	BM	CR	GR	JK	LG	NM	SM	SR	TH
			Study Areas								
PLATOCC	96	PLATANUS OCCIDENTALIS	4	.	1	4	1	2	.	.	.
AGRIGRY	97	AGRIMONIA GRYPOSEPALA	4	1	2	2	.	2	.	3	.
AGRIPAR	97	AGRIMONIA PARVIFLORA	.	.	.	.	.	1	.	.	1
AGRIPUB	97	AGRIMONIA PUBESCENS	.	3	1	.	.	4	.	.	.
AGRIROS	97	AGRIMONIA ROSTELLATA	.	.	.	.	.	3	.	.	2
AMELARB	97	AMELANCHIER ARBOREA	47	46	37	98	52	81	62	88	79
AMELCAN	97	AMELANCHIER CANADENSIS	.	.	2	.	.	.	.	.	.
AMELSANS	97	AMELANCHIER SANGUINEA VAR SANGUINEA	.	.	.	.	1	.	.	.	.
ARONARB	97	ARONIA ARBUTIFOLIA	1	.	.	.	2	2	.	.	.
ARONMEL	97	ARONIA MELANOCARPA	4	.	.	1	.	3	.	2	.
ARUNDIOD	97	ARUNCUS DIOICUS VAR DIOICUS	8	.	.	7	1	4	1	.	7
CRAT1S1	97	CRATEGUS SP.#1	17	7	12	1	2	19	2	17	.
FILIRUB	97	FILIPENDULA RUBRA	1	.	.	.	.	.	.	.	.
FRAGVIRV	97	FRAGARIA VIRGINIANA VAR VIRGINIANA	1	.	1	.	.	2	.	.	.
GEUMCAN	97	GEUM CANADENSE	1	.	1	4	.	5	.	4	.
GEUMGEN	97	GEUM GENICULATUM	.	.	7	.	.	.	.	.	.
GEUMVIR	97	GEUM VIRGINIANUM	.	2	2	.	.	1	.	.	.
MALUANGA	97	MALUS ANGUSTIFOLIA VAR ANGUSTIFOLIA	.	.	.	.	.	1	.	.	.
MALUCOR	97	MALUS CORONARIA	.	.	.	.	1	1	.	.	.
MALUPUM	97	MALUS PUMILA	.	.	.	.	.	.	.	1	.
PHYSOPUO	97	PHYSOCARPUS OPULIFOLIUS VAR OPULIFOLIUS	.	.	.	.	.	8	.	.	.
PORTTRI	97	PORTERANTHUS TRIFOLIATUS	11	11	1	5	2	17	2	4	57
POTECAN	97	POTENTILLA CANADENSIS	23	13	7	28	16	31	12	36	45
POTEREC	97	POTENTILLA RECTA	.	.	.	.	.	.	.	.	1
PRUNPEN	97	PRUNUS PENSYLVANICA	8	.	10	53	6	4	11	51	.
PRUNSER	97	PRUNUS SEROTINA	77	15	36	40	5	58	63	38	19
ROSACAR	97	ROSA CAROLINA	.	.	3	.	.	3	.	.	.
ROSAMUL	97	ROSA MULTIFLORA	.	.	.	.	1	1	.	1	.
ROSAPAL	97	ROSA PALUSTRIS	1	.	.	.	.	.	.	.	.
ROSAWIC	97	ROSA WICHURAIANA	.	.	.	.	.	.	.	1	.
RUBUALLA	97	RUBUS ALLEGHENIENSIS VAR ALLEGHENIENSIS	53	19	46	108	22	56	32	68	.
RUBUFLA	97	RUBUS FLAGELLARIS	.	1	.	3	.	3	.	1	.
RUBUHIS	97	RUBUS HISPIDUS	2	.	.	.	.	2	.	.	.
RUBUIDA	97	RUBUS IDAEUS	5	.	.	.	.	.	.	.	.
RUBUOCC	97	RUBUS OCCIDENTALIS	.	.	1	.	.	2	.	.	.

Code	Family number	Scientific name	Study Areas BM	CR	GR	JK	LG	NM	SM	SR	TH
RUBUODOO	97	RUBUS ODORATUS VAR ODORATUS	1	.	.	2	.	4	.	.	.
RUBU1S1	97	RUBUS SP.	2	3	1	.	.	3	26	.	72
RUBUTRI	97	RUBUS TRIVIALIS	.	.	1	.	.	.	.	.	.
SANGCNN	97	SANGUISORBA CANADENSIS	.	.	.	.	.	5	.	.	.
SORBAME	97	SORBUS AMERICANA	21	.	18	2	.	9	.	21	.
SPIRLAT	97	SPIREA LATIFOLIA	.	.	.	.	.	3	.	.	.
AMORGLA	98	AMORPHA GLABRA	.	.	.	.	.	.	.	.	1
AMPHBRA	98	AMPHICARPAEA BRACTEATA	.	11	10	38	9	24	20	20	34
APIOAME	98	APIOS AMERICANA	1	.	.	.	.	1	.	.	.
BAPTTIN	98	BAPTISIA TINCTORIA	.	3	1	6	.	3	.	.	13
CERCCANC	98	CERCIS CANADENSIS VAR CANADENSIS	.	.	.	2	.	.	2	.	.
CHAMNICN	98	CHAMAECRISTA NICTITANS VAR NICTITANS	.	2	.	.	.	.	.	.	1
CLADKEN	98	CLADRASTIS KENTUKEA	.	.	.	4	.	5	1	.	.
CLITMAR	98	CLITORIA MARIANA	.	.	.	5	2	4	1	3	.
DESMGLU	98	DESMODIUM GLUTINOSUM	.	2	3	5	.	6	1	.	.
DESMNUD	98	DESMODIUM NUDIFLORUM	3	26	3	50	12	23	13	11	67
DESMPAN	98	DESMODIUM PANICULATUM	.	.	.	1	1	1	1	.	1
DESMROT	98	DESMODIUM ROTUNDIFOLIUM	.	.	.	3	.	2	.	.	1
DESM1S1	98	DESMODIUM SP. #1	14	5	2	.	.	2	.	.	17
GLEDTRI	98	GLEDITSIA TRIACANTHOS	.	.	.	.	.	1	.	.	.
LATHVEN	98	LATHYRUS VENOSUS	.	.	1	.	.	.	.	.	.
LESP1S1	98	LESPEDEZA SPECIES 1	.	.	1	4	3	4	.	3	4
MIMOQUAA	98	MIMOSA QUADRIVALVIS VAR ANGUSTATA	.	.	.	.	.	2	.	.	.
PHASPOL	98	PHASEOLUS POLYSTACHIOS	.	.	.	.	.	.	.	.	1
ROBIHIS	98	ROBINIA HISPIDA	.	.	1	.	.	.	.	1	2
ROBIPSE	98	ROBINIA PSEUDOACACIA	35	45	16	83	44	39	35	81	127
SCHRMIC	98	SCHRANKIA MICROPHYLLA	.	.	.	.	.	.	.	.	4
STYLBIF	98	STYLOSANTHES BIFLORA	.	.	.	.	.	2	.	.	.
TEPHVIR	98	TEPHROSIA VIRGINIANA	1	.	.	6	.	5	1	.	1
THERFRA	98	THERMOPSIS FRAXINIFOLIA	.	.	.	.	1	.	.	.	5
TRIFINC	98	TRIFOLIUM INCARNATUM	.	.	.	.	1	.	.	.	.
VICICAR	98	VICIA CAROLINIANA	.	.	.	.	3	7	2	5	.
LINUVIR	99	LINUM VIRGINIANUM	.	.	1	.	.	.	.	.	.
OXALGRA	100	OXALIS GRANDIS	.	.	1	2	.	6	.	.	.
OXALMON	100	OXALIS MONTANA	26	.	14	18	.	2	11	1	.

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
OXAL1S1	100	OXALIS SP. #1	.	.	.	.	.	1	4	.	2
OXALSTR	100	OXALIS STRICTA	2	2	.	6	3	1	.	5	.
OXALVIO	100	OXALIS VIOLACEA	.	.	1	.	.	.	.	.	.
GERAMAC	101	GERANIUM MACULATUM	8	.	.	9	1	8	.	7	.
POLYPAU	106	POLYGALA PAUCIFOLIA	.	.	.	.	.	6	.	.	.
POLYPLG	106	POLYGALA POLYGAMA	.	2	.	.	.	.	.	.	.
ACAL1S1	107	ACALYPHA SPECIES	.	.	.	1	.	1	.	.	.
CHAMMAC	107	CHAMAESYCE MACULATA	.	1	.	.	.	.	.	.	.
CROTELL	107	CROTONOPSIS ELLIPTICA	.	.	.	.	.	.	.	.	1
EUPHCOR	107	EUPHORBIA COROLLATA	.	18	3	9	.	15	.	8	56
EUPHPUR	107	EUPHORBIA PURPUREA	.	.	.	.	.	2	.	.	.
EUPHSPA	107	EUPHORBIA SPATHULATA	.	.	1	.	.	.	.	.	.
RHUSCOP	110	RHUS COPALLINA	.	.	.	1	2	2	.	.	3
RHUSGLA	110	RHUS GLABRA	.	.	.	.	.	1	.	.	.
RHUSTYP	110	RHUS TYPHINA	.	.	.	.	.	.	.	1	.
TOXIRAD	110	TOXICODENDRON RADICANS	18	10	10	19	9	22	5	4	16
ILEXMON	112	ILEX MONTANA	58	9	24	79	19	48	47	39	23
ILEXOPAO	112	ILEX OPACA VAR OPACA	3	44	2	41	23	7	26	.	52
ILEXVER	112	ILEX VERTICILLATA	1	.	.	.	1	1	.	.	.
CELASCA	113	CELASTRUS SCANDENS	.	.	1	.	.	1	.	.	.
EUONAME	113	EUONYMUS AMERICANA	3	23	2	46	6	11	14	6	25
EUON1S1	113	EUONYMUS SPECIES	.	.	.	.	.	.	3	.	.
EUONOBO	113	EVONYMUS OBOVATA	16	.	.	15	.	5	4	4	.
ACERNIG	115	ACER NIGRUM	.	.	.	.	.	4	.	.	.
ACERPEN	115	ACER PENSYLVANICUM	102	1	47	154	44	55	78	109	2
ACERRUB	115	ACER RUBRUM	84	72	40	157	157	85	93	117	150
ACERSCMS	115	ACER SACCHARUM VAR SACCHARUM	81	.	33	95	.	34	69	60	.
ACERSPI	115	ACER SPICATUM	27	.	34	9	.	6	8	15	.
AESCFLA	116	AESCULUS FLAVA	74	5	32	65	2	29	47	51	.
IMPACAP	118	IMPATIENS CAPENSIS	3	.	4	10	.	1	.	.	2
IMPAPAL	118	IMPATIENS PALLIDA	31	1	27	11	2	19	14	21	.
CEANAMEA	119	CEANOTHUS AMERICANUS VAR AMERICANUS	.	.	1	.	.	6	.	2	.
PARTQUIQ	120	PARTHENOCISSUS QUINQUEFOLIA VAR QUINQUEFOLIA	19	19	14	57	31	32	22	12	29
VITIAES	120	VITIS AESTIVALIS	2	29	9	42	23	18	23	25	.
VITICINB	120	VITIS CINEREA VAR BAILEYANA	.	.	1	15	2	2	1	.	.

Code	Family number	Scientific name	BM	CR	GR	JK	LG	NM	SM	SR	TH
			Study Areas								
VITILAB	120	VITIS LABRUSCA	.	.	1	.	.	.	.	.	.
VITIROT	120	VITIS ROTUNDIFOLIA	.	13	1	9	2	2	2	1	50
VITI1S1	120	VITIS SP. #1	.	2	.	.	.	1	16	.	66
VITIVUL	120	VITIS VULPINA	.	1	.	21	2	1	4	2	.
TILIAMEH	121	TILIA AMERICANA VAR HETEROPHYLLA	50	11	18	82	7	33	34	37	8
STEWOVA	124	STEWARTIA OVATA	.	.	.	7	.	.	.	.	.
HYPECRU	126	HYPERICUM CRUX-ANDREAE	.	.	.	.	.	1	.	.	.
HYPEDNS	126	HYPERICUM DENSIFLORUM	.	.	.	.	3	.	.	.	.
HYPEHYP	126	HYPERICUM HYPERICOIDES	.	.	.	.	1	.	.	.	8
HYPEMUTM	126	HYPERICUM MUTILUM VAR MUTILUM	.	.	1	.	.	.	.	.	.
HYPEPRO	126	HYPERICUM PROLIFICUM	.	.	.	.	.	1	.	.	.
HYPE1S1	126	HYPERICUM SP. #1	2	1	.	.	3	4	.	5	.
HYPE1S2	126	HYPERICUM SP. #2	.	.	.	1	.	.	.	.	.
HYPESTR	126	HYPERICUM STRAGULUM	.	.	.	5	1	2	.	1	.
LECH1S1	129	LECHEA SP. #1	.	.	.	.	.	1	.	.	.
HYBACON	130	HYBANTHUS CONCOLOR	.	.	1	.	.	2	.	.	.
VIOLAFF	130	VIOLA AFFINIS	.	.	.	.	10	3	.	7	.
VIOLBLA	130	VIOLA BLANDA	31	11	17	77	11	3	28	66	.
VIOLCAN1	130	VIOLA CANADENSIS VAR CANADENSIS	41	.	14	31	1	13	22	4	.
VIOLCUC	130	VIOLA CUCULLATA	2	2	4	.	3	7	.	2	.
VIOLHAS	130	VIOLA HASTATA	19	39	8	111	42	21	43	43	53
VIOLLAB	130	VIOLA LABRADORICA	.	.	.	.	.	4	.	.	.
VIOLPAL	130	VIOLA PALMATA	1	9	4	18	4	2	10	2	.
VIOLPED	130	VIOLA PEDATA	.	1	.	.	.	3	.	.	2
VIOLPRI	130	VIOLA PRIMULIFOLIA	.	1	.	.	.	1	.	.	.
VIOLPUB	130	VIOLA PUBESCENS	16	3	1	8	1	3	6	9	.
VIOLROS	130	VIOLA ROSTRATA	.	.	.	.	.	1	.	.	.
VIOLROT	130	VIOLA ROTUNDIFOLIA	49	10	16	48	6	13	25	42	23
VIOLSAG	130	VIOLA SAGITTATA	1	.	.	.	.	3	.	1	.
VIOLSOR	130	VIOLA SORORIA	38	11	6	59	1	37	.	16	.
VIOL1S1	130	VIOLA SP. #1	20	3	13	.	.	6	35	.	87
VIOLSTR	130	VIOLA STRIATA	.	.	3	4	.	.	.	.	.
VIOLTRP	130	VIOLA TRIPARTITA	.	1	.	.	.	.	.	.	.
PASSLUT	131	PASSIFLORA LUTEA	.	3	2	1	.	2	1	.	.
DIRCPAL	133	DIRCA PALUSTRIS	.	.	.	.	.	1	.	.	.

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
CIRCALPA	137	CIRCAEA ALPINA VAR ALPINA	5	.	13	4	.	6	4	10	.
CIRCCAN	137	CIRCAEA CANADENSIS	.	4	3	7	2	11	4	7	.
OENOFSS	137	OENOTHERA FRUTICOSA	.	.	.	.	.	10	.	1	.
OENOTET	137	OENOTHERA TETRAGONA	.	.	.	.	.	1	.	.	.
ARALNUD	139	ARALIA NUDICAULIS	4	.	3	1	13	6	1	3	3
ARALRACR	139	ARALIA RACEMOSA VAR RACEMOSA	3	1	.	12	1	7	1	21	6
ARALSPI	139	ARALIA SPINOSA	.	.	.	3	2	1	.	.	14
PANAQUI	139	PANAX QUINQUEFOLIUS	6	4	3	28	1	15	6	9	19
ANGETRI	140	ANGELICA TRIQUINATA	22	.	17	6	.	6	1	12	.
ANGEVEN	140	ANGELICA VENOSA	.	2	1	7	.	9	.	.	.
CICUMACM	140	CICUTA MACULATA VAR MACULATA	.	.	1	.	.	.	.	.	.
CONICHI	140	CONIOSELINUM CHINENSE	.	.	1	.	.	.	.	.	.
CRYPCAN	140	CRYPTOTAENIA CANADENSIS	3	.	3	8	3	9	2	.	.
ERYNYUC	140	ERYNGIUM YUCCIFOLIUM	.	.	.	.	.	1	.	.	1
HERALAN	140	HERACLEUM LANATUM	.	.	.	.	.	1	1	1	.
LIGUCAN	140	LIGUSTICUM CANADENSE	7	4	1	.	1	17	.	12	17
OSMOCLA	140	OSMORHIZA CLAYTONII	27	.	15	36	2	18	12	14	.
OSMOLON	140	OSMORHIZA LONGISTYLIS	2	.	2	.	.	1	1	.	.
OXYPRIG	140	OXYPOLIS RIGIDIOR	.	1	.	3	1	9	.	.	.
SANICANC	140	SANICULA CANADENSIS VAR CANADENSIS	.	6	5	20	2	13	6	10	10
SANIMAR	140	SANICULA MARILANDICA	1	.	.	.	.	.	.	.	.
SANIODO	140	SANICULA ODORATA	23	.	3	6	.	5	.	11	.
SANISMA	140	SANICULA SMALLII	.	2	2	3	.	1	.	.	.
SANI1S1	140	SANICULA SP.	.	.	.	.	.	1	6	.	.
SANITRI	140	SANICULA TRIFOLIATA	19	2	2	3	.	2	2	.	1
TAENINT	140	TAENIDIA INTEGERRIMA	.	.	1	.	.	.	.	.	.
THASBAR	140	THASPIUM BARBINODE	12	.	5	5	10	4	.	11	.
THASPIN	140	THASPIUM PINNATIFIDUM	.	.	1	.	.	.	.	.	.
THASTRI	140	THASPIUM TRIFOLIATUM	.	1	1	1	.	2	.	.	7
ZIZIAPT	140	ZIZIA APTERA	.	.	.	.	.	2	.	.	.
ZIZIAUR	140	ZIZIA AUREA	4	.	.	.	.	.	.	.	.
ZIZITRI	140	ZIZIA TRIFOLIATA	13	1	9	2	27	6	.	43	21
NYSSSYL	141	NYSSA SYLVATICA	27	63	20	76	134	37	49	19	141
CORNALT	142	CORNUS ALTERNIFOLIA	41	12	23	29	.	32	22	13	17
CORNAMOA	142	CORNUS AMOMUM VAR AMOMUM	.	.	.	.	.	2	.	.	.

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
CORNFLO	142	CORNUS FLORIDA	39	54	10	70	43	28	43	38	129
CLETACU	143	CLETHRA ACUMINATA	3	13	4	12	17	16	8	11	23
CHIMMACM	145	CHIMAPHILA MACULATA VAR MACULATA	22	63	9	68	62	47	30	42	110
EPIGREP	145	EPIGAEA REPENS	7	10	3	31	27	15	13	11	30
GAULPRO	145	GAULTHERIA PROCUMBENS	4	2	6	8	39	7	6	.	1
GAYLBAC	145	GAYLUSSACIA BACCATA	5	1	7	9	44	13	5	5	10
GAYLDUMD	145	GAYLUSSACIA DUMOSA VAR DUMOSA	.	1	.	.	.	.	.	.	.
GAYLURS	145	GAYLUSSACIA URSINA	.	51	.	81	.	32	42	.	98
KALMLAT	145	KALMIA LATIFOLIA	47	51	22	71	143	52	32	63	130
LEIOBUX	145	LEIOPHYLLUM BUXIFOLIUM	.	.	.	.	6	.	.	.	.
LEUCFON	145	LEUCOTHOE FONTANESIANA	12	14	1	23	4	8	10	7	23
LEUCREC	145	LEUCOTHOE RECURVA	7	8	7	.	56	11	1	12	18
LYONLIGL	145	LYONIA LIGUSTRINA VAR LIGUSTRINA	3	5	9	11	57	13	6	13	24
MENZPIL	145	MENZIESIA PILOSA	4	1	4	.	2	2	.	3	.
MONOHYP	145	MONOTROPA HYPOPITHYS	.	11	1	4	3	1	4	1	12
MONOUNI	145	MONOTROPA UNIFLORA	17	26	13	27	13	26	16	27	38
MONOODO	145	MONOTROPSIS ODORATA	.	.	.	.	1	.	.	.	.
OXYDARB	145	OXYDENDRUM ARBOREUM	33	58	16	93	121	28	54	35	139
PIERFLO	145	PIERIS FLORIBUNDA	.	.	.	.	.	.	.	12	.
RHODARB	145	RHODODENDRON ARBORESCENS	.	.	.	1	.	4	.	.	.
RHODCAL	145	RHODODENDRON CALENDULACEUM	12	10	3	46	5	33	24	32	50
RHODCAT	145	RHODODENDRON CATAWBIENSE	22	.	13	1	26	14	2	29	.
RHODMAX	145	RHODODENDRON MAXIMUM	73	40	26	90	111	50	46	58	82
RHODMIN	145	RHODODENDRON MINUS	.	12	2	4	55	.	.	24	32
RHODPER	145	RHODODENDRON PERICLYMENOIDES	.	.	.	2	4	.	.	.	.
RHODVAS	145	RHODODENDRON VASEYI	.	.	2	.	.	.	.	.	2
RHODVIS	145	RHODODENDRON VISCOSUM	2	.	.	.	.	3	.	.	1
VACCARBA	145	VACCINIUM ARBOREUM VAR ARBOREUM	.	1	.	.	.	1	.	.	10
VACCCOR	145	VACCINIUM CORYMBOSUM	34	12	9	18	28	34	11	20	8
VACCERY	145	VACCINIUM ERYTHROCARPUM	15	.	11	17	.	9	11	18	.
VACCFUS	145	VACCINIUM FUSCATUM	.	.	1	.	1	.	.	.	.
VACCHIR	145	VACCINIUM HIRSUTUM	.	.	.	25	.	.	15	.	.
VACCPAL	145	VACCINIUM PALLIDUM	15	46	13	59	75	29	23	28	77
VACCSIM	145	VACCINIUM SIMULATUM	.	3	7	29	35	25	15	30	10
VACCSTA	145	VACCINIUM STAMINEUM	6	24	2	49	45	30	16	30	83

Code	Family number	Scientific name	BM	CR	GR	JK	LG	NM	SM	SR	TH
			Study Areas								
GALAURC	146	GALAX URCEOLATA	33	33	17	56	103	27	32	34	71
SHORGAL	146	SHORTIA GALACIFOLIA	.	.	.	.	.	.	.	.	3
LYSICIL	147	LYSIMACHIA CILIATA	.	.	.	.	.	2	.	.	.
LYSIFRA	147	LYSIMACHIA FRASERI	.	4	.	.	.	.	.	.	.
LYSIQUA	147	LYSIMACHIA QUADRIFOLIA	32	26	6	60	16	39	24	49	72
LYSITER	147	LYSIMACHIA TERRESTRIS	.	.	.	.	3	.	.	.	.
DIOSVIR	150	DIOSPYROS VIRGINIANA	.	17	.	7	11	6	.	1	38
SYMPTIN	151	SYMPLOCOS TINCTORIA	15	31	12	.	97	6	.	.	63
HALETET	152	HALESIA TETRAPTERA	.	37	1	127	22	14	69	67	43
CHIOVIRV	153	CHIONANTHUS VIRGINICUS VAR VIRGINICUS	.	1	1	.	4	4	.	.	.
FRAXAME	153	FRAXINUS AMERICANA	61	14	27	86	6	51	35	45	22
LIGUSIN	153	LIGUSTRUM SINENSE	.	.	.	.	.	2	.	.	.
BARTVIR	155	BARTONIA VIRGINICA	.	.	.	.	.	1	.	.	.
FRASCAR	155	FRASERA CAROLINIENSIS	.	.	.	.	.	2	.	.	.
GENT2S1	155	GENTIANA SPECIES	27	3	8	32	17	14	7	29	4
GENTCRI	155	GENTIANOPSIS CRINITA	.	.	.	.	.	1	.	.	.
SABAANG	155	SABATIA ANGULARIS	.	.	1	.	.	2	.	.	.
APOCAND	156	APOCYNUM ANDROSAEMIFOLIUM	.	.	.	.	1	2	.	.	2
APOCCAN	156	APOCYNUM CANNABINUM	.	.	1	.	.	2	.	.	.
ASCLEXA	157	ASCLEPIAS EXALTATA	4	.	5	9	.	16	.	10	9
ASCLINC	157	ASCLEPIAS INCARNATA	.	1	.	.	.	.	.	.	.
ASCLQUA	157	ASCLEPIAS QUADRIFOLIA	1	6	3	.	.	3	.	1	.
ASCLTUBT	157	ASCLEPIAS TUBEROSA VAR TUBEROSA	.	.	2	.	.	.	.	1	.
ASCLVAR	157	ASCLEPIAS VARIEGATA	.	.	.	.	3	.	.	5	3
ASCLVER	157	ASCLEPIAS VERTICILLATA	.	.	1	.	.	1	.	.	.
ASCLVIR	157	ASCLEPIAS VIRIDIFLORA	.	.	.	.	.	1	.	.	.
MATE1S1	157	MATELIA SP.	.	.	4	.	.	.	.	.	.
CALYCATS	158	CALYSTEGIA CATESBIANA VAR SERICATA	.	1	.	.	.	.	.	.	1
CALYSEP	158	CALYSTEGIA SEPIUM	.	.	.	.	.	.	.	.	1
CALYSPIP	158	CALYSTEGIA SPITHAMAEA VAR PURSHIANA	.	.	.	.	2	.	.	.	.
CUSC1S1	158	CUSCUTA SP. #1	12	.	2	7	1	7	6	14	.
IPOM1S1	158	IPOMEA SP. #1	.	.	2	.	.	3	.	.	.
PHLOCAR	159	PHLOX CAROLINA	.	.	.	.	.	12	3	1	19
PHLOOVA	159	PHLOX OVATA	.	.	.	.	.	3	.	.	.
PHLO1S1	159	PHLOX SPECIES	.	.	.	.	.	.	.	.	6

Code	Family number	Scientific name	BM	CR	GR	JK	LG	NM	SM	SR	TH
			Study Areas								
PHLOSTO	159	PHLOX STOLONIFERA	4	.	1	.	.	1	.	.	.
HYDRCNN	160	HYDROPHYLLUM CANADENSE	25	.	11	19	.	14	4	7	.
HYDRVIR	160	HYDROPHYLLUM VIRGINIANUM	.	.	4	.	.	1	2	3	.
PHACBIP	160	PHACELIA BIPINNATIFIDA	2	.	1	2	2	1	.	2	.
PHACFIM	160	PHACELIA FIMBRIATA	.	.	1	.	.	.	.	.	.
CYNOVIRV	161	CYNOGLOSSUM VIRGINIANUM VAR VIRGINIANUM	1	.	1	.	.	1	.	.	.
PHRYLEP	162	PHRYMA LEPTOSTACHYA	4	5	4	5	.	21	1	1	1
COLLCAN	164	COLLINSONIA CANADENSIS	40	9	7	45	10	19	24	42	8
GLECHEDM	164	GLECHOMA HEDERACEA VAR MICRANTHA	.	.	.	.	1	1	.	.	.
LYCO1S1	164	LYCOPUS SP. #1	.	.	.	.	.	.	5	.	.
LYCOUNI	164	LYCOPUS UNIFLORUS	1	.	.	.	.	.	.	.	.
LYCOVIR	164	LYCOPUS VIRGINICUS	2	1	.	.	.	.	.	.	.
MENTSPI	164	MENTHA SPICATA	.	.	.	.	.	.	2	.	.
MONACLI	164	MONARDA CLINOPODIA	.	11	1	20	2	28	4	23	14
MONADID	164	MONARDA DIDYMA	3	.	5	15	4	6	1	4	.
MONAFIS	164	MONARDA FISTULOSA	.	2	5	.	.	6	.	.	.
MONA1S1	164	MONARDA SPECIES	1	.	.	.	.	1	7	.	1
PHYSVRG*	164	PHYSOSTEGIA VIRGINIANA	.	.	.	.	.	.	.	2	.
PRUNVUL	164	PRUNELLA VULGARIS	.	.	1	4	3	13	1	4	.
PYCNINC	164	PYCNANTHEMUM INCANUM	17	1	2	.	.	.	.	.	2
PYCNMON	164	PYCNANTHEMUM MONTANUM	3	.	1	.	8	3	3	39	1
PYCNPYCP	164	PYCNANTHEMUM PYCNANTHEMOIDES VAR PYCNANTHEMOIDES	.	.	1	3	2	1	.	3	.
PYCNPYCV	164	PYCNANTHEMUM PYCNANTHEMOIDES VAR VIRIDIFOLIUM	.	.	.	.	1	.	.	1	.
SALVLYR	164	SALVIA LYRATA	.	.	.	.	.	2	.	.	.
SCUTELL	164	SCUTELLARIA ELLIPTICA	.	.	2	13	.	8	1	4	2
SCUTINCP	164	SCUTELLARIA INCANA VAR PUNCTATA	.	.	.	1	.	.	.	1	.
SCUTOVA	164	SCUTELLARIA OVATA	9	.	.	.	.	2	.	1	.
SCUT1S1	164	SCUTELLARIA SPECIES	.	.	1	.	.	.	.	.	.
STACCLI	164	STACHYS CLINGMANII	.	.	.	21	.	1	3	.	.
STACLAT	164	STACHYS LATIDENS	.	.	3	.	4	18	.	20	.
STAC1S1	164	STACHYS SPECIES	.	.	.	.	.	.	9	.	.
PHYSHET	165	PHYSALIS HETEROPHYLLA	.	.	.	.	.	1	.	.	.
PHYS1S1	165	PHYSALIS SP.	.	.	1	.	.	1	.	.	.
PHYSVGNV	165	PHYSALIS VIRGINIANA VAR VIRGINIANA	.	.	2	.	.	1	.	.	.
SOLAAMEA	165	SOLANUM AMERICANUM VAR AMERICANUM	.	.	.	.	1	.	.	.	.

Code	Family number	Scientific name	BM	CR	GR	JK	LG	NM	SM	SR	TH
			Study Areas								
AUREFLA	166	AUREOLARIA FLAVA	.	.	1	1	1	1	.	1	2
AURELAE	166	AUREOLARIA LAEVIGATA	12	1	.	29	7	8	15	17	3
AURE1S1	166	AUREOLARIA SP #1	.	.	.	.	.	.	1	.	14
AUREVIR	166	AUREOLARIA VIRGINICA	.	1	1	.	.	2	1	.	.
CASTCOC	166	CASTILLEJA COCCINEA	.	.	1	.	.	2	.	.	.
CHELGLA	166	CHELONE GLABRA	1	.	1	9	.	6	3	11	.
CHELLYO	166	CHELONE LYONII	16	.	8	1	.	.	2	1	.
MELALIN	166	MELAMPYRUM LINEARE	8	2	2	27	13	21	7	24	2
PEDICND	166	PEDICULARIS CANADENSIS	7	.	2	10	.	9	5	13	4
PENSCAN	166	PENSTEMON CANESCENS	.	.	.	.	.	.	.	1	.
PENSSMA	166	PENSTEMON SMALLII	.	.	1	.	2	.	.	.	.
SCROMAR	166	SCROPHULARIA MARILANDICA	.	.	1	.	.	.	.	.	.
VEROOFFO	166	VERONICA OFFICINALIS VAR OFFICINALIS	.	.	.	.	.	.	.	1	.
BIGNCAP	167	BIGNONIA CAPREOLATA	.	1	.	9	.	.	2	.	11
CONOAME	169	CONOPHOLIS AMERICANA	34	1	2	26	1	26	3	64	23
EPIFVIR	169	EPIFAGUS VIRGINIANA	25	.	5	8	1	.	19	.	.
GALIAPA	173	GALIUM APARINE	.	.	4	8	.	2	.	.	.
GALICIR	173	GALIUM CIRCAEZANS	.	2	5	24	7	13	6	40	1
GALILAN	173	GALIUM LANCEOLATUM	.	.	3	5	.	9	15	1	.
GALILAT	173	GALIUM LATIFOLIUM	27	16	5	35	2	19	2	6	33
GALIPIL	173	GALIUM PILOSUM	.	1	.	.	.	4	.	.	2
GALI1S1	173	GALIUM SP.	7	2	1	.	.	1	3	.	1
GALITRI	173	GALIUM TRIFLORUM	18	6	22	36	2	29	18	25	2
HOUSCAE	173	HOUSTONIA CAERULEA	11	.	.	14	.	5	.	2	.
HOUSLONC	173	HOUSTONIA LONGIFOLIA VAR COMPACTA	.	.	.	.	.	2	.	.	.
HOUSLONG	173	HOUSTONIA LONGIFOLIA VAR GLABRA	.	.	.	.	.	1	.	4	.
HOUSPUR	173	HOUSTONIA PURPUREA	22	11	8	58	13	22	18	46	28
HOUSSER	173	HOUSTONIA SERPYLLIFOLIA	9	1	7	9	.	14	13	18	3
HOUSTEN	173	HOUSTONIA TENUIFOLIA	.	.	.	1	.	.	1	.	.
MITCREP	173	MITCHELLA REPENS	20	21	11	71	40	13	48	5	39
DIERSES	174	DIERVILLA SESSILIFOLIA	.	.	.	.	.	4	.	4	1
LONICAN	174	LONICERA CANADENSIS	.	.	.	.	.	1	.	.	.
LONIDIO	174	LONICERA DIOICA	2	.	.	.	.	1	.	.	.
LONIJAP	174	LONICERA JAPONICA	.	.	.	.	.	4	.	.	1
LONISEM	174	LONICERA SEMPERVIRENS	.	.	1	.	1	.	.	.	.

Code	Family number	Scientific name	Study Areas BM	CR	GR	JK	LG	NM	SM	SR	TH
SAMBCANC	174	SAMBUCUS CANADENSIS VAR CANADENSIS	1	3	4	2	.	2	2	1	9
SAMBRACP	174	SAMBUCUS RACEMOSA VAR PUBENS	11	.	20	4	.	2	8	7	.
TRIOAURA	174	TRIOSTEUM AURANTIACUM VAR AURANTIACUM	.	.	.	.	.	3	.	.	.
VIBUACE	174	VIBURNUM ACERIFOLIUM	29	9	4	47	9	18	28	30	26
VIBUDEN	174	VIBURNUM DENTATUM	7	.	.	.	.	2	1	.	1
VIBULAN	174	VIBURNUM LANTANOIDES	60	.	26	11	.	3	10	6	.
VIBUNUDC	174	VIBURNUM NUDUM VAR CASSINOIDES	4	4	4	7	3	25	1	6	8
VIBURUF	174	VIBURNUM RUFIDULUM	.	.	1	.	.	.	.	.	.
CAMPDIV	178	CAMPANULA DIVARICATA	31	1	3	28	15	13	6	11	4
CAMPAME	178	CAMPANULASTRUM AMERICANUM	.	.	.	.	2	.	.	5	.
LOBEINF	178	LOBELIA INFLATA	1	3	.	.	.	.	.	.	.
LOBENUT	178	LOBELIA NUTTALLII	.	1	.	.	.	.	.	.	.
LOBEPUB	178	LOBELIA PUBERULA	.	.	.	5	.	4	.	.	.
LOBESIP	178	LOBELIA SIPHILITICA	.	.	.	.	.	1	.	.	.
ACHIMIL	179	ACHILLEA MILLEFOLIUM	.	.	.	.	1	.	1	1	.
AGERALT	179	AGERATINA ALTISSIMA	42	12	39	74	17	52	48	78	43
AGERARO	179	AGERATINA AROMATICA	.	.	.	2	.	1	.	.	39
AMBRART	179	AMBROSIA ARTEMISIIFOLIA	.	.	1	.	.	1	.	.	.
ANTEPLA	179	ANTENNARIA PLANTAGINIFOLIA	.	.	1	5	3	6	.	3	9
ANTESOL	179	ANTENNARIA SOLITARIA	.	3	.	.	.	.	.	.	1
ARNOATR	179	ARNOGLOSSUM ATRIPLICIFOLIUM	1	1	4	8	5	4	3	10	9
ARNOMUH	179	ARNOGLOSSUM MUHLENBERGII	8	.	8	1	1	6	.	.	.
ASTEACUA	179	ASTER ACUMINATUS VAR ACUMINATUS	67	3	29	.	2	.	.	40	.
ASTECOR	179	ASTER CORDIFOLIUS	.	10	3	7	3	11	.	13	.
ASTEDIV	179	ASTER DIVARICATUS	66	10	47	120	22	46	65	98	53
ASTEINF	179	ASTER INFIRMUS	.	1	1	1	.	.	.	.	5
ASTELAE	179	ASTER LAEVIS	.	.	.	.	.	4	.	.	.
ASTELATL	179	ASTER LATERIFLORUS VAR LATERIFLORUS	.	.	1	5	.	10	2	5	.
ASTELOW	179	ASTER LOWRIEANUS	.	.	.	.	.	1	6	.	.
ASTEMAC	179	ASTER MACROPHYLLUS	19	2	.	4	10	11	5	45	.
ASTEPTNP	179	ASTER PATENS VAR PATENS	.	.	1	1	.	2	.	6	.
ASTEPHL	179	ASTER PHLOGIFOLIUS	.	.	3	.	.	6	.	.	.
ASTEPRE	179	ASTER PRENANTHOIDES	.	.	1	1	2	.	.	.	.
ASTEPUN	179	ASTER PUNICEUS	.	.	.	1	.	.	.	.	.
ASTERET	179	ASTER RETROFLEXUS	4	.	.	13	.	5	.	6	.

Code	Family number	Scientific name	BM	CR	GR	JK	LG	NM	SM	SR	TH
			Study Areas								
ASTESAG	179	ASTER SAGITTIFOLIUS	19	.	.	.	.	.	.	.	.
ASTE1S1	179	ASTER SP. #1	24	.	1	.	.	7	10	.	38
ASTE1S2	179	ASTER SP. #2	.	.	.	.	.	3	.	.	.
ASTESUR	179	ASTER SURCULOSUS	.	.	.	.	.	.	2	.	.
ASTEUMB	179	ASTER UMBELLATUS	1	.	.	.	.	.	.	.	.
ASTEUND	179	ASTER UNDULATUS	6	.	3	23	11	14	6	15	10
BIDEBIP	179	BIDENS BIPINNATA	.	.	.	.	.	1	.	.	.
CARDNUT	179	CARDUUS NUTANS	1	.	.	.	.	.	.	.	.
CHRYMAR	179	CHRYSOPSIS MARIANA	1	.	.	.	.	1	.	.	.
CICHINT	179	CICHORIUM INTYBUS	.	.	.	.	.	1	.	.	.
CIRSALT	179	CIRSIUM ALTISSIMUM	.	.	1	.	.	.	.	.	.
CIRSDIS	179	CIRSIUM DISCOLOR	.	.	1	.	1	1	.	2	.
CIRSMUT	179	CIRSIUM MUTICUM	.	.	.	.	.	1	.	.	.
CONYCAN	179	CONYZA CANADENSIS	.	2	.	.	.	.	.	.	.
CORELAT	179	COREOPSIS LATIFOLIA	.	.	.	.	.	1	.	.	.
COREMAJ	179	COREOPSIS MAJOR	.	13	2	31	19	26	5	13	44
CORETRI	179	COREOPSIS TRIPTERIS	.	.	.	.	.	1	.	.	.
ELEPCAR	179	ELEPHANTOPUS CAROLINIANUS	.	1	.	.	.	2	.	.	.
ELEPTOM	179	ELEPHANTOPUS TOMENTOSUS	.	.	.	2	.	.	.	.	3
ERECHIEH	179	ERECHTITES HIERACIIFOLIA VAR HIERACIIFOLIA	.	9	1	2	4	4	1	.	.
ERIGPULP	179	ERIGERON PULCHELLUS VAR PULCHELLUS	6	6	4	13	6	6	.	18	20
EUPAALB	179	EUPATORIUM ALBUM	.	2	.	.	.	.	1	.	3
EUPAFIS	179	EUPATORIUM FISTULOSUM	.	.	1	.	.	2	.	.	6
EUPAMACM	179	EUPATORIUM MACULATUM VAR MACULATUM	.	2	1	.	.	7	.	.	.
EUPAPURP	179	EUPATORIUM PURPUREUM VAR PURPUREUM	11	16	14	67	6	26	32	37	63
EUPASES	179	EUPATORIUM SESSILIFOLIUM	.	.	2	.	.	1	.	.	.
EUPA1S1	179	EUPATORIUM SP.	16	1	.	.	.	2	2	.	.
GAMOPUR	179	GAMOCHAETA PURPUREA	.	.	.	.	1	.	.	.	.
GNAPOBTO	179	GNAPHALIUM OBTUSIFOLIUM VAR OBTUSIFOLIUM	.	.	.	.	.	1	.	.	.
HELEAUT	179	HELENIUM AUTUMNALE	1	.	.	.	.	.	.	.	.
HELN1S1	179	HELIANATHUS SP.	.	.	2	.	.	3	2	.	.
HELIATR	179	HELIANTHUS ATRORUBENS	.	.	.	.	.	1	.	.	2
HELIDEC	179	HELIANTHUS DECAPETALUS	3	.	.	.	.	.	.	.	20
HELIDIV	179	HELIANTHUS DIVARICATUS	.	.	1	.	.	.	.	.	.
HELIMIC	179	HELIANTHUS MICROCEPHALUS	.	.	1	14	.	9	.	2	7

Code	Family number	Scientific name	Study Areas								
			BM	CR	GR	JK	LG	NM	SM	SR	TH
HELIRES	179	HELIANTHUS RESINOSUS	.	.	.	.	.	.	.	1	6
HELISTR	179	HELIANTHUS STRUMOSUS	.	.	2	10	.	4	.	11	.
HELIHELH	179	HELIOPSIS HELIANTHOIDES VAR HELIANTHOIDES	.	.	.	.	2	2	.	1	.
HIERCAE	179	HIERACIUM CAESPITOSUM	.	.	.	.	1	.	.	.	.
HIERPAN	179	HIERACIUM PANICULATUM	8	1	4	30	5	17	3	25	15
HIERSCAS	179	HIERACIUM SCABRUM VAR SCABRUM	.	.	.	.	.	.	.	2	.
HIERVEN	179	HIERACIUM VENOSUM	.	3	3	9	8	9	3	4	28
IONALIN	179	IONACTIS LINARIIFOLIA	1	.	1	.	.	2	.	.	1
KRIGMON	179	KRIGIA MONTANA	1	.	.	.	.	1	.	.	.
LACTBIE	179	LACTUCA BIENNIS	.	.	1	1	2	.	.	3	.
LACTFLOV	179	LACTUCA FLORIDANA VAR VILLOSA	.	.	.	.	.	2	.	.	.
LACT1S1	179	LACTUCA SP. #1	.	.	1	.	.	3	.	.	1
LEUCVUL	179	LEUCANTHEMUM VULGARE	1	.	.	.	.	.	.	.	.
LIATGRA	179	LIATRIS GRAMINIFOLIA	.	.	.	.	1	.	.	.	.
LIATHEL	179	LIATRIS HELLERI	.	.	1	.	.	.	.	.	.
LIATSCAS	179	LIATRIS SCARIOSA VAR SCARIOSA	.	.	1	.	.	.	.	.	.
LIAT1S1	179	LIATRIS SP. #1	.	.	2	.	.	.	.	.	.
PARTINT	179	PARTHENIUM INTEGRIFOLIUM	.	.	.	.	.	2	.	1	1
PITYGRAL	179	PITYOPSIS GRAMINIFOLIA VAR LATIFOLIA	.	1	.	1	2	3	.	.	6
PREN1S1	179	PRENANTHES SP. #1	69	3	30	101	21	45	50	86	58
RUDBHIR	179	RUDBECKIA HIRTA	.	.	1	2	.	1	.	1	3
RUDBLAC	179	RUDBECKIA LACINIATA	3	1	5	10	1	3	4	2	1
RUDBTRI	179	RUDBECKIA TRILOBA	.	.	3	.	.	.	.	.	.
SENEANO	179	SENECIO ANONYMUS	.	.	.	.	.	6	.	.	.
SENEAUR	179	SENECIO AUREUS	11	2	1	2	.	2	.	4	.
SENEOBO	179	SENECIO OBOVATUS	.	.	1	1	.	1	.	1	.
SENEPLA	179	SENECIO PLATTENSIS	.	.	.	.	.	8	.	.	.
SENE1S1	179	SENECIO SPECIES	.	.	.	.	.	1	1	.	.
SERIAST	179	SERICOCARPUS ASTEROIDES	.	1	1	1	1	4	.	2	.
SERILIN	179	SERICOCARPUS LINIFOLIUS	.	.	.	.	.	1	.	.	.
SILPCOM	179	SILPHIUM COMPOSITUM	.	3	.	.	.	2	.	.	18
SILPTRIT	179	SILPHIUM TRIFOLIATUM VAR TRIFOLIATUM	.	.	2	.	.	.	.	.	.
SMALUVE	179	SMALLANTHUS UVEDALIA	.	2	4	.	1	3	.	.	1
SOLIARG	179	SOLIDAGO ARGUTA	.	.	1	30	22	10	1	38	1
SOLIBIC	179	SOLIDAGO BICOLOR	.	.	.	.	.	8	.	.	.

Code	Family number	Scientific name	Study Areas BM	CR	GR	JK	LG	NM	SM	SR	TH
SOLICAE	179	SOLIDAGO CAESIA	21	8	21	120	21	61	33	98	54
SOLIFLA	179	SOLIDAGO FLACCIDIFOLIA	.	.	4	2	.	7	1	.	.
SOLIFLE	179	SOLIDAGO FLEXICAULIS	.	.	9	3	.	5	3	.	.
SOLIGLO	179	SOLIDAGO GLOMERATA	8	.	3	.	.	.	.	.	.
SOLIJUNJ	179	SOLIDAGO JUNCEA VAR JUNCEA	.	.	1	.	.	.	.	.	.
SOLILAN	179	SOLIDAGO LANCIFOLIA	.	.	15	.	.	.	.	.	.
SOLINEMN	179	SOLIDAGO NEMORALIS VAR NEMORALIS	.	.	.	.	.	4	.	.	.
SOLIODOO	179	SOLIDAGO ODORA VAR ODORA	.	.	1	10	4	4	.	.	6
SOLIPAT	179	SOLIDAGO PATULA	1	.	1	.	.	.	.	4	.
SOLIPUB	179	SOLIDAGO PUBERULA	.	.	.	.	1	.	.	.	.
SOLIRIGR	179	SOLIDAGO RIGIDA VAR RIGIDA	.	.	1	.	.	.	.	.	.
SOLIROA	179	SOLIDAGO ROANENSIS	.	.	2	.	.	7	.	.	.
SOLIRUG	179	SOLIDAGO RUGOSA	.	.	.	1	.	2	.	.	.
SOLI1S1	179	SOLIDAGO SP. #1	40	5	4	6	.	14	42	1	27
SOLI1S2	179	SOLIDAGO SP. #2	.	.	.	2	.	2	.	.	.
SOLI1S3	179	SOLIDAGO SP. #3	.	.	.	.	.	1	.	.	.
SOLISPE	179	SOLIDAGO SPECIOSA	.	.	2	10	.	1	.	3	4
SOLISPH	179	SOLIDAGO SPHACELATA	.	.	1	.	.	.	.	.	.
TARAOFF	179	TARAXACUM OFFICINALE	.	.	1	.	.	.	.	.	.
VERBALT	179	VERBESINA ALTERNIFOLIA	.	.	2	.	.	2	.	.	.
VERBENCE	179	VERBESINA ENCELIOIDES VAR ENCELIOIDES	.	.	.	.	.	1	.	.	.
VERBOCC	179	VERBESINA OCCIDENTALIS	.	.	2	.	.	2	.	.	.

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