THE SCIENCE PLAN
FOR THE ALL TAXA BIODIVERSITY INVENTORY
IN GREAT SMOKY MOUNTAINS NATIONAL PARK,
NORTH CAROLINA AND TENNESSEE

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Introduction

The All Taxa Biodiversity Inventory, a project of Discover Life in America, seeks to inventory the estimated 100,000 species of living organisms in Great Smoky Mountains National Park and to develop checklists, reports, maps, databases, and natural history profiles that describe the biology of this rich landscape to a wide audience. The species level of biological diversity is central to the ATBI, but the project is developed within an ecological and conservation context and encourages understanding at other levels of organization, including genetic variation within species and ecosystem descriptions.

This *Science Plan* presents the rationale for this project and the organizing themes and objectives that structure the work. This plan was drafted by the Science Committee of Discover Life in America in collaboration with Taxonomic Working Groups that lead the effort for particular groups of organisms.

Rationale for the ATBI

We describe the rationale for the project under three headings: Why do we want to do this project? Why the Smokies, Why now? And What are the questions to be addressed?

Why do we want to do this project?

The ATBI is important for the scientific community

The project is important to science because it will invent and test new paradigms for large scale and long-term biological inventory.

The ATBI supports museums, universities, researchers, and students, and thus fosters the survival of these institutions and the taxonomic knowledge that is essential to society. By supporting museums and academia, we support the ability to know and to name and we enhance the taxonomic expertise of the nation.

The specimens from the ATBI can be used comparatively by researchers working elsewhere. In this way, the project indirectly benefits biological inventory beyond Park boundaries. The specimens and data will constitute an archive of information to be used by future generations, as well.

The ATBI supports the National Park Service and Great Smoky Mountains National Park

The ATBI supports and enhances the basic conservation mission of the National Park system. The project helps develop the idea that Parks are oases, storehouses, and protectors of biological diversity, not just recreational areas or vacation destinations.

The ATBI creates basic information for management—as many have said about protected areas, you cannot manage what you do not know. Information from the ATBI will be important for counteracting existing threats to the Park and for detecting and resisting new threats.

The ATBI is important for society at large

Biological diversity benefits people (for example, pharmaceuticals and microbes that support forest productivity), but we must also inventory nature to understand potential threats to human well being (e.g., parasites and diseases). Knowledge about biological diversity is essential to society.

Ecosystems and species provide for an early warning system for the health of the biosphere and the human habitat. Living things in Great Smoky Mountains National Park depend on clean air and water, just as people do. Understanding biological diversity supports our understanding of environmental change. Species in the Park have different sensitivities to environmental change—for example, soil fungi, which play a critical ecological role, may be essential to understanding pollutant effects on forest productivity. In studying the unknown, we are carrying out an activity in which serendipitous discovery is likely.

Human beings have an innate love of distinguishing, identifying, and naming. From wildlife watchers to birders to wildflower hunters to fall color enthusiasts, people repeatedly demonstrate enthusiasm for a diverse environment and for recognizing species. The act of identification leads to an interest in habitats, the physical environment, species interactions, and the history of life. The project will draw people from the human scale to see the hidden, unknown, and obscure, but often beautiful, intricate, and ecologically important species of natural ecosystems.

The ATBI seeks participation from people of all ages, educational backgrounds, and abilities and seeks to enthuse the public with biological science. The project will bridge the gap between academic and public education.

Why the Smokies, Why now?

In the temperate zone, the Smokies are a hot spot of biological diversity because of the Park has a great range in environmental conditions and because the land has been above sea level and unglaciated for millions of years. The Southern Appalachians harbor global high points, at least for the temperate zone, of diversity and endemics in several groups, including plants, amphibians, fish, land snails, and aquatic insects. The Park comprises 5% of the high peak region of the Southern Appalachians, a substantial portion of this biotic province.

The Park supports diverse ecosystems that represent the major ecological gradients of the eastern United States, from warm and dry oak-pine forests to cold and wet spruce-fir forests. Mountain landscapes offer gradients over relatively small distances, allowing for assessment of climate change effects.

The Park contains the best old growth watersheds in the eastern United States. These old forests harbor species missing from more human affected lands and are essential for comparisons with human dominated landscapes and for understanding human impacts generally. These forests may hold the key to understanding forest productivity and the effects of soil erosion during the early 1900s on lands outside the Park.

The Park has substantial past taxonomic research and continuing interest and enthusiasm of the academic community.

The Park supports the project through staff time, financial support, and facilities.

The Park was set aside partly for its wildlife and rich array of species and continues to enjoy that image—people love the wildlife, fall color, and spring wildflowers of the Park.

The Park has and will continue to change. We need to study the Park now to understand future change.

What questions will be addressed?

The habitats and taxonomic groups to be addressed are diverse and research questions will often be specific to particular taxonomic groups and habitats. Nonetheless, we can express some generic project-wide questions that ATBI will address. We group representative questions under three headings: How should the ATBI be done? What species are present: Where are they and When are they present? What explains patterns of diversity and distribution?

How should an ATBI be done?

Because the scope of this project is unprecedented, the first group of questions addresses overall approaches to inventory in the Park.

Can we integrate traditional methods of taxonomic inventory with the establishment of a set if structured observations at biodiversity reference areas?
How many biodiveristy reference areas do we need and how do we select areas to represent the diversity of environments and histories within the Park? What is the trade-off between intensive (increase in effort at each location at the expense of number of locations) and extensive (increase in the number of locations at the expense of effort at each location) inventory at the biodiversity reference areas?
Can we incorporate the public and volunteers into the taxonomic inventory through biodiversity reference areas, sampling protocols, and sorting centers?
Can we use an integrated computer mapping system to structure the inventory and to register accumulating information?
Can we use species-effort curves to estimate checklist completeness? How do we estimate how many species are yet to be discovered? Can we formulate stopping rules based on species-effort curves? Can we create a quantitative and repeatable estimate of diversity through documentation of the species-effort curve?
How can we use new technologies to capture and transmit data?

What species are present: where are they and when are they present?

The core questions of the project focus on the documentation of diversity in the Smokies.

What species occur in the Park, where do they occur (for example, by community, habitat, and geography) and when do they occur (for example, by season and time of day)? Does access and the proximity of trails and roads influence what species are present?

How complete are existing Park checklists? As the project progresses, how many of species are new Park records, new county records, new state records, new national records, and new to science?
What species are endemic or nearly endemic to the Park?
What rare or listed species occur in the Park? What habitats do they occur in and are they secure?
What invasive exotic species occur in the Park? Are particular habitats vulnerable to exotic invasions? Are exotics expanding?

What explains patterns of diversity and distribution?

As knowledge accumulates about the species present in the Park, we will seek to address questions about the pattern of species distribution, the factors which control that distribution, and the conservation implications of project results. Major factors that determine species distributions are the physical environment (warmth, moisture, geology and soils), disturbance history (human and natural disturbance), and spatial properties (how large or isolated a habitat is, the spatial location of habitats relative to other terrain features). Species with different niche characteristics, vagilities, and rates of gene flow will react differently to the Park's environments, histories, and spatial characteristics so that the answers to these questions will differ in interesting ways among taxonomic groups.

What is the relationship between biological distributions and the physical environment and human and natural disturbance? What environmental and ecological factors correlate with diversity? Does diversity increase with warmth, moisture, and productivity and decrease with elevation? Is diversity higher in old growth compared to second growth areas?
Is diversity higher in areas of large contiguous habitat than in small isolated habitats? Is there an effect on high elevation species of the maximum local elevation (because climates were warmer in the past, it has been hypothesized that extirpation of high elevation species was most intense on mountains which are lower than 5700-6000 ft)?
How does environment and geography contribute to species diversity patterns in groups with different inherent vagilities and rates of gene flow?
Are there hot spots of diversity within the Park?
Can we use known locations to predict distributions from computer map data?
Are some species limited to old growth or second growth areas?
Is diversity correlated among groups? Can we use one group to predict diversity in another?
How well doe the umbrella species approach and the indicator species approach (in both of these a few taxa are used to index diversity in other taxa) work?
Are particular habitats more vulnerable to exotic species invasions or to other kinds of change?
What species and habitats are the most vulnerable to change?
How do known threats overlay species distributions?

The Five Science Plan Themes

Central themes and a new paradigm for biological inventory

The southern Appalachians have attracted scientific exploration for over two centuries. Great Smoky Mountains National Park itself has been explored by taxonomists since it was established in 1934. Indeed, scientists were among those campaigning for a national park in the southern mountains in the early 1900s. All conservationists recognized the importance of the rich plant and animal life of this landscape as they argued for creation of the Park. The ATBI will document past scientific observations, expand and enhance ongoing interest, and develop a new, systematic approach to observation throughout the Park's landscape.

We define five themes for this Science Plan. These themes describe our basic approach and form the philosophical underpinnings of our objectives. Collectively they produce a new paradigm for biological inventory. After an overview of each theme, we list objectives for each. Two appendices are included: *Appendix A: The User's Guide* and *Appendix B: Traditional and Structured Collecting and Observing.*

The five Themes are:

Theme 1: An inventory for all taxa and coordination across taxonomic groups;
Theme 2: Taxonomic Working Groups (TWIGs) and the taxonomic inventory;
Theme 3: Taxonomic inventory in an ecological and conservation context;
Theme 4: A Geographic Information System (GIS) as an organizing and analysis tool; and
Theme 5: Involvement of the public, schools, and volunteers.

- ***Theme 1: An inventory for all taxa and coordination across taxonomic groups***

  The first theme is that this inventory will address all taxonomic groups. This establishes Great Smoky Mountains National Park as the first site in North America and one of the first sites in the world to have a thorough and integrated inventory of its living things. Not only will this project add tremendously to the understanding of the Park and its conservation of biological diversity, but it will also stimulate the training of taxonomists by drawing attention to the importance of taxonomy and systematics as fields of human knowledge.

  We seek to harness the interest that field biologists have always had in the Park and to stimulate an expansion of this work. We seek to reach all biologists who visit the Park with the goals and structure of ATBI and to enlist cooperation, capture information, and enhance information quality. The Park's collecting permit system is one vehicle for this communication. Information on ATBI can be distributed when collecting permits are applied for or issued and in mailings that request Annual Investigator Reports.

  Taxonomic Working Groups (TWIGs) have been organized for major groups of living things. Through the TWIGs, the project seeks to reach professional societies and individual investigators to expand taxonomic effort in the Park. The TWIG organization is described below in more detail as our second theme. The Science Committee and the ATBI Coordinating Office will work with the TWIGs to create common protocols and guidelines across taxonomic groups.

Even with promotion of ATBI, there will be taxonomic groups that are receiving inadequate attention. The Science Committee must play a role in identifying understudied groups—groups that have no TWIG or for which the TWIG needs assistance in organizing, groups for which the methods for inventory are obscure within ATBI, and other special opportunities (e.g., bringing in an expert in a particular group to advise ATBI on how to approach that group). The Science Committee will seek to promote work in those problematic or poorly known groups. The Science Committee will seek opportunities to bring specialists to the Park to consult on inventory approaches and techniques. The Science Committee will recruit TWIG leaders for “orphaned” groups—groups without current leadership.

The Science Committee will seek the establishment of fellowships and sabbatical leave programs, as well as other forms of support (for example, travel and housing), that will give taxonomists and graduate students the opportunity to reside in the Park for varying periods of time—for a summer or 6 months or a full year or more to work on particular priority groups and problems.

Bioquests will be used to expand taxonomic work in the Park. Bioquests will bring groups of scientists and amateur naturalists to the Park for short but intense periods of work. The TWIGs and Science Committee will develop guidelines for Bioquests (including organization, support functions, and data capture) and for quality control and assurance for all data, including specimen labels and checklists.

We envision an ATBI central office that will be an information center for collectors, will operate the bulk sampling, sorting center, and volunteer programs, will coordinate TWIG Bioquests, and will serve as the interface between the Park’s collecting permit system and field collectors. The office will maintain the running scoreboard of the taxonomic inventory, including working checklists and newsworthy statistics (e.g., species new to North Carolina and Tennessee, new to the Park, new to the five counties of the Park, and new to science). The office will track and archive the developing history of the project and will maintain the registry of participants.

The ATBI office will oversee support functions for field work, including housing, temporary work space, storage facilities (e.g., freezers), microscopes, cameras, bar coding machines, software, computers, and transportation.

Objectives of Theme 1

Objective 1-1: Establish an office in Great Smoky Mountains National Park that will provide information to field workers, operate the bulk sampling and sorting center protocols, archive samples from the sorting center if no TWIG is organized to work on those samples, archive information and data, coordinate TWIG Bioquests and other field activities of the TWIGs, oversee or coordinate the availability of support functions (housing, temporary work space, storage facilities, microscopes, cameras, bar coding equipment, software, computers, and transportation), and maintain the volunteer program and registry of participants.

Objective 1-2: Keep the project scoreboard: a running checklist of all organisms in the Park, including working checklists and newsworthy statistics of species new to North Carolina and Tennessee, new to the Park, new to the five counties of the Park, new to science, and estimates of inventory completeness.

Objective 1-3: Describe and archive the field effort, history of the project, and observational methods in sufficient detail to permit repeat of these methods and to allow future detection of change for appropriate observations.

Objective 1-4: Work with TWIGs and Database Committee on protocols to capture data on collections and observations made in the Park, whether by independent investigators, TWIG projects, Bioquests, Park employees, or the public.

Objective 1-5: Work with TWIGs to develop guidelines for Bioquests.

Objective 1-6: Promote ATBI through, and capture information from, the Park's collecting permit system and Annual Investigator Reports.

Objective 1-7: Expand taxonomic interest by assisting TWIGs in promoting ATBI to professional societies.

Objective 1-8: Promote training of a new generation of taxonomic specialists in participating Universities by targeting grant dollars for graduate research assistantships in taxonomy and systematics.

Objective 1-9: Improve job-market opportunities for newly-trained taxonomists and systematists, for example by demonstrating to universities and museums the availability of extramural support for inventories, collection improvement, and systematics research.

Objective 1-10: Budget support for graduate fellowships, faculty sabbatical leave grants, and other financial assistance to facilitate intensive investigation of priority groups and problems by visiting specialists living temporarily in the Park

Objective 1-11: Regularly review the organizational status and composition of TWIGs and aggressively seek specialists for understudied groups, funding the work on such groups appropriately.

- ***Theme 2: Taxonomic Working Groups (TWIGs) and the taxonomic inventory***

  The fundamental work of ATBI will be done by Taxonomic Working Groups (TWIGs) organized around specific biological groups. The Science Committee depends on the work of the TWIGs to build the long-term Science Plan.

  TWIGs have key tasks:

  enlisting the participation of, and communicate with, a network of taxonomists and professional societies;

assessing the current state of knowledge about each taxonomic group (including drafting preliminary checklists and bibliographies, addressing synonymy, and identifying important holdings of specimens);
producing running checklists, including, as appropriate, common names, synonymy, and status (for example, field-sighting record, specimen-based record, extant taxon, believed-extirpated taxon, most-recent record);
planning field work and determining collection methods;
participating in the effort to design and adopt structures for specimen label and observational data;
writing an annual report, plan, and budget request; and
propose the benchmarks for and moving each taxonomic group through a series of ‘Levels of Knowledge’ from inventory of past research to checklists to distribution maps to synthetic natural history profiles.

The efforts of the TWIGs will generate important products, including:

Checklists, including synonymy and common names, as appropriate
Assessments of status of species in the Park (e.g., site record, specimen-based record, historic record, extirpated, extant, doubtful, abundance)
New species descriptions
New distributional records
Voucher specimens
Field guides, identification aids, interactive keys, drawings, and photographs
Information for web page profiles

The *TWIG Theme* includes three subthemes that are distinctive and original elements of this project:

Traditional and structured collecting and observing: the project will encompass two kinds of field work: we term these traditional and structured. The project will place heavy emphasis on expanding both kinds of taxonomic survey in the Park.

Traditional collecting and observing is here defined as field survey in its general sense. Collecting and observing will be accomplished by individual investigators based on their experience, knowledge, time constraints, and methods. ATBI will assist these investigators and capture their records for the accumulating database. ATBI will establish guidelines for collecting, including methods for promoting spatial resolution. ATBI will also establish guidelines for Bioquests: intense, short-term field experiences organized around particular biological groups. Traditional activities are based on the experience and intuition of scientists working directly in the field. Such activities are usually the most efficient means to building a checklist and discovering rarities. However, it is often difficult to document the effort expended and to describe the work in a way that makes it repeatable by future investigators.

Structured collecting and observing is here defined as those activities that take place at predetermined sampling points (Biodiversity Reference Points) chosen to represent the diversity of environments and histories of the Park’s landscape. Structured sampling points will be available to all field workers and will be especially valuable for bulk sampling, particularly sampling done by the public and volunteers (groups that lack the experience and knowledge that is essential to traditional collecting and observing). Structured sampling points will be documented by ATBI, including latitude, longitude, soil, geology, topography, habitat and vegetation, and human history. Structured collecting and observing will allow comparisons among seasons and years, among habitats and places with different disturbance histories, and along environmental gradients. Structured sampling will allow documentation of species-effort curves and will allow estimates of species turnover and complementarity among sites, thus contributing to assessment of how many biodiversity reference areas are needed.

Sorting centers and bulk sampling: TWIGs will devise methods for bulk sampling for certain groups and set up centers for sorting and distributing them to taxonomic experts. ATBI will establish protocols for the Sorting Centers, including tracking specimens from the Park to specialists and museums or other institutions.

Estimating completeness: we will estimate completeness of effort for taxonomic groups, where appropriate and possible, through analysis of species-effort, species-area, and species-time curves. We will track the number of species new to the Park and new to science as a function of the number of individuals collected. We will seek to incorporate methods that will allow us to keep a running tally of species inventoried, including species new to science, as well as the locations and times of observation. We will develop and encourage use of methods such as species-area, species-individual, species-time, and species-effort curves so that completeness can be assessed. We will test our predictions about completeness through additional field work using the stratification parameters for the Biodiversity Reference Points. We will estimate richness through methods that compare ratios between well-known and poorly-known taxonomic groups. We will seek ways of making the discovery of new species as efficient as possible as a function of the number of individuals or samples analyzed.

Objectives of Theme 2

Objective 2-1: Develop, maintain, and document lists of all taxa in the Park, determine the percentage of species new to the Park and new to science, and estimate the total number of species in the Park and the completeness of the inventory for each taxonomic group; create bibliographies of past research and index the location of specimens in museums and other institutions

Objective 2-2: Expand and harness taxonomic interest in the Park by networking with professional societies, museums, and research centers

Objective 2-3: Define levels of knowledge and products: the stages for moving taxonomic groups from the incomplete checklist to final synthesis

Objective 2-4: Propose Bioquests as appropriate

Objective 2-5: Establish procedures for bulk sampling and for specimen sorting and processing centers for distribution of specimens to TWIG experts

Objective 2-6: Develop methods to estimate inventory completeness and efficiency

· ***Theme 3: Taxonomic inventory in an ecological and conservation context***

Taxonomists typically assess a group across its entire distribution. Ecologists often collect quantitative data on multiple biota but focus on particular study areas. Managers of conservation areas require information on threats to resources, need an ability to monitor and predict change, and must devise management actions to protect or restore natural ecosystems. The ATBI will seek to unite these activities by establishing an explicit ecological and conservation context for taxonomic inventory.

The principle ways that we will accomplish this are: (1) we will link field observation to location and environmental, historical, and geological factors that affect species distributions; (2) we will seek ways to facilitate the association of observations with community type (the ecological address of species); (3) we will seek ways to build knowledge about species interactions and associations; (4) we will document observation methods and index and archive findings to facilitate future detection of change; (5) where possible, we will link taxonomic inventories to long-term monitoring sites and projects; and (6) we will map species occurrences and model species distributions.

Objectives of Theme 3

Objective 3-1: Using accumulating observations, map known locations, develop methods to predict the distribution of species in the Park, and be able to associate species with particular habitats and conditions

Objective 3-2: Determine how richness and distributions of species (and important subsets of species such as endemics, threatened species, exotic/invasive species, and species with key ecological roles) are related to:

the legacy of past human disturbance (e.g., logging, farming, hydrologic changes, fire, and exotic species invasions);
environmental variables (community structure and composition, elevation, temperature regime, moisture, resource availability, energy flow);
spatial characteristics such as the size and isolation of habitats and the relationship of the habitat to surrounding terrain; and
organism characteristics (e.g., niche width, vagility and gene flow).

Objective 3-3: Seek opportunities to link field collecting with monitoring sites and management questions.

· ***Theme 4: A Geographic Information System (GIS) as an organizing and analysis tool***

There are two essential features of all observations of species occurrences: place and time of observation. Time of observation is straightforward to record (nonetheless, guidelines should be established for the resolution and format of these data); on the other hand, spatial resolution can be difficult in these rugged mountains and yet is a key to associating observations with environmental factors, historical influences, communities, and management concerns. Mapping of observations is also key to modeling and predicting distributions and to understanding any distortions caused by overcollection in accessible areas and undercollection in inaccessible ones. As a result we must work to maximize spatial resolution for observations.

We will use a GIS for a variety of interrelated purposes. We will use a GIS to select a series of Biodiversity Reference Points clustered within larger blocks called Landscape Reference Areas. The Landscape Reference Areas will represent the Park's characteristic landscapes. The Landscape Reference Areas and Biodiversity Reference Points will cover environmental, historical, and geologic variation in the Park and are distributed across its full geography. The establishment of observation areas will enhance our ability to model species distributions. We will use a GIS as a general framework for keeping an ongoing record of all collecting activities and for mapping the locations for species collected and observed. We will also be able to identify over- and undercollected areas and compare more accessible to less accessible sites. We will use a GIS to identify hot spots of diversity and areas sensitive to change. We will use a GIS to model and predict species distributions, as well as to pick areas to test such maps in the field.

Objectives of Theme 4

Objective 4-1: Use a GIS to produce a User's Guide to collecting in Great Smoky Mountains National Park to facilitate field work and to maximize cooperation of investigators

Objective 4-2: Use a GIS to track field observations, to register and prevent incompatible activities, to identify potential for overlap of activities, to identify under- and overcollected areas, and to select test plots for comparing accessible and inaccessible areas

Objective 4-3: Use GIS to produce a stratification of the Park's diverse environments, history, and geology in order to select Biodiversity Reference Points clustered within Landscape Reference Areas

- ***Theme 5: Involvement of the public, schools, and volunteers***

One of the unique features of ATBI is the close involvement envisioned for the public. Volunteers will carry out bulk sampling, undertake taxonomic sorting, provide field assistance to specialists, and participate in intensive taxonomic forays. These volunteers may come for a day or serve for many years. They can be involved individually or as part of school groups, scout groups, clubs, or civic organizations. We seek to interweave the activities of scientists, Park service employees, public educators, interpreters, museums, and the public in this project. We seek to train a variety of "parataxonomists"—members of the public who have been trained to make critical natural history observations and collect specimens for evaluation by specialists.

Volunteers, school children, and parataxonomists: we seek to involve and train nonprofessionals in most aspects of the work, from field collection to specimen sorting and data processing. Younger children will be exposed to the project to excite and inspire them with biological exploration, while older children will be encouraged to participate in ways appropriate to age, experience, and available supervision.

Dissemination of knowledge to a wide audience: just as the project seeks to involve the public and nonprofessionals, it also seeks to make results of the project widely available to audiences ranging from schools to universities, and from tourists to amateur naturalists.

Objectives of Theme 5

Objective 5-1: Involve volunteers and non-scientists with inventory, sorting and specimen processing centers, data processing, and administration

Objective 5-2: Work with the Education Committee to make the results of research widely available in a variety of media and for people of all backgrounds, skills, and abilities

Objective 5-3: Work with the Education Committee to develop programs and activities that will provide learning opportunities about biodiversity for a full range of potential participants at all educational levels, including pre-schoolers, primary and secondary students and teachers, college, university, and post-doctoral students, and amateur naturalists and the general public.

Appendix A: The User's Guide

The User's Guide will depict and analyze environmental and historical factors that control the distribution of plants and animals in the Park, including factors important in terrestrial, aquatic, and subterranean ecosystems. Such factors include: elevation; topographic aspect; shape, and position; geology; human and disturbance history; geographic position; and ecosystem structure and composition (e.g., vegetation type). Taxonomy and Collecting Committees, as well as all TWIGs, should help define requirements for the User's Guide.

The template of the User's Guide allows the assignment of an Ecological Address to each observation—as important as its geographic address.

The User's Guide will also depict and analyze information on Park access in order to allow efficient planning of field work, but also, in combination with information on collecting history, to identify over- and under-collected areas.

The User's Guide will also serve as the template for accumulating the history of the ATBI effort by registering field projects. This registration will also help identify areas in which overlap of field work in time or space or both is desirable or to be avoided. The accumulating history will be a running scoreboard of taxonomic groups and the times and places of inventory. The User's Guide will help guide and register both structured and unstructured collecting and observing activities. The User's Guide can be cross referenced to efforts to document existing checklists and past research efforts as defined by the Taxonomy Committee and TWIGs.

The User's Guide is not just a set of maps and lists, but provides useful summaries and analyses of the diversity of sites and histories in the Park. The underlying GIS database will be maintained for further analysis and queries.

Some version will be accessible through the Web site. The material will also be made available in hardcopy.

Appendix B: Traditional and Structured Collecting and Observing

Collecting and Observing will involve *Traditional collecting and observing* and *Structured collecting and observing*
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Traditional collecting and observing activities

These are defined as those activities that are not formally oriented around Landscape Reference Areas and Biodiversity Reference Points. The duration of the activities is anything from days to years and from ongoing to intermittent. These activities also include serendipitous and ad hoc observations—anything from chance discoveries by Park staff and the visiting public to visits by specialists or university classes. These activities include the relatively intense and short-term field investigations called Bioquests.

Structured collecting and observing activities

The User's Guide can also be used to publicize specific places in the Park that collectively represent the diversity of environments and histories of the whole Park and do so with replication. We suggest two scales for this analysis: Landscape Reference Areas and Biodiversity Reference Points. The selection of these areas should be done by running scenarios against GIS-based information for the Park.

Each Landscape Reference Area would be a representative piece of the Park's Landscape.
The Biodiversity Reference Points would represent the local gradients and heterogeneity within LRAs and would offer a range of local observation points to investigators.
The User's Guide would describe the LRAs at higher resolution than for the rest of the landscape—e.g., a high resolution vegetation map would be made for each LRA from aerial images. The User's Guide would indicate what collecting activities were permissible at, or in the vicinity of, Biodiversity Reference Points.

Quantitative Sampling at Biodiversity Reference Points

Documentation of field activities is important for all activities, whether structured or not. For example, it will be important to know how long an investigator spent in the field, what trails and places were inventoried, at what season, time of day and weather conditions the observations covered, what sampling methods used, and so on.

Beyond the capture of this information, species lists and estimates of diversity can be made quantitatively meaningful if some portion of the effort goes into construction of species-area, species-time, species-effort, or species-individual curves. By repeating methods in the future and by rebuilding these curves, we can track changes in diversity even when the inventory for the Park as a whole is incomplete.