02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.C.a. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Robert K Peet

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race:
(Select one or more)
☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian or Other Pacific Islander
☒ White

Disability Status:
(Select one or more)
☐ Hearing Impairment
☐ Visual Impairment
☐ Mobility/Orthopedic Impairment
☐ Other
☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization’s eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

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PI/PD Name: Alan S Weakley

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
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Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

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PI/PD Name: Peter S White

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

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Black or African American. A person having origins in any of the black racial groups of Africa.
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PI/PD Name: Dean L Urban

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

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Black or African American. A person having origins in any of the black racial groups of Africa.
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White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1

NSF 10-558 **07/13/11**

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

1147391

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

DEB - Long-Term Research in Environmental Biology

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
07/13/2011	1	08010000 DEB	1196	608195277	09/11/2011 10:42pm S

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

566001393

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

University of North Carolina at Chapel Hill

AWARDEE ORGANIZATION CODE (IF KNOWN)

0029744000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

University of North Carolina at Chapel Hill
104 Airport Drive Suite 2200
Chapel Hill, NC. 275991350

NAME OF PRIMARY PLACE OF PERF

University of North Carolina at Chapel Hill

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

University of North Carolina at Chapel Hill
104 Airport Drive Suite 2200
Chapel Hill ,NC ,275991350 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS
☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **LTREB: Collaborative Research: Long-term forest dynamics in a changing world**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 320,751	60 months	01/01/12	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________
PHS Animal Welfare Assurance Number ________
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________
Exemption Subsection ________ or IRB App. Date ________
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT

Department of Biology

PI/PD FAX NUMBER

919-962-6930

PI/PD POSTAL ADDRESS

CB#3280

Chapel Hill, NC 275143280
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Robert K Peet	Ph.D	1975	919-962-6942	peet@unc.edu
CO-PI/PD Alan S Weakley	PhD	2005	919-962-0578	weakley@unc.edu
CO-PI/PD Peter S White	Ph.D.	1976	919-962-6939	pswhite@unc.edu
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution’s expenditure of any funds under the award, in accordance with the institution’s conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ‘‘Disclosure of Lobbying Activities,’’ in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Martha E Martin	Electronic Signature	Jul 13 2011 1:52PM

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
919-962-7255	martha_martin@unc.edu	919-962-5011

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1

NSF 10-558 **07/13/11**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

DEB - Long-Term Research in Environmental Biology

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

1147362

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
07/13/2011	1	08010000 DEB	1196	044387793	09/11/2011 10:43pm S

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

560532129

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Duke University

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Duke University
2200 W. Main St, Suite 710
Durham, NC. 277054010

AWARDEE ORGANIZATION CODE (IF KNOWN)

0029207000

NAME OF PRIMARY PLACE OF PERF

Duke University

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

Duke University

NC ,277054010 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **LTREB: Collaborative Research: Long-term forest dynamics in a changing world**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 128,523	60 months	06/01/12	

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☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
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PHS Animal Welfare Assurance Number ________
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____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT

Nicholas School of the Environment

PI/PD FAX NUMBER

919-684-8741

PI/PD POSTAL ADDRESS

A320 LSRC

Durham, NC 277080328
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Dean L Urban	PhD	1986	919-613-8076	deanu@duke.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Kenneth MacDonald**	**Electronic Signature**	**Jul 13 2011 12:38PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
919-681-5988	**kwmac@duke.edu**	**919-684-2418**

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

Directorate for Biological Sciences
Division of Environmental Biology
Long-term Research in Environmental Biology

Proposal Classification Form
PI: Peet, Robert / Proposal Number: 1147391

CATEGORY I: INVESTIGATOR STATUS (Select ONE)

- [ ] Beginning Investigator - No previous Federal support as PI or Co-PI, excluding fellowships, dissertations, planning grants, etc.
- [x] Prior Federal support only
- [ ] Current Federal support only
- [ ] Current & prior Federal support

CATEGORY II: FIELDS OF SCIENCE OTHER THAN BIOLOGY INVOLVED IN THIS RESEARCH (Select 1 to 3)

- [ ] Astronomy
- [ ] Chemistry
- [ ] Computer Science
- [ ] Earth Science
- [ ] Engineering
- [ ] Mathematics
- [ ] Physics
- [ ] Psychology
- [ ] Social Sciences
- [x] None of the Above

CATEGORY III: SUBSTANTIVE AREA (Select 1 to 4)

- [ ] BIOGEOGRAPHY
- [ ] Island Biogeography
- [ ] Historical/ Evolutionary Biogeography
- [ ] Phylogeography
- [ ] Methods/Theory
- [ ] CHROMOSOME STUDIES
- [ ] Chromosome Evolution
- [ ] Chromosome Number
- [ ] Mutation
- [ ] Mitosis and Meiosis
- [x] COMMUNITY ECOLOGY
- [ ] Community Analysis
- [x] Community Structure
- [ ] Community Stability
- [x] Succession
- [ ] Experimental Microcosms/ Mesocosms
- [x] Disturbance
- [ ] Patch Dynamics
- [ ] Food Webs/ Trophic Structure
- [ ] Keystone Species
- [ ] COMPUTATIONAL BIOLOGY
- [ ] CONSERVATION & RESTORATION BIOLOGY
- [ ] DATABASES
- [ ] ECOSYSTEMS LEVEL
- [ ] Physical Structure
- [ ] Decomposition
- [ ] Biogeochemistry
- [ ] Limnology/Hydrology
- [ ] Climate/Microclimate
- [ ] Whole-System Analysis
- [ ] Productivity/Biomass
- [ ] System Energetics
- [ ] Landscape Dynamics
- [ ] Chemical & Biochemical Control
- [ ] Global Change
- [ ] Climate Change
- [ ] Regional Studies
- [ ] Global Studies
- [ ] Forestry
- [ ] Resource Management (Wildlife, Fisheries, Range, Other)
- [ ] Agricultural Ecology
- [ ] EXTREMOPHILES
- [ ] GENOMICS (Genome sequence, organization, function)
  - [ ] Viral
  - [ ] Microbial
  - [ ] Fungal
  - [ ] Plant
  - [ ] Animal
- [ ] MARINE MAMMALS
- [ ] MOLECULAR APPROACHES
- [ ] Molecular Evolution
- [ ] Methodology/Theory
- [ ] Isozymes/ Electrophoresis
- [ ] Nucleic Acid Analysis (general)
  - [ ] Restriction Enzymes
  - [ ] Nucleotide Sequencing
  - [ ] Nuclear DNA
  - [ ] Mitochondrial DNA
  - [ ] Chloroplast DNA
  - [ ] RNA Analysis
  - [ ] DNA Hybridization
  - [ ] Recombinant DNA
- [ ] Amino Acid Sequencing
- [ ] Gene/Genome Mapping
- [ ] Natural Products
- [ ] Serology/Immunology
- [ ] PALEONTOLOGY
- [ ] Floristic
- [ ] Faunistic
- [ ] Paleoecology
- [ ] Biostratigraphy
- [ ] Palynology
- [ ] Micropaleontology
- [ ] Paleoclimatology
- [ ] Archeozoic
- [ ] Paleozoic
- [ ] Mesozoic

- ☐ Cenozoic
- ☐ POPULATION DYNAMICS & LIFE HISTORY
- ☐ Demography/ Life History
- ☐ Population Cycles
- ☐ Distribution/Patchiness/ Marginal Populations
- ☐ Population Regulation
- ☐ Intraspecific Competition
- ☐ Reproductive Strategies
- ☐ Gender Allocation
- ☐ Metapopulations
- ☐ Extinction
- ☐ POPULATION GENETICS & BREEDING SYSTEMS
- ☐ Variation
- ☐ Microevolution
- ☐ Speciation
- ☐ Hybridization
- ☐ Inbreeding/Outbreeding
- ☐ Gene Flow Measurement
- ☐ Inheritance/Heritability
- ☐ Quantitative Genetics/ QTL Analysis
- ☐ Ecological Genetics
- ☐ Gender Ratios
- ☐ Apomixis/ Parthenogenesis
- ☐ Vegetative Reproduction
- ☐ SPECIES INTERACTIONS
- ☐ Predation
- ☐ Herbivory
- ☐ Omnivory
- ☐ Interspecific Competition
- ☐ Niche Relationships/ Resource Partititioning
- ☐ Pollination/ Seed Dispersal
- ☐ Parasitism
- ☐ Mutualism/ Commensalism
- ☐ Plant/Fungal/ Microbial Interactions
- ☐ Mimicry
- ☐ Animal Pathology
- ☐ Plant Pathology
- ☐ Coevolution
- ☐ Biological Control
- ☐ STATISTICS & MODELING
- ☐ Methods/ Instrumentation/ Software
- ☐ Modeling (general)
- ☐ Statistics (general)
  - ☐ Multivariate Methods
  - ☐ Spatial Statistics & Spatial Modeling
  - ☐ Sampling Design & Analysis
  - ☐ Experimental Design & Analysis
- ☐ SYSTEMATICS
- ☐ Taxonomy/Classification
- ☐ Nomenclature
- ☐ Monograph/Revision
- ☐ Phylogenetics
- ☐ Phenetics/Cladistics/ Numerical Taxonomy
- ☐ Macroevolution
- ☐ NONE OF THE ABOVE

CATEGORY IV: INFRASTRUCTURE (Select 1 to 3)

COLLECTIONS/STOCK CULTURES

- ☐ Natural History Collections
- ☑ DATABASES

FACILITIES

- ☐ Controlled Environment Facilities
- ☑ Field Stations
  - ☐ Field Facility Structure
  - ☐ Field Facility Equipment
- ☐ LTER Site
- ☐ INDUSTRY PARTICIPATION
- ☐ Technique Development

TRACKING SYSTEMS

- ☐ Geographic Information Systems
- ☐ Remote Sensing
- ☐ NONE OF THE ABOVE

CATEGORY V: HABITAT (Select 1 to 2)

TERRESTRIAL HABITATS

- ☐ GENERAL TERRESTRIAL
- ☐ TUNDRA
- ☐ BOREAL FOREST
- ☐ TEMPERATE
  - ☑ Deciduous Forest
  - ☑ Coniferous Forest
  - ☐ Rain Forest
  - ☐ Mixed Forest
  - ☐ Prairie/Grasslands
  - ☐ Desert
- ☐ SUBTROPICAL
  - ☐ Rain Forest
  - ☐ Seasonal Forest
  - ☐ Savanna
  - ☐ Thornwoods
  - ☐ Deciduous Forest
  - ☐ Coniferous Forest
  - ☐ Desert
- ☐ TROPICAL
  - ☐ Rain Forest
  - ☐ Seasonal Forest
  - ☐ Savanna
  - ☐ Thornwoods
  - ☐ Deciduous Forest
  - ☐ Coniferous Forest
  - ☐ Desert
- ☐ CHAPPARAL/ SCLEROPHYLL/ SHRUBLANDS
- ☐ ALPINE
- ☐ MONTANE
- ☐ CLOUD FOREST
- ☐ RIPARIAN ZONES
- ☐ ISLANDS (except Barrier Islands)
- ☐ BEACHES/ DUNES/ SHORES/ BARRIER ISLANDS
- ☐ CAVES/ ROCK OUTCROPS/ CLIFFS
- ☐ CROPLANDS/ FALLOW FIELDS/ PASTURES
- ☐ URBAN/SUBURBAN
- ☐ SUBTERRANEAN/ SOIL/ SEDIMENTS
- ☐ EXTREME TERRESTRIAL ENVIRONMENT
- ☐ AERIAL

AQUATIC HABITATS

- ☐ GENERAL AQUATIC
- ☐ FRESHWATER
  - ☐ Wetlands/Bogs/Swamps
  - ☐ Lakes/Ponds
  - ☐ Rivers/Streams
  - ☐ Reservoirs
- ☐ MARINE
  - ☐ Open Ocean/Continental Shelf
  - ☐ Bathyal
  - ☐ Abyssal
  - ☐ Estuarine
  - ☐ Intertidal/Tidal/Coastal
  - ☐ Coral Reef
  - ☐ HYPERSALINE
- ☐ EXTREME AQUATIC ENVIRONMENT
- ☐ CAVES/ ROCK OUTCROPS/ CLIFFS
- ☐ MANGROVES
- ☐ SUBSURFACE WATERS/ SPRINGS
- ☐ EPHEMERAL POOLS & STREAMS
- ☐ MICROPOOLS (Pitcher Plants, Tree Holes, Other)

MAN-MADE ENVIRONMENTS

- ☐ LABORATORY
- ☐ THEORETICAL SYSTEMS
- ☐ OTHER ARTIFICIAL SYSTEMS

NOT APPLICABLE

- ☐ NOT APPLICABLE

CATEGORY VI: GEOGRAPHIC AREA OF THE RESEARCH (Select 1 to 2)

- ☐ WORLDWIDE
- ☐ NORTH AMERICA
  - ☐ United States
    - ☐ Northeast US (CT, MA, ME, NH, NJ, NY, PA, RI, VT)
    - ☐ Northcentral US (IA, IL, IN, MI, MN, ND, NE, OH, SD, WI)
    - ☐ Northwest US (ID, MT, OR, WA, WY)
    - ☑ Southeast US (DC, DE, FL, GA, MD, NC, SC, WV, VA)
    - ☐ Southcentral US (AL, AR, KS, KY, LA, MO, MS, OK, TN, TX)
    - ☐ Southwest US (AZ, CA, CO, NM, NV, UT)
    - ☐ Alaska
    - ☐ Hawaii
    - ☐ Puerto Rico
    - ☐ Canada
  - ☐ Mexico
- ☐ CENTRAL AMERICA (Mainland)
  - ☐ Caribbean Islands
  - ☐ Bermuda/Bahamas
- ☐ SOUTH AMERICA
  - ☐ Eastern South America (Guyana, Fr. Guiana, Suriname, Brazil)
  - ☐ Northern South America (Colombia, Venezuela)
  - ☐ Southern South America (Chile, Argentina, Uruguay, Paraguay)
  - ☐ Western South America (Ecuador, Peru, Bolivia)
- ☐ EUROPE
  - ☐ Eastern Europe
  - ☐ Russia
  - ☐ Scandinavia
  - ☐ Western Europe
- ☐ ASIA
  - ☐ Central Asia
  - ☐ Far East
  - ☐ Middle East
  - ☐ Siberia
  - ☐ South Asia
  - ☐ Southeast Asia
- ☐ AFRICA
  - ☐ North Africa
  - ☐ African South of the Sahara
    - ☐ East Africa
    - ☐ Madagascar
    - ☐ South Africa
    - ☐ West Africa
- ☐ AUSTRALASIA
  - ☐ Australia
  - ☐ New Zealand
  - ☐ Pacific Islands
- ☐ ANTARCTICA
- ☐ ARCTIC
- ☐ ATLANTIC OCEAN
- ☐ PACIFIC OCEAN
- ☐ INDIAN OCEAN
- ☐ OTHER REGIONS (Not defined)
- ☐ NOT APPLICABLE

CATEGORY VII: CLASSIFICATION OF ORGANISMS (Select 1 to 4)

- ☐ VIRUSES
  - ☐ Bacterial
  - ☐ Plant
  - ☐ Animal
- ☐ PROKARYOTES
  - ☐ Archaebacteria
  - ☐ Cyanobacteria
  - ☐ Eubacteria
- ☐ PROTISTA (PROTOZOA)
  - ☐ Amoebae
  - ☐ Apicomplexa
  - ☐ Ciliophora
  - ☐ Flagellates
  - ☐ Foraminifera
  - ☐ Microspora
  - ☐ Radiolaria
- ☐ FUNGI
  - ☐ Ascomycota
  - ☐ Basidiomycota
  - ☐ Chytridiomycota
  - ☐ Mitosporic Fungi
  - ☐ Oomycota
  - ☐ Zygomycota
- ☐ LICHENS
- ☐ SLIME MOLDS
- ☐ ALGAE
  - ☐ Bacillariophyta (Diatoms)
  - ☐ Charophyta
  - ☐ Chlorophyta
  - ☐ Chrysophyta
  - ☐ Dinoflagellata
  - ☐ Euglenoids
  - ☐ Phaeophyta
  - ☐ Rhodophyta
- ☐ PLANTS
  - ☐ N0N-VASCULAR PLANTS
    - ☐ BRYOPHYTA
      - ☐ Anthocerotae (Hornworts)
      - ☐ Hepaticae (Liverworts)
      - ☐ Musci (Mosses)
  - ☑ VASCULAR PLANTS
    - ☐ FERNS & FERN ALLIES
    - ☐ GYMNOSPERMS
      - ☐ Coniferales (Conifers)
      - ☐ Cycadales (Cycads)

- ☐ Ginkgoales (Ginkgo)
- ☐ Gnetales (Gnetophytes)
- ☐ ANGIOSPERMS
  - ☐ Monocots
    - ☐ Arecaceae (Palmae)
    - ☐ Cyperaceae
    - ☐ Liliaceae
    - ☐ Orchidaceae
    - ☐ Poaceae (Graminae)
  - ☐ Dicots
    - ☐ Apiaceae (Umbelliferae)
    - ☐ Asteraceae (Compositae)
    - ☐ Brassicaceae (Cruciferae)
    - ☐ Fabaceae (Leguminosae)
    - ☐ Lamiaceae (Labiatae)
    - ☐ Rosaceae
    - ☐ Solanaceae

- ☐ ANIMALS
  - ☐ INVERTEBRATES
    - ☐ MESOZOA/PLACOZOA
    - ☐ PORIFERA (Sponges)
    - ☐ CNIDARIA
      - ☐ Hydrozoa (Hydra, etc.)
      - ☐ Scyphozoa (Jellyfish)
      - ☐ Anthozoa (Corals, Sea Anemones)
    - ☐ CTENOPHORA (Comb Jellies)
    - ☐ PLATYHELMINTHES (Flatworms)
      - ☐ Turbellaria (Planarians)
      - ☐ Trematoda (Flukes)
      - ☐ Cestoda (Tapeworms)
      - ☐ Monogenea (Flukes)
    - ☐ GNATHOSTOMULIDA
    - ☐ NEMERTINEA (Rynchocoela) (Ribbon Worms)
    - ☐ ENTOPROCTA (Bryozoa) (Plant-like Animals)
    - ☐ ASCHELMINTHES
      - ☐ Gastrotricha
      - ☐ Kinorhyncha
      - ☐ Loricifera
      - ☐ Nematoda (Roundworms)
      - ☐ Nematomorpha (Horsehair Worms)
      - ☐ Rotifera (Rotatoria)
    - ☐ ACANTHOCEPHALA (Spiny-headed Worms)
    - ☐ PRIAPULOIDEA
    - ☐ BRYOZOA (Ectoprocta) (Plant-like Animals)
    - ☐ PHORONIDEA (Lophophorates)
    - ☐ BRACHIOPODA (Lamp Shells)
    - ☐ MOLLUSCA
      - ☐ Monoplacophora
      - ☐ Aplacophora (Solenogasters)
      - ☐ Polyplacophora (Chitons)
      - ☐ Scaphopoda (Tooth Shells)
      - ☐ Gastropoda (Snails, Slugs, Limpets)
      - ☐ Pelecypoda (Bivalvia) (Clams, Mussels, Oysters, Scallops)
      - ☐ Cephalopoda (Squid, Octopus, Nautilus)
    - ☐ ANNELIDA (Segmented Worms)
      - ☐ Polychaeta (Parapodial Worms)
      - ☐ Oligochaeta (Earthworms)
      - ☐ Hirudinida (Leeches)
    - ☐ POGONOPHORA (Beard Worms)
    - ☐ SIPUNCULOIDEA (Peanut Worms)
    - ☐ ECHIUROIDEA (Spoon Worms)
    - ☐ ARTHROPODA
      - ☐ Cheliceriformes
        - ☐ Merostomata (Horseshoe Crabs)
        - ☐ Pycnogonida (Sea Spiders)
        - ☐ Scorpionida (Scorpions)
        - ☐ Araneae (True Spiders)
        - ☐ Pseudoscorpionida (Pseudoscorpions)
        - ☐ Acarina (Free-living Mites)
        - ☐ Parasitiformes (Parasitic Ticks & Mites)
      - ☐ Crustacea
        - ☐ Branchiopoda (Fairy Shrimp, Water Flea)
        - ☐ Ostracoda (Sea Lice)
        - ☐ Copepoda
        - ☐ Cirripedia (Barnacles)
        - ☐ Amphipoda (Skeleton Shrimp, Whale Lice, Freshwater Shrimp)
        - ☐ Isopoda (Wood Lice, Pillbugs)
        - ☐ Decapoda (Lobster, Crayfish, Crabs, Shrimp)
      - ☐ Hexapoda (Insecta) (Insects)
        - ☐ Apterygota (Springtails, Silverfish, etc.)
        - ☐ Odonata (Dragonflies, Damselflies)
        - ☐ Ephemeroptera (Mayflies)
        - ☐ Orthoptera (Grasshoppers, Crickets)
        - ☐ Dictyoptera (Cockroaches, Mantids, Phasmids)
        - ☐ Isoptera (Termites)
        - ☐ Plecoptera (Stoneflies)
        - ☐ Phthiraptera (Mallophaga & Anoplura) (Lice)
        - ☐ Hemiptera (including Heteroptera) (True Bugs)
        - ☐ Homoptera (Cicadas, Scale Insects, Leafhoppers)
        - ☐ Thysanoptera (Thrips)
        - ☐ Neuroptera (Lacewings, Dobsonflies, Snakeflies)
        - ☐ Trichoptera (Caddisflies)
        - ☐ Lepidoptera (Moths, Butterflies)
        - ☐ Diptera (Flies, Mosquitoes)
        - ☐ Siphonaptera (Fleas)
        - ☐ Coleoptera (Beetles)
        - ☐ Hymenoptera (Ants, Bees, Wasps, Sawflies)
      - ☐ Chilopoda (Centipedes)
      - ☐ Diplopoda (Millipedes)
      - ☐ Pauropoda
      - ☐ Symphyta (Symphyla)
    - ☐ PENTASTOMIDA (Linguatulida) (Tongue Worms)
    - ☐ TARDIGRADA (Tardigrades, Water Bears)
    - ☐ ONYCHOPHORA (Peripatus)
    - ☐ CHAETOGNATHA (Arrow Worms)
    - ☐ ECHINODERMATA
      - ☐ Crinoidea (Sea Lilies, Feather Stars)
      - ☐ Asteroidea (Starfish, Sea Stars)
      - ☐ Ophiuroidea (Brittle Stars, Serpent Stars)
      - ☐ Echinoidea (Sea Urchins, Sand Dollars)
      - ☐ Holothuroidea (Sea Cucumbers)
    - ☐ HEMICHORDATA (Acorn Worms, Pterobranchs)
    - ☐ UROCHORDATA (Tunicata) (Tunicates, Sea Squirts, Salps, Ascideans)
    - ☐ CEPHALOCHORDATA (Amphioxus/Lancelet)
  - ☐ VERTEBRATES
    - ☐ AGNATHA (Hagfish, Lamprey)
    - ☐ FISHES
      - ☐ Chondrichthyes (Cartilaginous Fishes) (Sharks, Rays, Ratfish)
      - ☐ Osteichthyes (Bony Fishes)
    - ☐ AMPHIBIA
      - ☐ Anura (Frogs, Toads)
      - ☐ Urodela (Salamanders, Newts)
      - ☐ Gymnophiona (Apoda) (Caecilians)
    - ☐ REPTILIA
      - ☐ Chelonia (Turtles, Tortoises)
      - ☐ Serpentes (Snakes)
      - ☐ Sauria (Lizards)
      - ☐ Crocodylia (Crocodilians)
    - ☐ AVES (Birds)
      - ☐ Passeriformes (Passerines)
    - ☐ MAMMALIA
      - ☐ Monotremata (Platypus, Echidna)
      - ☐ Marsupalia (Marsupials)
      - ☐ Eutheria (Placentals)
        - ☐ Insectivora (Hedgehogs, Moles, Shrews, Tenrec, etc.)
        - ☐ Chiroptera (Bats)
        - ☐ Primates
          - ☐ Humans
        - ☐ Rodentia
        - ☐ Lagomorphs (Rabbits, Hares, Pikas)
        - ☐ Carnivora (Bears, Canids, Felids, Mustelids, Viverrids, Hyena, Procyonids)
          - ☐ Perissodactyla (Odd-toed Ungulates) (Horses, Rhinos, Tapirs, etc.)

☐ Artiodactyla (Even-toed Ungulates) (Cattle, Sheep, Deer, Pigs, etc.) ☐ Marine Mammals (Seals, Walrus, Whales, Otters, Dolphins, Porpoises)	☐ TRANSGENIC ORGANISMS ☐ FOSSIL OR EXTINCT ORGANISMS	☐ NO ORGANISMS

CATEGORY VIII: MODEL ORGANISM (Select ONE)

☑ NO MODEL ORGANISM MODEL ORGANISM (Choose from the list)	☐ Escherichia coli ☐ Mouse-Ear Cress (Arabidopsis thaliana)	☐ Fruitfly (Drosophila melanogaster)

Directorate for Biological Sciences
Division of Environmental Biology
Long-term Research in Environmental Biology

Proposal Classification Form
PI: Urban, Dean / Proposal Number: 1147362

CATEGORY I: INVESTIGATOR STATUS (Select ONE)

- [ ] Beginning Investigator - No previous Federal support as PI or Co-PI, excluding fellowships, dissertations, planning grants, etc.
- [ ] Prior Federal support only
- [ ] Current Federal support only
- [x] Current & prior Federal support

CATEGORY II: FIELDS OF SCIENCE OTHER THAN BIOLOGY INVOLVED IN THIS RESEARCH (Select 1 to 3)

- [ ] Astronomy
- [ ] Chemistry
- [ ] Computer Science
- [ ] Earth Science
- [ ] Engineering
- [ ] Mathematics
- [ ] Physics
- [ ] Psychology
- [ ] Social Sciences
- [x] None of the Above

CATEGORY III: SUBSTANTIVE AREA (Select 1 to 4)

- [ ] BIOGEOGRAPHY
- [ ] Island Biogeography
- [ ] Historical/ Evolutionary Biogeography
- [ ] Phylogeography
- [ ] Methods/Theory
- [ ] CHROMOSOME STUDIES
- [ ] Chromosome Evolution
- [ ] Chromosome Number
- [ ] Mutation
- [ ] Mitosis and Meiosis
- [ ] COMMUNITY ECOLOGY
- [ ] Community Analysis
- [ ] Community Structure
- [ ] Community Stability
- [x] Succession
- [ ] Experimental Microcosms/ Mesocosms
- [x] Disturbance
- [ ] Patch Dynamics
- [ ] Food Webs/ Trophic Structure
- [ ] Keystone Species
- [ ] COMPUTATIONAL BIOLOGY
- [ ] CONSERVATION & RESTORATION BIOLOGY
- [ ] DATABASES
- [ ] ECOSYSTEMS LEVEL
- [ ] Physical Structure
- [ ] Decomposition
- [ ] Biogeochemistry
- [ ] Limnology/Hydrology
- [x] Climate/Microclimate
- [ ] Whole-System Analysis
- [ ] Productivity/Biomass
- [ ] System Energetics
- [ ] Landscape Dynamics
- [ ] Chemical & Biochemical Control
- [ ] Global Change
- [ ] Climate Change
- [ ] Regional Studies
- [ ] Global Studies
- [ ] Forestry
- [ ] Resource Management (Wildlife, Fisheries, Range, Other)
- [ ] Agricultural Ecology
- [ ] EXTREMOPHILES
- [ ] GENOMICS (Genome sequence, organization, function)
  - [ ] Viral
  - [ ] Microbial
  - [ ] Fungal
  - [ ] Plant
  - [ ] Animal
- [ ] MARINE MAMMALS
- [ ] MOLECULAR APPROACHES
- [ ] Molecular Evolution
- [ ] Methodology/Theory
- [ ] Isozymes/ Electrophoresis
- [ ] Nucleic Acid Analysis (general)
  - [ ] Restriction Enzymes
  - [ ] Nucleotide Sequencing
  - [ ] Nuclear DNA
  - [ ] Mitochondrial DNA
  - [ ] Chloroplast DNA
  - [ ] RNA Analysis
  - [ ] DNA Hybridization
  - [ ] Recombinant DNA
- [ ] Amino Acid Sequencing
- [ ] Gene/Genome Mapping
- [ ] Natural Products
- [ ] Serology/Immunology
- [ ] PALEONTOLOGY
- [ ] Floristic
- [ ] Faunistic
- [ ] Paleoecology
- [ ] Biostratigraphy
- [ ] Palynology
- [ ] Micropaleontology
- [ ] Paleoclimatology
- [ ] Archeozoic
- [ ] Paleozoic
- [ ] Mesozoic

- ☐ Cenozoic
- ☐ POPULATION DYNAMICS & LIFE HISTORY
- ☐ Demography/ Life History
- ☐ Population Cycles
- ☐ Distribution/Patchiness/ Marginal Populations
- ☐ Population Regulation
- ☐ Intraspecific Competition
- ☐ Reproductive Strategies
- ☐ Gender Allocation
- ☐ Metapopulations
- ☐ Extinction
- ☐ POPULATION GENETICS & BREEDING SYSTEMS
- ☐ Variation
- ☐ Microevolution
- ☐ Speciation
- ☐ Hybridization
- ☐ Inbreeding/Outbreeding
- ☐ Gene Flow Measurement
- ☐ Inheritance/Heritability
- ☐ Quantitative Genetics/ QTL Analysis
- ☐ Ecological Genetics
- ☐ Gender Ratios
- ☐ Apomixis/ Parthenogenesis
- ☐ Vegetative Reproduction
- ☐ SPECIES INTERACTIONS
- ☐ Predation
- ☐ Herbivory
- ☐ Omnivory
- ☐ Interspecific Competition
- ☐ Niche Relationships/ Resource Partititioning
- ☐ Pollination/ Seed Dispersal
- ☐ Parasitism
- ☐ Mutualism/ Commensalism
- ☐ Plant/Fungal/ Microbial Interactions
- ☐ Mimicry
- ☐ Animal Pathology
- ☐ Plant Pathology
- ☐ Coevolution
- ☐ Biological Control
- ☐ STATISTICS & MODELING
- ☐ Methods/ Instrumentation/ Software
- ☐ Modeling (general)
- ☐ Statistics (general)
  - ☑ Multivariate Methods
  - ☐ Spatial Statistics & Spatial Modeling
  - ☐ Sampling Design & Analysis
  - ☐ Experimental Design & Analysis
- ☐ SYSTEMATICS
- ☐ Taxonomy/Classification
- ☐ Nomenclature
- ☐ Monograph/Revision
- ☐ Phylogenetics
- ☐ Phenetics/Cladistics/ Numerical Taxonomy
- ☐ Macroevolution
- ☐ NONE OF THE ABOVE

CATEGORY IV: INFRASTRUCTURE (Select 1 to 3)

COLLECTIONS/STOCK CULTURES

- ☐ Natural History Collections
- ☐ DATABASES

FACILITIES

- ☐ Controlled Environment Facilities
- ☐ Field Stations
  - ☐ Field Facility Structure
  - ☐ Field Facility Equipment
- ☐ LTER Site
- ☐ INDUSTRY PARTICIPATION
- ☐ Technique Development

TRACKING SYSTEMS

- ☑ Geographic Information Systems
- ☐ Remote Sensing
- ☐ NONE OF THE ABOVE

CATEGORY V: HABITAT (Select 1 to 2)

TERRESTRIAL HABITATS

- ☐ GENERAL TERRESTRIAL
- ☐ TUNDRA
- ☐ BOREAL FOREST
- ☐ TEMPERATE
  - ☐ Deciduous Forest
  - ☐ Coniferous Forest
  - ☐ Rain Forest
  - ☑ Mixed Forest
  - ☐ Prairie/Grasslands
  - ☐ Desert
- ☐ SUBTROPICAL
  - ☐ Rain Forest
  - ☐ Seasonal Forest
  - ☐ Savanna
  - ☐ Thornwoods
  - ☐ Deciduous Forest
  - ☐ Coniferous Forest
  - ☐ Desert
- ☐ TROPICAL
  - ☐ Rain Forest
  - ☐ Seasonal Forest
  - ☐ Savanna
  - ☐ Thornwoods
  - ☐ Deciduous Forest
  - ☐ Coniferous Forest
  - ☐ Desert
- ☐ CHAPPARAL/ SCLEROPHYLL/ SHRUBLANDS
- ☐ ALPINE
- ☐ MONTANE
- ☐ CLOUD FOREST
- ☐ RIPARIAN ZONES
- ☐ ISLANDS (except Barrier Islands)
- ☐ BEACHES/ DUNES/ SHORES/ BARRIER ISLANDS
- ☐ CAVES/ ROCK OUTCROPS/ CLIFFS
- ☐ CROPLANDS/ FALLOW FIELDS/ PASTURES
- ☑ URBAN/SUBURBAN
- ☐ SUBTERRANEAN/ SOIL/ SEDIMENTS
- ☐ EXTREME TERRESTRIAL ENVIRONMENT
- ☐ AERIAL

AQUATIC HABITATS

- [ ] GENERAL AQUATIC
- [ ] FRESHWATER
  - [ ] Wetlands/Bogs/Swamps
  - [ ] Lakes/Ponds
  - [ ] Rivers/Streams
  - [ ] Reservoirs
- [ ] MARINE
  - [ ] Open Ocean/Continental Shelf
  - [ ] Bathyal
  - [ ] Abyssal
  - [ ] Estuarine
  - [ ] Intertidal/Tidal/Coastal
  - [ ] Coral Reef
  - [ ] HYPERSALINE
- [ ] EXTREME AQUATIC ENVIRONMENT
- [ ] CAVES/ ROCK OUTCROPS/ CLIFFS
- [ ] MANGROVES
- [ ] SUBSURFACE WATERS/ SPRINGS
- [ ] EPHEMERAL POOLS & STREAMS
- [ ] MICROPOOLS (Pitcher Plants, Tree Holes, Other)

MAN-MADE ENVIRONMENTS

- [ ] LABORATORY
- [ ] THEORETICAL SYSTEMS
- [ ] OTHER ARTIFICIAL SYSTEMS

NOT APPLICABLE

- [ ] NOT APPLICABLE

CATEGORY VI: GEOGRAPHIC AREA OF THE RESEARCH (Select 1 to 2)

- [ ] WORLDWIDE
- [ ] NORTH AMERICA
  - [ ] United States
    - [ ] Northeast US (CT, MA, ME, NH, NJ, NY, PA, RI, VT)
    - [ ] Northcentral US (IA, IL, IN, MI, MN, ND, NE, OH, SD, WI)
    - [ ] Northwest US (ID, MT, OR, WA, WY)
    - [x] Southeast US (DC, DE, FL, GA, MD, NC, SC, WV, VA)
    - [ ] Southcentral US (AL, AR, KS, KY, LA, MO, MS, OK, TN, TX)
    - [ ] Southwest US (AZ, CA, CO, NM, NV, UT)
    - [ ] Alaska
    - [ ] Hawaii
    - [ ] Puerto Rico
    - [ ] Canada
  - [ ] Mexico
- [ ] CENTRAL AMERICA (Mainland)
  - [ ] Caribbean Islands
  - [ ] Bermuda/Bahamas
- [ ] SOUTH AMERICA
  - [ ] Eastern South America (Guyana, Fr. Guiana, Suriname, Brazil)
  - [ ] Northern South America (Colombia, Venezuela)
  - [ ] Southern South America (Chile, Argentina, Uruguay, Paraguay)
  - [ ] Western South America (Ecuador, Peru, Bolivia)
- [ ] EUROPE
  - [ ] Eastern Europe
  - [ ] Russia
  - [ ] Scandinavia
  - [ ] Western Europe
- [ ] ASIA
  - [ ] Central Asia
  - [ ] Far East
  - [ ] Middle East
  - [ ] Siberia
  - [ ] South Asia
  - [ ] Southeast Asia
- [ ] AFRICA
  - [ ] North Africa
  - [ ] African South of the Sahara
    - [ ] East Africa
    - [ ] Madagascar
    - [ ] South Africa
    - [ ] West Africa
- [ ] AUSTRALASIA
  - [ ] Australia
  - [ ] New Zealand
  - [ ] Pacific Islands
- [ ] ANTARCTICA
- [ ] ARCTIC
- [ ] ATLANTIC OCEAN
- [ ] PACIFIC OCEAN
- [ ] INDIAN OCEAN
- [ ] OTHER REGIONS (Not defined)
- [ ] NOT APPLICABLE

CATEGORY VII: CLASSIFICATION OF ORGANISMS (Select 1 to 4)

- [ ] VIRUSES
  - [ ] Bacterial
  - [ ] Plant
  - [ ] Animal
- [ ] PROKARYOTES
  - [ ] Archaebacteria
  - [ ] Cyanobacteria
  - [ ] Eubacteria
- [ ] PROTISTA (PROTOZOA)
  - [ ] Amoebae
  - [ ] Apicomplexa
  - [ ] Ciliophora
  - [ ] Flagellates
  - [ ] Foraminifera
  - [ ] Microspora
  - [ ] Radiolaria
- [ ] FUNGI
  - [ ] Ascomycota
  - [ ] Basidiomycota
  - [ ] Chytridiomycota
  - [ ] Mitosporic Fungi
  - [ ] Oomycota
  - [ ] Zygomycota
- [ ] LICHENS
- [ ] SLIME MOLDS
- [ ] ALGAE
  - [ ] Bacillariophyta (Diatoms)
  - [ ] Charophyta
  - [ ] Chlorophyta
  - [ ] Chrysophyta
  - [ ] Dinoflagellata
  - [ ] Euglenoids
  - [ ] Phaeophyta
  - [ ] Rhodophyta
- [ ] PLANTS
  - [ ] N0N-VASCULAR PLANTS
    - [ ] BRYOPHYTA
      - [ ] Anthocerotae (Hornworts)
      - [ ] Hepaticae (Liverworts)
      - [ ] Musci (Mosses)
  - [x] VASCULAR PLANTS
    - [ ] FERNS & FERN ALLIES
    - [ ] GYMNOSPERMS
      - [ ] Coniferales (Conifers)
      - [ ] Cycadales (Cycads)

☐ Ginkgoales (Ginkgo)
☐ Gnetales (Gnetophytes)
☐ ANGIOSPERMS
☐ Monocots
☐ Arecaceae (Palmae)
☐ Cyperaceae
☐ Liliaceae
☐ Orchidaceae
☐ Poaceae (Graminae)
☐ Dicots
☐ Apiaceae (Umbelliferae)
☐ Asteraceae (Compositae)
☐ Brassicaceae (Cruciferae)
☐ Fabaceae (Leguminosae)
☐ Lamiaceae (Labiatae)
☐ Rosaceae
☐ Solanaceae

☐ ANIMALS

☐ INVERTEBRATES
☐ MESOZOA/PLACOZOA
☐ PORIFERA (Sponges)
☐ CNIDARIA
☐ Hydrozoa (Hydra, etc.)
☐ Scyphozoa (Jellyfish)
☐ Anthozoa (Corals, Sea Anemones)
☐ CTENOPHORA (Comb Jellies)
☐ PLATYHELMINTHES (Flatworms)
☐ Turbellaria (Planarians)
☐ Trematoda (Flukes)
☐ Cestoda (Tapeworms)
☐ Monogenea (Flukes)
☐ GNATHOSTOMULIDA
☐ NEMERTINEA (Rynchocoela) (Ribbon Worms)
☐ ENTOPROCTA (Bryozoa) (Plant-like Animals)
☐ ASCHELMINTHES
☐ Gastrotricha
☐ Kinorhyncha
☐ Loricifera
☐ Nematoda (Roundworms)
☐ Nematomorpha (Horsehair Worms)
☐ Rotifera (Rotatoria)
☐ ACANTHOCEPHALA (Spiny-headed Worms)
☐ PRIAPULOIDEA
☐ BRYOZOA (Ectoprocta) (Plant-like Animals)
☐ PHORONIDEA (Lophophorates)
☐ BRACHIOPODA (Lamp Shells)
☐ MOLLUSCA
☐ Monoplacophora
☐ Aplacophora (Solenogasters)
☐ Polyplacophora (Chitons)
☐ Scaphopoda (Tooth Shells)
☐ Gastropoda (Snails, Slugs, Limpets)
☐ Pelecypoda (Bivalvia) (Clams, Mussels, Oysters, Scallops)
☐ Cephalopoda (Squid, Octopus, Nautilus)
☐ ANNELIDA (Segmented Worms)
☐ Polychaeta (Parapodial Worms)
☐ Oligochaeta (Earthworms)
☐ Hirudinida (Leeches)
☐ POGONOPHORA (Beard Worms)
☐ SIPUNCULOIDEA (Peanut Worms)
☐ ECHIUROIDEA (Spoon Worms)
☐ ARTHROPODA
☐ Cheliceriformes
☐ Merostomata (Horseshoe Crabs)
☐ Pycnogonida (Sea Spiders)
☐ Scorpionida (Scorpions)
☐ Araneae (True Spiders)
☐ Pseudoscorpionida (Pseudoscorpions)
☐ Acarina (Free-living Mites)
☐ Parasitiformes (Parasitic Ticks & Mites)
☐ Crustacea
☐ Branchiopoda (Fairy Shrimp, Water Flea)
☐ Ostracoda (Sea Lice)
☐ Copepoda
☐ Cirripedia (Barnacles)
☐ Amphipoda (Skeleton Shrimp, Whale Lice, Freshwater Shrimp)
☐ Isopoda (Wood Lice, Pillbugs)
☐ Decapoda (Lobster, Crayfish, Crabs, Shrimp)
☐ Hexapoda (Insecta) (Insects)
☐ Apterygota (Springtails, Silverfish, etc.)
☐ Odonata (Dragonflies, Damselflies)
☐ Ephemeroptera (Mayflies)
☐ Orthoptera (Grasshoppers, Crickets)
☐ Dictyoptera (Cockroaches, Mantids, Phasmids)
☐ Isoptera (Termites)
☐ Plecoptera (Stoneflies)
☐ Phthiraptera (Mallophaga & Anoplura) (Lice)
☐ Hemiptera (including Heteroptera) (True Bugs)
☐ Homoptera (Cicadas, Scale Insects, Leafhoppers)
☐ Thysanoptera (Thrips)
☐ Neuroptera (Lacewings, Dobsonflies, Snakeflies)
☐ Trichoptera (Caddisflies)
☐ Lepidoptera (Moths, Butterflies)
☐ Diptera (Flies, Mosquitoes)
☐ Siphonaptera (Fleas)
☐ Coleoptera (Beetles)
☐ Hymenoptera (Ants, Bees, Wasps, Sawflies)
☐ Chilopoda (Centipedes)
☐ Diplopoda (Millipedes)
☐ Pauropoda
☐ Symphyta (Symphyla)
☐ PENTASTOMIDA (Linguatulida) (Tongue Worms)
☐ TARDIGRADA (Tardigrades, Water Bears)
☐ ONYCHOPHORA (Peripatus)
☐ CHAETOGNATHA (Arrow Worms)
☐ ECHINODERMATA
☐ Crinoidea (Sea Lilies, Feather Stars)
☐ Asteroidea (Starfish, Sea Stars)
☐ Ophiuroidea (Brittle Stars, Serpent Stars)
☐ Echinoidea (Sea Urchins, Sand Dollars)
☐ Holothuroidea (Sea Cucumbers)
☐ HEMICHORDATA (Acorn Worms, Pterobranchs)
☐ UROCHORDATA (Tunicata) (Tunicates, Sea Squirts, Salps, Ascideans)
☐ CEPHALOCHORDATA (Amphioxus/Lancelet)
☐ VERTEBRATES
☐ AGNATHA (Hagfish, Lamprey)
☐ FISHES
☐ Chondrichthyes (Cartilaginous Fishes) (Sharks, Rays, Ratfish)
☐ Osteichthyes (Bony Fishes)
☐ AMPHIBIA
☐ Anura (Frogs, Toads)
☐ Urodela (Salamanders, Newts)
☐ Gymnophiona (Apoda) (Caecilians)
☐ REPTILIA
☐ Chelonia (Turtles, Tortoises)
☐ Serpentes (Snakes)
☐ Sauria (Lizards)
☐ Crocodylia (Crocodilians)
☐ AVES (Birds)
☐ Passeriformes (Passerines)
☐ MAMMALIA
☐ Monotremata (Platypus, Echidna)
☐ Marsupalia (Marsupials)
☐ Eutheria (Placentals)
☐ Insectivora (Hedgehogs, Moles, Shrews, Tenrec, etc.)
☐ Chiroptera (Bats)
☐ Primates
☐ Humans
☐ Rodentia
☐ Lagomorphs (Rabbits, Hares, Pikas)
☐ Carnivora (Bears, Canids, Felids, Mustelids, Viverrids, Hyena, Procyonids)
☐ Perissodactyla (Odd-toed Ungulates) (Horses, Rhinos, Tapirs, etc.)

☐ Artiodactyla (Even-toed Ungulates) (Cattle, Sheep, Deer, Pigs, etc.) ☐ Marine Mammals (Seals, Walrus, Whales, Otters, Dolphins, Porpoises)	☐ TRANSGENIC ORGANISMS ☐ FOSSIL OR EXTINCT ORGANISMS	☐ NO ORGANISMS

CATEGORY VIII: MODEL ORGANISM (Select ONE)

☑ NO MODEL ORGANISM MODEL ORGANISM (Choose from the list)	☐ Escherichia coli ☐ Mouse-Ear Cress (Arabidopsis thaliana)	☐ Fruitfly (Drosophila melanogaster)

Project Summary

Intellectual Merit – Forests of the North Carolina Piedmont have long served as a model system for the study of secondary succession, both because of many classic studies and the availability of long-term monitoring data. Permanent research plots in the Duke Forest date to the 1930's and during the subsequent 80+ years old-fields have succeeded to mature pine stands and those pines are now dying from the canopy. During this same time this system has experienced at least 2 hurricanes, 1 tornado, 2 major ice storms, 2 extreme droughts, a dramatic increase in deer populations and a proliferation of exotic species. In addition, climate has warmed substantially on average, with profound spatial variability as a result of local heat-island effects. Although classical succession theory may be necessary to predict future ecosystem change, it is far from sufficient. This proposal describes a long-term empirical study to resolve uncertainties about the future dynamics of Piedmont forests and in the process serve as a model for study of patterns and processes in other forest systems where classic successional processes and novel factors interact. The project takes advantage of 3 sets of long-term field surveys: (1) 0.1-ha plots with individual tree records dating from the 1930's and remeasured approximately every 5 years (N=34); (2) several (N=13) large, completely mapped stands dating variously from 1950 to 1985 and last resampled around 2001, with detailed records of seedling demography over the period of 1978-2001, and (3) survey plots from 1977 (N=247) with some (N~100) remeasured in 2000 and again in 2010 that include tree stem inventories plus frequency and cover measures for all vascular plant species, along with similar samples established in the NC Botanical Garden in the 1980's and resurveyed in 1997 (N=62). As part of this study, old plots will be resurveyed and new survey plots will be added to explicitly incorporate variation across gradients of local temperature as mediated by land cover and a gradient of proximity to edges and urban development. Additionally, deer exclosure plots will be erected to assess the impact of browsing. These new data sets will be combined with the archival data to quantitatively address several fundamental questions: (1) What is the 'natural' course of succession for Piedmont forests, and to what extent can this be understood in terms of tree population processes? (2)What are the roles of land-use legacies and topo-edaphic controls on forest change? (3) What role does episodic canopy disturbance have in influencing the direction and rate of forest change? (4) How does deer browsing pressure alter long-term changes in forest composition? (5) How does forest fragmentation and proximity to edge influence forest composition? (6) Is there a detectable temperature signal in the vegetation, either over time or as a spatial response to local heat islands and cooler refugia? While the study focuses on Piedmont forests in North Carolina, these issues are general to much of the eastern United States and to similar systems elsewhere. The intellectual merit of this project stems from its value as a model system for understanding forest dynamics as governed by a variety of factors including climate, topo-edaphic variables, and disturbances (natural as well as human-mediated). The proposed extensions to the archival datasets will update this iconic study so that it is relevant to the modern landscape, and ensure its continued value as a model system.

Broader Impacts – The broader impacts of the study are in 3 areas. (1) Provision of curated data on a model system, for research and teaching. As part of this project, the Duke Forest archives will be updated, with standard metadata and thorough documentation. These data will be freely available from a well-publicized server. (2) Student traineeship that will provide research experience and mentoring to 20 students over 5 years; this long-term study has already trained ~100 students. (3) Educational outreach. The project will generate educational modules on forest succession and landscape change, packaged as web-based tutorials, self-guided walking tours in the Duke Forest and NC Botanical Garden, and continuing education workshops for local teachers hosted by the Duke Forest Office and the NC Botanical Garden. Through the very active educational centers at the Duke Forest and Botanical Garden, results of this study will reach a huge audience in this rapidly growing metropolitan area.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

Appendix Items:

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Project Description

1. Introduction

The Duke Forest and the adjacent Piedmont landscape is perhaps the best known model system for forest succession, with many papers published—some dating back to the 1930s—and references in most standard textbooks. Many of the classic papers on succession in eastern North American were based on this study area (e.g., Billings 1938, Oosting 1942, Keever 1950, Bormann 1953). Much of the continuing value of this model system stems from the availability of long-term monitoring data. Thus, the model of secondary succession for Duke Forest is not simply inferred from chronosequences, but rather, has been documented and tested empirically in real time since the 1930s.

Our data sets on forest succession and dynamics in and near the Duke Forest derive from several initiatives (data sets are described in more detail in section 3). The oldest plots were established by Prof. Clarence Korstian of the Duke Forestry School in the early 1930s to assess both natural stand dynamics and the impact of various silvicultural practices. These plots have had all tree stems remeasured for diameter and height at roughly 5-year intervals. The plots have proven useful for many purposes not anticipated by Korstian, including study of tree population processes (Peet & Christensen 1980b, 1987), mechanisms of tree competition (Peet and Christensen 1987, Knox et al. 1989), patterns of mortality (Peet & Christensen 1987), changes in biomass and production (Peet 1981, 1992), change in genetic structure (Baker-Brosh 1996), impacts of hurricanes and wind events (DeCoster 1996, Xi & Peet 2008a, 2008b, 2010; Xi et al. 2008a, 2008b) and predictability and convergence in composition (Christensen & Peet 1981, 1984). Other new and emerging issues can be uniquely addressed by this sort of data, such as the controversial claim that forests are increasing in productivity (e.g., McMahon et al. 2010, but compare Foster et al. 2010).

The second set of plots includes mapped forest stands, significantly larger than those established by Korstian, wherein spatial pattern is more readily observed and where sample sizes are larger allowing generalization to more species. The earliest of these mapped plot dates from H. Bormann in 1950, and others were established in the 1970s and 1980s. The number of measurement cycles has been on the order of 4-5. Several mapped plots have had extensive monitoring of tree seedling and sapling dynamics, in addition to tree stems. The plots have been used in a series of studies examining spatial pattern (Bormann 1950, Christensen 1977, Palmer & White 1994, Palmer et al. 2007), species diversity (Christensen 1977, Peet and Christensen 1987), seedling establishment, growth and survival (Philippi et al. 1993, 1994), trajectory of species composition (McDonald et al. 2002), spatial pattern of tree regeneration (McDonald et al. 2003) and scale-dependence of vegetation-environment correlations (Palmer 1990, Reed et al. 1993).

The third set of plots, established by R.K. Peet and N.L. Christensen in 1977, documents the abundance and cover of all vascular plant species in 247 plots of 1000-m^2 distributed across the range of site conditions and forest ages encountered in the Duke Forest vicinity. These plots were later supplemented by 62 similar plots established on nearby NC Botanical Garden lands. The original plots were used to document patterns of composition in Piedmont forests (Peet and Christensen 1980a, 1980b Christensen and Peet 1981), patterns of convergence during succession (Christensen and Peet 1984), and patterns of diversity (Peet and Christensen 1988, Fridley et al 2005). Approximately 100 plots have subsequently been remeasured twice more (~2000 and ~2010), plus 62 Botanical Garden plots were resurveyed in 1997 (White 1999). The results of the first remeasurement (Taverna 2004, Taverna et al. 2005b, Schwarz 2007, White 1999) documented both successional change and a different, landscape-scale set of changes unrelated to succession. These latter changes include loss of species susceptible to deer browse, introduction of exotics, and other unexplained compositional changes. Data from the 2010 resampling event are still being analyzed (Israel, *in draft*), but results to date show changes similar in character to those observed in 2000, but with a much greater rate of change.

Now, several decades after Billings and Oosting, it seems clear that the classical model of succession is much too simple to faithfully represent this system, that numerous other factors are driving change and that these factors are largely independent of stand age. The species that appear most likely to dominate the new canopy of the successional stands are not the ones predicted in the classic studies. Catastrophic wind events have significantly damaged a substantial number of our study plots. Deer populations have recently exploded with a resultant decline in herb diversity and an as-yet unknown impact on tree regeneration, and exotic species have become common in the groundcover layer of many areas. The landscape is now highly dissected, with a high incidence of forest edges, and parts of the study area are adjacent to local urban heat islands and thus experience a much warmer climate than large forest patches. In short, the Duke Forest can continue to serve as the leading model system for forest succession—but only if we adopt a more general model of forest dynamics and address the multiple and varied drivers of forest change. We propose this more general synthesis, by extending the historic data sets while establishing new field studies to support a richer model of forest community dynamics.

2. Conceptual Framework and Objectives

The overall aim of our research program is to understand the dynamics of forest communities using North Carolina Piedmont forests as a model system. In general, we are interested in the relative importance of classical successional processes, land-use legacies, episodic disturbances, and novel environmental pressures in structuring forest communities. The overall objective of this research proposal is to make it possible for us to maintain and, where appropriate, expand long-term observations that will help us and other workers achieve a better understanding of forest dynamics, both in the Southeast and more generally.

One basic conceptual issue to be addressed is the extent to which forest dynamics and succession are predictable and can be understood in the context of the population dynamics of the dominant tree species (Peet and Christensen (1980b, 1987, 1988; Peet 1992). The slow growth of forest trees greatly limits opportunities to document tree dynamics over the full period of stand development, and, thus, greatly limits our ability to investigate the population processes that underlie succession and community dynamics. The present proposal is designed to continue and expand efforts needed to build a database adequate for such population-based studies of forest dynamics.

A second conceptual issue to be addressed is the degree to which chance and unexpected events (wind damage, exotic species, browsing pressure, climatic warming) result in qualitatively different forest dynamics or simply alter the direction and rate of 'natural' succession. As inevitably future studies of succession will need to balance intrinsic successional processes with extrinsic influences, it is important that our critical model systems incorporate both types of change.

We propose to build upon the rich legacy of the Duke Forest archives to enrich our understanding of long-term forest dynamics and to document the influences of specific drivers of forest change. We will extend measurements of long-term monitoring plots to document compositional trends in trees, understory, and ground-layer vegetation. We also will deploy new samples to augment the historical samples to address specific, newly-emerging questions about these changing forests. In the following sections, we describe the key data sets and field measurements (section 3); itemize a series of research questions and which data will be used to answer these questions (section 4); outline the research schedule for this project and a decadal research plan (section 5); and highlight the significance and broader impacts of this project (section 6). Our plans for data management and dissemination are detailed separately as a Supplementary Document.

Prior submission. We proposed a similar project in January 2011 and received generally enthusiastic reviews but were not recommended for funding. Reviewers noted three main issues in terms of the intellectual merit of the proposal: (1) a lack of integration among the various datasets and research issues, (2) a failure to identify specific research products from the project, and (3) (from one reviewer) a perceived need to integrate the data into a simulation model to provide forecasting capacity. We have greatly clarified the integration of the several research pieces, especially expanding the analytic framework for integration. We have also itemized separately (section 4) a series of specific research questions indicating which data will be used to address each question, and the research products we expect from these analyses. We do not propose to build or parameterize a simulation model, as we believe this is beyond the scope (and budget) of an LTREB proposal. We have, however, explained how our data might be used in this way, as part of the broader impacts of this work. We have also expanded the discussion of broader impacts by detailing how these data will be used to develop education and outreach at many levels, extending the value of this model system.

3. Core Data and Field Measurements

It would be ideal—even idyllic—if there existed a single historic data set that recorded all the key forest measurements we desired, and did so for a very long time. We know of no such data set. Instead, we have multiple data sets that have been assembled over time, each designed to complement or augment other data sets. During the course of this project, we will extend measurements of three invaluable core datasets: (1) Permanent Sample Plots established by Korstian in the 1930s (hereafter, “Korstian plots”), (2) tree stem maps and associated seedling maps established in between 1950 and 1985 (“mapped stands” or “stem maps”), and (3) full-floristic survey plots established in 1977 and afterwards (“survey plots”). These constitute the Core Data for this project. The three data sets are complementary and together support a much richer understanding of forest dynamics than the original Korstian plots. But these core data present a narrow and limited view of forest dynamics in the region, as all of these samples are located in largely intact forests. In this rapidly developing landscape, the core data sets have, over time, become increasingly unrepresentative of the forests actually covering this landscape. To this end, we will establish three new sets of samples to address issues now but only recently facing this system: (4) exclosures to assess deer browsing impacts, (5) samples to monitor edge effects from habitat fragmentation, and (6) plots stratified over a gradient of temperature owing to local heat islands. Our intent is that these new samples will, over time, become part of the core data sets representing this model system. The field methods for each of these sample types are detailed below. The following section outlines how these data will be brought to bear on specific research questions.

3.1. Extant datasets

Our proposed work consists of two related components: recensuses of long-term, permanent plots and establishment of critical new supporting datasets. The richness of our collection of plot data and the budgetary constraints imposed by the LTREB program will preclude resurvey of some established plots that it would be desirable to include. Below we list the plots that we plan to recensus, and assign priorities to the varied tasks. Our intention is to begin with the highest-priority tasks and to complete as much additional work as time and resources allow.

1. Korstian Plots. Between 1931 and 1935 Professor Korstian (Korstian & Coile 1938) and staff of the Duke Forest established 51 permanent sample plots with individually numbered trees in the Duke Forest; additional plots were established in the nearby in the Hill Experimental Forest of North Carolina

State University in 1947. Some of these plots were experimentally manipulated in the 1930s and 40s to modify tree density and size structure for assessment of silvicultural practices, but most served as controls. There is little contemporary legacy of the past forest density manipulations. These plots have been censused with individual tree diameters and heights recorded at roughly 5-year intervals since establishment, though the last census was ~10 years ago. During the period of 1978 – 2001 we were able to resurvey the 34 extant plots several times. These plots include mature hardwood forests on a range of site conditions, plus successional pine stands on old fields abandoned between 1900 and 1930. During remeasurements we mapped and recorded the diameter and height of all trees over 1 cm dbh, including new in-growth. In the resurveys of 1997-2001 hurricane damage codes were assigned to indicate the impact of the 1996 Hurricane Fran. These plots cover a total of ~4 ha of forest, contain nearly 11,000 mapped and measured trees at establishment, of which nearly 1300 remain and which have been supplemented by approximately 8400 extant new stems All data have been systematically checked for errors and inconsistencies (see (http://www.bio.unc.edu/faculty/peet/lab/PEL/df.htm).

2. Mapped Stands. The original Korstian plots ranged in area from 405 to 1012 m^2 (0.1-0.25 acre). This modest size precludes meaningful studies of spatial patterns, gap dynamics, and demographic investigations of other than the few dominant species—features critical to understanding forest community dynamics. For this reason we mapped large forest stands, including 13 that have been remapped over time (see http://www.bio.unc.edu/faculty/peet/lab/PEL/df.htm). These 13 large plots, comprising our second core data set, range in size from 4047 to 65000 m^2 and together cover approximately 24 ha of forest and include ~40,000 living trees. Most plots were established during the period 1977-1986, though one dates from 1950 and one from 1989. All stems > 1cm dbh were mapped to the nearest decimeter, and diameter and tree height were recorded for each stem. In resurveys of 1997-2001, hurricane damage codes were assigned to indicate the impact of the 1996 Hurricane Fran.

Five plots were designated in 1989 for intensive study, with seedlings and sapling subplots (see below). These included two old pine stands (70 & 80 years old in 1986) and three uneven-aged hardwood forests on contrasting sites. The remaining 6 plots span a range of upland site conditions. All trees in each of the intensive study plots will be resurveyed. During each resurvey, all stems >1 cm diameter will be mapped and recorded by species and diameter, and deaths (or missing trees) will be recorded.

Seedling Plots. Despite their foresight, the foresters who established our permanent plots were not interested in seedlings or saplings. Consequently, we inherited extensive, long-term records for trees, but not for seedlings. This is unfortunate as establishment is often the critical step in determining whether a species will succeed in a particular habitat (Grubb 1977, Harper 1975). To compensate, we initiated observations of seedling demography in 1978. Seedlings were mapped along permanently marked transects 1-m wide and 10 to 50-m long. These transects cross the normal range of spatial variation in each stand. Annually, seedlings of all dominant tree species were mapped by Cartesian coordinates along each transect. Using data sheets prepared from the previous year's census, field crews found it relatively easy to relocate survivors and to identify new in-growth. The identity of each seedling, whether it was alive, and its height, and number of leaves (up to 20) were recorded. We initially established 10 intensive seedling study plots (250-300 m of transect), but starting in 1989 we shifted to maintaining 5 intensive seedling plot sites representing three types of mature hardwood forest and two stands near the stage of transition from loblolly pine to hardwoods. Annual measurements continued through 1994. For these five sites we also monitored sapling (> 1m tall and < 1 cm dbh) growth annually in a set of 4x50 m transects that overlap the seedling transects. Measurements were resumed for the period of 1997-2001 to assess the impact of damage by Hurricane Fran on seedling growth and survival. Approximately 84000 seedlings have been observed on these transects with approximately 10000 alive in any one year. We propose to again assess seedling growth and survival twice during this sampling period. Because of the period since the previous survey we do not expect to be able to identify specific individuals for many of the stems during the first resample, but for the larger seedlings and saplings of 2001 this should be possible.

3. Compositional Survey Plots. In 1977-8 247 0.1 ha (20x50-m) plots were distributed across the Duke Forest and nearby forest lands to better represent landscape-scale variation in species composition and tree population structure. These plots and their remeasurements comprise our third core data set. Unlike the great majority of permanent plots in North America, these plots have detailed information on cover of all vascular plant species as well as soil chemistry and texture. In addition, during the early 1990's 62 0.1 ha plots with detailed tree and herb data were established across a range of natural areas within the NC Botanical Garden lands, approximately 8 miles from the Duke Forest. In 1999-2001 we relocated and resampled 88 of the 1977 Duke Forest plots (many more examined and rejected because of major land-use changes such as clearcutting) (Taverna et al. 2005a). In addition, 42 of the 62 N.C. Botanical Garden permanent plots were resampled in the summer of 1997 (White 1999). Finally, approximately 75 of the Duke Forest plots sampled in 1977 were sampled a third time in 2010 (Israel 2011, *in draft*). The sampling protocol is consistent with that of the standardized Carolina Vegetation Survey (CVS; Peet et al. 1998), augmented to include some additional information recorded in 1977.

Permanent plots with detailed herb data are extremely uncommon in North America, yet herbs are well known to be especially sensitive to the changing environment and competitive status of forest stands. We propose to again relocate and resample as many of these plots as possible during this project. Importantly, these survey plots are now nearly 35 years old—sufficient to document successional changes in these forests as well as forest response to other influences over that time.

3.2. New Data Sets

As valuable as the core data sets have been, they are not sufficient to support continued, inferential studies of forest dynamics in this system. Only 34 of the original 51 Korstian plots remain, the others lost to development. Similarly, the mapped stands and survey plots are in intact forests; and while these samples include detailed measurements that are quite valuable, they were not deployed to yield insights into the forces now shaping these forests, such as fragmentation, browsing, and heat island effects. In short, we will need to augment the core data sets to increase their usefulness. We propose to establish three sets of samples that, over time, will become part of the core data. In particular, all new plots will follow CVS survey protocols, which means that the new data can be pooled with the archival data (Korstian and Survey plots) for analyses. In addition, some plots (indicated below) will have individual trees mapped to conform to the format of the original Korstian plots.

4. Deer exclosure plots. We will screen existing compositional survey plots over a range of topo-edaphic settings for locations where we can establish new paired 20x50-m deer-exclosure plots in close proximity to existing plots. Initial selection of plots will be based on geospatial data associated with existing plots (georeferenced in ArcGIS), including soil type (SSURGO data) and topographic position (slope, aspect, and slope position). We will then screen candidate sites via field visits to verify vegetation and site conditions, as well as to assess the logistics of establishing a paired plot. We aim to establish as many as 12 exclosures, based on opportunities in the field and available funding.

Each exclosure will be a few meters larger than the 20x50-m plot, surveyed according to CVS protocols. We will surround each plot with 8-ft plastic deer fencing attached to metal stakes or trees and fortified with a stabilizing wire at a height of 3 ft. Fencing will have a mesh size that allows small mammals to pass. We will collect pre-exclosure data in year 1 and then fence-in the sites at the end of the first field season.

We should emphasize that while there are exclosures already established in the Duke Forest by our colleague Jim Clark (Duke Biology/Nicholas School), his sites are few and local to his on-going studies of tree recruitment. By contrast, our new sites will be explicitly matched to historical survey plots and stratified over a range of topo-edaphic settings as well as broadly distributed over the study area. That is, the new plots are designed to be pooled with the archival survey plots for analysis.

5. Forest edge and old-field plots. We will establish new plots, using the CVS protocol, to sample forest edges in a variety of topo-edaphic settings. Previous work in these forests (e.g., McDonald & Urban 2006a) has shown that the biophysical effects of the forest edge (e.g., light, temperature, humidity) are expressed within a few meters of the edge itself and so we can capture these with a 20x50-m modified CVS plots starting at the forest edge, as done by Fridley et al (2009). We will aim to establish ~30 such plots, stratified over soil type and topographic position. As part of another study, we have extended a land-cover classification similar to the National Land Cover dataset (Homer et al. 2004) to the entire Landsat Thematic Mapper mission, thus giving us consistent land cover maps dating back to the early 1980s (Sexton et al., *in review*). Using these data and older land use maps available for Duke Forest and UNC's Mason Farm (adjacent to and including a large portion of the NC Botanical Garden lands), we can also stratify over edge age, choosing locations that were developed long ago (and hence are "old" edges) and sites that have been developed quite recently. Because the existence of an edge implies a non-forest land use adjacent to a forest, we will also establish some new plots in current old fields or cut-over forests in close proximity to the edge plots—which will become interesting in comparisons with longer-term remeasurement plots. Duke Forest and UNC's Mason Farm are both actively managed "working lands" and so provide ample opportunity to sample fields and forest edges under controlled conditions. Such plot placement will not be possible for every edge plot (some land uses adjacent to forest edges, e.g. lawns, will not undergo succession), but this will allow us to establish some new "initial conditions" for secondary succession for the first time since Korstian established his plots nearly 80 years ago. Indeed, while the Korstian plots have been invaluable in developing our ideas about succession, they are, in fact, now late-successional and without new early-successional plots we can no longer truly study this process. Thus, our project will establish a new baseline that will become increasingly valuable decades in the future.

6. Urban heat islands and temperature gradients. All of the core data sets were designed to sample forests that were large and mostly intact, and thus are not very representative of the larger, rapidly developing landscape. The edge plots (above) will correct for this to some extent. But large forest patches are also cooler, while smaller fragments experience a warmer micoclimate due to local heat-island effects (White et al. 2002, Gregg et al. 2003, Carreiro & Tripler 2005, Imhoff et al. 2010). We will establish new survey plots at locations selected to sample a gradient in local temperature reflecting urban heat islands from developed areas and cooler refugia in more densely forested sites. We will stratify locations based on recent land cover classified from Landsat Thematic Mapper (TM) data (Sexton et al., *in review*) and TM thermal data calibrated as part of the same project (J. Sexton, *unpublished data*). These data show that local temperatures vary by more than 10 ^{o}C between intact forests and highly developed land covers (and this at a 10 am Landsat overflight time), and that warmer temperatures can extend appreciably into forests from adjacent developed areas. Using these data, Losordo et al. (*in prep.*) found that the average temperature of small forest patches in our study area is profoundly affected by developed land cover nearby (R^2=0.51 in regressions based on percent developed in 500-m buffers around forest patches). Thus, we can use the TM thermal images and land cover data to select a stratified sampling frame, with actual sites to be chosen after field visits.

Sampling plots will follow the established CVS protocols, which can be readily compared to data collected for the older compositional survey plots. We aim to establish 30 new survey plots in more developed settings (existing plots already sample more heavily forested settings). Each plot will be georeferenced, and field measurements will be made of topographic settings. Local temperatures can be estimate crudely from TM thermal data, but we will collect actual air temperature by installing micro-loggers (Hobo Pro Temp, Onset Computer Corporation) in a subsample of locations to calibrate actual temperatures. These loggers can record hourly temperatures for more than a year per battery, which should be ample to quantify site-specific thermal regimes. We have a number of loggers already from a previous project, and have had good success with by mounting the loggers at 1-m height on the north side of trees (to minimize effects of direct radiation) (Lookingbill & Urban 2003, McDonald and Urban 2004).

To account for the association of heat islands due to developed land cover and edges associated with human land uses, we will co-locate some samples to address each issue. In this, we will establish new samples in edges or in small forest patches close to developed land covers (and consequently warmer), but in close proximity to existing survey plots. Again, we will attempt to match locations in terms of soils and topographic position. This will provide some statistical control over the covariation of temperature and edginess caused mutually by land cover. (The converse association, that large patches of interior forests tend to be cooler, will be more difficult to isolate because these locations will not be edgy; but we can query our GIS databases to find possible candidate sampling sites.)

4. Research Questions, Analyses, and Integration

4.1 Research questions

We will use the data collected to immediately address questions exploring seven key themes, each leading to a discrete, publishable set of results and one or more publications:

1. What is the 'natural' course of secondary succession in Piedmont forests, and can this be interpreted as a population process? This is the core question our research program has been addressing since its inception. We have in several publications (e.g., Peet & Christensen 1980b, Peet 1992) described how secondary forest succession can be understood as a population process involving the dominant trees. However, we have lacked tree population data from the critical transition phase from pines to hardwoods. The iconic model of Billings, Oosting, and others based on chronosequences posits succession from old fields, through pines, to oak-hickory hardwoods (the presettlement forest). But plots established by Korstian in young pine stands now represent a transition to all-aged hardwood stands, with pines being replaced by hardwood species that were not an important component of the presettlement forest (e.g., red maple, sweetgum; see Peroni 1994, McDonald et al. 2002), a pattern reported more broadly for eastern North America by Abrams (1992, 1998). We are now on the cusp of fully documenting this compositional change, as the pines are now senescing from the canopy and we can assess how this transition and the associated relaxation of competition owing to rapid loss of the original pine cohort impacts recruitment into and development of the new canopy. This is the last big missing piece in the Piedmont succession puzzle and we are fortunate to be in a position to witness this directly over the next decade.

We will address this question by using remeasurements of both the Korstian plots and the mapped forest plots to complete documentation of age- and size-based rates of change in tree populations over time spanning the full transition from young old-field pine to hardwood forest. In particular, we will focus on the apparent decline of the oak populations in stands that were mature when established, the advance and loss of the even-aged pine population in plots established in early-successional stands, and the recruitment of an uneven-aged population of species that were uncommon in historical records but are coming into dominance now (especially red maple, beech and sweetgum).

2. What are the roles and relative importance of land-use legacies versus topo-edaphic controls in forest dynamics and successional trajectory? Our 1977 survey showed considerable differentiation of forest composition with topo-edaphic setting, and our resurvey of mixed-age hardwood survey plots has shown a general trajectory of compositional change with the pattern differing with topo-edaphic setting (Taverna et al. 2005b).This is particularly important as remnant oak-hickory forests occupy distinctly different topo-edaphic positions from typical post-agricultural fields (Taverna et al. 2005a). This prior land use has left a rich legacy on current forests, as certain topo-edaphic settings were favored for agriculture, thus requiring a deep understanding of the linkage of dynamics to site if we are to understand future compositional change.

In addition, succession, albeit more subtle than in the old-field pines, is also taking place in the stands that were dominated by hardwoods when our plots were established, probably as a consequence of a 19th-century history of grazing and fire. Our prior demographic work has shown that while oak and hickory seedlings and saplings do become established and can eventually achieve canopy status, there has been a steady decline in the dominance of these genera over the past 70 years, along with a simultaneous increase in abundance of red maple and beech. One popular hypothesis is that the oaks and hickories were well adapted to chronic, low-intensity fires that ceased during the 1800s (see Abrams 1992, 1998). However, another hypothesis that has received consistent support is that these relatively shade-intolerant species are adapted to rapid growth following major canopy disturbances such as those associated with hurricanes and tornados (see #3 below). These hypotheses can be addressed by using the compositional survey plots, as these are stratified over topo-edpahic gradients and include tallies of tree seedlings in the understory (the Korstian plots, though older, are few and do not span the range of land-use and topo-edaphic conditions). Thus, while potentially new canopy species have been increasing significantly in the seedling and sapling layer of our plots, we are now at a point where we can observe whether they enter the canopy and potentially result in a general homogenization of forests as the prior land-use legacies fade away.

3. What role does episodic disturbance play in determining the direction and rate of forest change? Past analyses of permanent sample plots from Duke Forest have supported a classical succession model—establishment, competitive thinning, transition, and steady-state — as articulated by Bormann & Likens (1979) and others (Oliver 1981, Peet 1981, Christensen & Peet 1984, Peet & Christensen 1988). These studies were based on largely undisturbed stands. Over the past few decades, however, our study area has experienced 2 major hurricanes (Hazel in 1954, Fran in 1996; see Carpino 1998), 2 tornadoes, 2 major ice storms, and the 2 worst droughts ever recorded in the Southeast. One might naturally ask, given this history, whether a signal of classical succession (i.e., mediated by shade tolerance) is evident in the empirical time series.

The occurrence of major disturbance events and particularly hurricanes allows us to track changes in tree populations and community composition, and to compare these changes on sites with different levels of disturbance. With Hurricane Fran now 15 years in the past, we can gain a substantive understanding of its impact on forest composition and the role of such events in driving forest composition. Two core data sets are key to this question. Resurveys of mapped forest stands established before Fran will be crucial to this task. A detailed analysis of 95,076 seedlings surveyed over a 17-yr period before Hurricane Fran provides a baseline for a demographic understanding of tree replacement (Philippi et al. 1993, 1994). Similar analyses immediately following Fran have documented the short-term (5-yr) response to this disturbance (Xi & Peet 2008a, 2010), one finding of which is that increased tree mortality was not simply immediate but continued for at least a 5-yr period. We are now in a position to extend these analyses to a more meaningful period following disturbance and address several hypotheses. For example, we expect that species distributions will have become less predictable for several years following major canopy disturbances associated with Hurricane Fran, while remaining relatively constant in undisturbed forests, a hypothesis supported by preliminary data reported by Xi & Peet (2008a, 2008b, 2010). Second, we can observe small-scale changes in seedling and sapling composition of the mapped stands to test the hypothesis that seedling and sapling diversity increases following significant canopy damage. We will also determine whether this anticipated increase in sapling diversity is attributable to differences in seedling establishment or to reduced mortality and/or increased growth of established individuals. Finally, we will determine the extent to which over a 20-year period large established seedlings experienced a sustained increase in growth rate in those portions of stands with significant hurricane damage. These analyses of the mapped stands can be complemented by parallel analyses of the compositional survey plots, which, although without individually-monitored trees, cover a broader range of site conditions and levels of disturbance severity.

4. How does deer browsing pressure alter long-term forest development and composition? Over the past decade, deer populations in our study area have increased to roughly 40-50 deer/mi^2 (~20/km^2; *unpublished data*, Duke Forest Office), compared to the maximum of 15-20 recommended by state wildlife authorities and <5 at the establishment of our permanent plots. Browsing pressure is now but only recently evident in many areas of the Forest. Comparison of understory composition between 1977 and 2000 found considerable loss in diversity and suggested deer were partly to blame, a loss that has accelerated over the past decade. However, only with deer exclusion experiments can we test this hypothesis, assess the impact, and quantify the recovery rate once deer are removed. While deer impacts are well-known and widely studied elsewhere (e.g., Rooney 2001, Rooney & Waller 2003, Cote et al. 2004), this component of the project will add a new and critical dimension to the understanding of our model system. We will assess this impact by installing deer exclosures on new sample plots matched pairwise to existing compositional survey plots. Because the new exclosures will be matched explicitly to existing survey plots, we can assess compositional change over time using a variation of a paired-sample MANOVA implemented as a partial Mantel test incorporating a design matrix to account for the sample pairs (see below).

5. What significance does forest fragmentation and proximity to forest edge have for forest composition? Based on recent landcover maps derived from Landsat Thematic Mapper imagery, the median distance to a non-forest edge for forested pixels in the study area is roughly 100 m (D. Urban, *unpublished data*). This pattern is common across much of the eastern US (Riitters et al. 2002). Forest edges experience different microclimates, support a characteristic mix of species (McDonald & Urban 2004, Fridley et al. 2009), and are prone to invasion by exotics (McDonald & Urban 2006a). While forest interior habitats persist throughout the region, they are increasingly the exception to the rule that most extant forests are edge habitat. We will establish new sample plots in forest-edge habitat, near to existing interior samples, to initiate a long-term study of these effects. As the edge plots will be located in close proximity to forest-interior plots, we can assess these differences using variations of MANOVA implemented as partial Mantel tests. We can use the new old-field plots, to be established adjacent to the edge and interior forest plots, to assess the compositional trends from field through edge to forest.

6. To what extent do climate warming and local heat-island effects already impact forest composition? Over the past 3 decades, the average temperature has increased significantly in the Triangle region of NC. At the same time, spatial variability in temperature as a result of local heat islands ranges as much as 10^o C over distances of hundreds of meters, based on data from the thermal band of Landsat Thematic Mapper imagery (very local temperatures, such as parking lots, can be much higher). Carreiro and Stripler (2005) promoted the use of urban systems as proxies for global change, noting that forests in urban landscapes already experience warmer temperatures, higher CO_2, increased nitrogen deposition, and other impacts associated with global change; they also acknowledge the challenges of controlling for these confounding factors and offer recommendations for sampling strategies. We will use the compositional survey plots to address temperature change over time (these plots span the past 34 yrs of warming), while also establishing new plots across a synoptic gradient of local temperatures to adopt a space-for-time substitution approach to explore local adaptation to temperature. In this initiative, we will focus on the relative abundances of understory plants.

We will examine species compositional response to temperature by adopting a weighted-averaging approach based on climate affinities extracted from the geographic ranges of selected plant species. In this, we will use coarse-resolution climate data (e.g., PRISM Climate Group, Oregon State University, http://www.prismclimate.org) and geospatial range data (USDA PLANTS database, the Flora of the Southeast Atlas) to extract a variety of climate indices (e.g., mean annual temperature, total growing-season precipitation) associated with the midpoint of each species' range (range extremes might be more interesting ecologically, but we expect these to be more biased by biogeographic idiosyncrasies such as shorelines). Species whose geographic ranges extend beyond the scope of available climate data and exotic species whose ranges are not in the US will be excluded from this analysis. From these climate indices, we will compute weighted-average scores for each sample site, based on the relative abundances of each species (McCune and Grace 2002). We expect sites in more developed locations to have 'hotter' and perhaps 'drier' weighted-average scores as compared to more heavily forested locations. A similar approach using ant communities has shown dramatic responses to local heat islands in nearby Raleigh, NC; urban ant communities show a decidedly southwestern biogeographic affinity as compared to ant communities in intact forests (Menke et al. 2011). In terms of our data sets, we expect to see a change in the weighted-average indices over time in the survey plots, and over space in the new heat-island plots as compared to extant plots in larger forest patches.

7. Is the unexpected appearance of invasive species altering the course of forest development and if so is this predictable? A trend that overlaps all of the above themes is the increase in the abundance of exotics, especially the invasive C4 grass *Microstegium* (Taverna et al. 2005b). Exotic species increase following agricultural land use (Fridley et al. 2009), in forest edges (McDonald & Urban 2006a), and in high-light or high-moisture settings such as disturbed sites (Bickel 2001; Brown & Peet 2003, Fridley et al. 2009). These changes can be independent of successional change, less predictable, and more pervasive owing to broader ecological tolerances and lower natural control, leading to homogenization of the landscape (McKinney 2004). At a minimum we can assess the range of sites already impacted by exotics and project the future distribution and impacts of species already present in the system (DeMeester & Richter 2010).

4.2 Analytic Framework for Integration and Synthesis

Many of the research questions outlined here will be assessed in terms of species-level response to a variety of drivers (topo-edaphic factors, disturbance, browsing, edges, climate). For this reason, it is convenient to outline the basic analytic approach collectively. Importantly, we note that all of the new samples can be pooled with archival Korstian and Survey plots for analyses (the stem maps are analyzed using different methods, see below).

1. Changes in species composition. Changes in species composition in response to a variety of factors (soils, topography, time, browsing pressure, edginess) invite a multiple analysis of variance (MANOVA). But because these data rarely meet the assumptions of a parametric MANOVA, alternative analyses are required. In the simplest case, a nonparametric MANOVA would suffice (Anderson 2001). A more versatile approach is to adopt variations of the Mantel test (Legendre & Legendre 1993, Goslee & Urban 2007). Mantel's test assesses the correlation between two distance or dissimilarity matrices. One of these matrices typically summarizes species-compositional dissimilarity (e.g., as Bray-Curtis 1957 or some other dissimilarity index) between all pairs of samples. The other matrix might be geographic distance, in which case the test is equivalent to a multivariate autocorrelation function. Or, the second matrix might be environmental dissimilarity, in which case the test asks, 'Are samples that are environmentally (dis)similar also compositionally (dis)similar?' A special case of the Mantel test has one of the matrices as a contrast matrix, such that two samples that take on the same value in a design matrix have a dissimilarity of 0, else 1. This case corresponds to the MANOVA case, and like a MANOVA, can be nested to match other experimental designs (Legendre and Legendre 1993). This family of tests includes variations that correspond to various instances of MRPP (Biondini et al. 1988, McCune & Grace 2002), ANOSIM (Clark 1993), and Adonis in the *vegan* package for R (Oksanen et al. 2010). We will conduct Mantel tests using the *ecodist* package for R (Goslee and Urban 2007).

An appealing feature of Mantel tests is the variety of ways in which distance or dissimilarity matrices may be configured for particular analyses. For example, a simple test of the correspondence between species compositional dissimilarity and environmental dissimilarity might be conducted using any appropriate compositional index (e.g., Bray & Curtis distance) and an index of environmental dissimilarity (e.g., Mahalanobis, to account for correlations among environmental variables). As an example, we will want to know whether plots that are similar in local temperature are also similar in species composition, given their similarity on other environmental factors; this partial Mantel test isolates the local climate effect we seek. This test will be significant if a single variable is quite responsive, or if several variables are weakly responsive. To sort through the individual variables, multiple dissimilarity matrices can be computed, one for each variable (species or environmental factor). Partial Mantel tests then can indicate which species (or environmental factor) is most responsive. In the case of factorial designs, contrast matrices can be constructed. In this, two samples are similar (dissimilarity=0) if they are in the same treatment (e.g., browsed or not) or dissimilar (=1) if they are in different groups (i.e., one browsed, the other not). Contrast matrices can be extended to correspond to more complicated designs (e.g., treatment groups for browsing, controlling for environmental dissimilarity). Most of the questions addressed in this project can be answered with some form of Mantel test. While there are alternative tests available, we will opt for consistency and the intuitive nature of Mantel tests and use these when appropriate.

2. Succession vectors. Many of our hypotheses about compositional change are more nuanced than the initial question 'Are these plots different?'. Often, we will want to know how samples vary in their trajectories. This can be visualized, in an exploratory mode, by plotting succession vectors within an ordination space (McCune & Grace 2002, Urban 2006). In this, sample plots are ordinated in an appropriate space (e.g., nonmetric multidimensional scaling, NMS; McCune & Grace 2002), and then vectors (arrows) are drawn to connect samples through time. In exploratory data analysis, a simple plot of the vectors is often immensely informative. In hypothesis testing, it is straightforward to devise tests about the direction or magnitude (length) of the vectors (McCune & Grace 2002). Thus, we might ask whether samples on mesic sites change faster (have longer vectors) than sites on xeric sites, and so on. These tests are typically evaluated using randomization methods.

The NMS framework is also useful because it provides an easy visualization of other effects of interest. For example, we can color-code samples in ordination space (e.g., browsed vs exclosures) to explore contrasts among groups. These contrasts can then be assessed inferentially using Mantel tests.

Bunn et al. (2005) used the above approach to explore recent growth rates of Sierran trees in response to climatic warming. They constructed a NMS ordination of their dendrochronological data, and then plotted 'succession vectors' to highlight recent increases in growth rates as net movement toward the 'warmer' region of the ordination space. In our study, we expect plant communities from warmer settings to be compositionally different from those in cooler settings, and thus occupy a different region of an NMS ordination. We also expect these samples, monitored over time, to 'move' toward the warmer region of the ordination space as plant populations adjust to local warming. Both expectations can be evaluated readily in ordination space. In this case, actual temperatures measured with Hobo data-loggers will be used to verify the role of temperature in the ordination, by regression (McCune and Grace 2002).

On the issue of climate and local heat islands, we can evaluate these communities directly by comparing their weighted-average climate indices (these being ordination scores as well). In this, we will use climate indices of species that respond strongly to temperature to make broader inferences about which aspects of climate best explain the response.

3. Demographic process. In the case of stem maps, demographic processes can be more complicated to evaluate. Detailed analyses of mapped stems can reveal a wealth of insight into these processes (Philippi et al. 1993, 1994; Xi et al. 2008a,b). In many instances, these tests amount to questions about the spatial pattern in trees of particular sizes or species. These are typically variations on Ripley's K analysis of spatial point patterns, elaborated toward more ecologically interesting processes than randomness (McDonald et al. 2003).

5. Project Oversight, Research Schedule and Decadal Research Plan

5.1. Responsibilities

Peet will be responsible for overall coordination and supervision of plot data collection and data management for the first five years. If we are awarded a renewal, Urban will be responsible for overall plot data collection and data management for the second five years. A research specialist (50% effort) will be responsible for the day-to-day data collection and management activities. This will include participation in and direct supervision of the undergraduate field crew. White will supervise data collection for the North Carolina Botanical Garden plots. Weakley will be responsible for resolving taxonomic uncertainties and for overseeing collection of the compositional survey plots. Urban will be responsible for archiving the data and for selection and supervision of the new urban and deer-exclosure plots; he will also help with multivariate analyses. Undergraduates supported by both the UNC and Duke budgets will participate for 12 weeks on the summer field crew and assist in data archiving activities.

5.2. Field Work Schedule (This schedule represents the minimum we expect to accomplish)

2011	First resurvey of 34 original permanent sample plots Establish and survey 12 new deer-exclosure plots Establish ~30 new plots in edges and fields
2012	First resurvey of 5 mapped stands for seedlings, saplings & trees Establish ~30 new composition plots in urban heat-island settings
2013	First resurvey of 4 mapped stands for trees Resurvey ~ 62 NCBG plots (as time allows)
2014	First resurvey of 2 mapped stands for trees Resurvey Compositional Survey (~130 plots)
2015	Second resurvey of 34 original permanent sample plots Probable resurvey of new deer-exclosure plots Second resurvey of 5 mapped stands for seedlings, saplings & trees

5.3. Decadal Research Plan

The first 5 years of this project will extend 3 historical data sets and establish 3 new data sets to be pooled with the archival sets. The value of these will only increase in the future. In particular, we do not anticipate any useful information from the deer exclosures for several years. Likewise, we expect that the new samples associated with local heat islands will become increasingly informative over the next decade. The permanent sample plots established long ago in pine stands are now in a transitional stage, and their successional fate should become clear over the next decade or so. Finally, new plots established in old fields will be interesting over the next decade, but increasingly so in the distant future.

Our intent over the next decade will be to continue to monitor the Korstian plots on the roughly 5-yr interval that has been maintained for ~ 80 yrs. This would imply resurvey in 2019-2020. Similarly, we aim to resurvey the mapped stands at least once during the 5 yrs following this project.

The new deer exclosures will be resurveyed to assess browsing impacts at least once during the 5 yrs following this project. Russell et al. (2005) found significant browsing impacts after 4 yrs in an exclosure experiment in Virginia Piedmont forests. We will casually inspect these plots periodically over the next several years to determine when it will be appropriate to conduct remeasurements. If the vegetation shows dramatic changes, we will resurvey them twice, at roughly 4-yr intervals. Similarly, we can use results from the resampled compositional survey plots to determine an appropriate resurvey interval for the new edge and heat-island samples. Again, we expect to resurvey these at least once over the next decade, twice if they show rapid compositional change.

Finally, we will revisit the compositional survey plots, and the new edge and heat-island samples based on preliminary analyses conducted during this project. We can anticipate that relationships that emerge from preliminary analyses will suggest hypotheses that are not well supported by the data (Urban et al. 2002). In response to these, we might establish new samples in locations that will best augment our existing data, using tactical sampling methods we have developed for similar landscape-scale applications (e.g., Urban 2002, Urban et al. 2002).

6. Research Significance and Broader Impacts

6.1. Significance

Ecology needs a few model systems where the details have been worked out in great detail and which can serve to illustrate how natural systems work. Such model systems are the rule in fields such as law, business and sociology, and we expect this to readily transfer to the equally complex and context-dependent field of ecology. The Duke Forest has served this role for secondary succession and forest development since the late 1930s and continues to provide perhaps the best-worked example of vegetation dynamics against which to compare other systems.

Humans are impacting ecosystems in many unanticipated way. It is important that we be able to recognize these impacts and assess their likely long-term implications and how these impacts are likely to generalize to other locations. The Duke Forest project aims at understanding vegetation change—not just secondary succession, but also changes resulting from anthropogenic impacts. We anticipate that this project will help guide future ecologists in assessing human impacts on natural ecosystems.

The Duke Forest and the adjacent landscape host a variety of complementary research programs related to this project. Notable among these efforts are on-going projects by Jim Clark (Duke University, http://www.nicholas.duke.edu/people/faculty/clark/), who is using local and intensive field studies to explore demographic mechanisms of forest dynamics in the Duke Forest. Our project provides a larger context for Clark's more site-specific research. Similarly, Justin Wright (Duke Biology, http://www.biology.duke.edu/wrightlab/) is working on a biogeographical synthesis of mechanisms and geographic variation in rates of secondary succession in collaboration with Jason Fridley (Syracuse, http://plantecology.syr.edu/fridley/). Our project would provide a thoroughly documented regional case study for this cross-site comparison.

While we believe that the development and testing of simulation models is beyond the scope of this LTREB proposal, our project will generate data that could be used to parameterize and validate models used to explore successional trends (e.g., by hindcasting with our historical data) or to forecast forest dynamics into the future. For example, we could support the validation of a landscape-scale extrapolation of a locally parameterized model under development by Jim Clark, or the calibration of a Piedmont version of Urban's model designed explicitly to simulate landscape-scale patterns in forests (Urban et al. 2000) or other models such as SORTIE (Pacala et al. 1993, 1996).

6.2. Broader Impacts

This project will have broader impacts in 3 areas: (1) providing curated data for research and teaching, (2) training of undergraduate and graduate students, and (3) educational outreach at several levels.

1. Curated Data for Research and Teaching. The core data sets are already archived and available on-line, with metadata appropriate to standards in effect at the time they were documented (nearly 10 years ago). These data have long been available on a "collaborator" basis (i.e., for researchers working with PI Peet or Urban), and frequently on a 'just-ask' basis. As part of this project, we will update the metadata to current standards (see supplemental Data Management Plan) and make the data sets freely available on-line. The data will remain housed at UNC-Chapel Hill, but will be mirrored at Duke's Landscape Ecology Laboratory and archived in permanent digital repositories. (Note that while these data have been collected largely in the Duke Forest, they are not actually connected to the Duke Forest Office that manages the Forest for Duke University—the data are curated by the researchers who collect them.) To better publicize the data, we will add appropriate links to our websites at Duke (the Landscape Ecology Lab, the Duke Forest) and UNC (the Botanical Garden). The data will be broadly available to anyone interested in exploring them for research or teaching. We anticipate that these core data sets will be especially useful for teaching analytic methods in community ecology (e.g., ordination and classification), as long-term compositional data sets are quite rare in ecology.

We anticipate that these data will also contribute to larger efforts to coordinate data-based research at the national (VegBank; see Jennings et al. 2009) and international level (Dengler et al. 2011). We have already conducted preliminary comparisons of mortality patterns between sites (Peet et al. 1991) and anticipate working with others who have contributed to the GIVD (Global Index of Vegetation-plot Databases) and BIEN (Botanical Information and Ecology Network) data archives to assess the generality of our results. Serving these datasets to a broader research community will greatly facilitate more widespread comparison and synthesis.

2. Student traineeship and mentoring. Over the years, numerous students have participated in monitoring the long-term plots in the Duke Forest. Between 1983 and 2001, 98 students were paid employees and additional students volunteered. During the summers, these students learned field methods in plant ecology: research design, plant taxonomy, and sampling techniques. Some also participated in data entry and exploratory data analysis. Many of these students went on to graduate school in ecology and have since taken research jobs within the field. Several others now hold faculty positions, including positions at UNC and Duke. We look forward to continuing this tradition with an additional 20 students who would participate over the next five years.

3. Educational outreach. The Triangle region of North Carolina is a growing population center and the Duke Forest and NC Botanical Garden play an important role regionally as a teaching laboratory for public engagement and recreation. We will collaborate with these education centers to contribute to educational outreach at three levels. Our intent is to develop an educational module on forest dynamics and landscape change, highlighting the succession model developed from these historic data. The module will be assembled initially for the Duke Forest and modified slightly to create a parallel version for the NC Botanical Garden. The module will be implemented initially as a web-based application, with embedded photos, research results, and video. The module will then be packaged for use in three ways: (1) as a web-based tutorial that can be viewed by visitors off-site (e.g., via their browsers); (2) as a self-guided walking tour in the forest, routed to highlight stops along established trails where specific lessons can be viewed; and (3) as small workshops hosted by educators at the Duke Forest and NC Botanical Garden. Both sites routinely host such workshops, focusing on class field trips from local schools and also on teacher training sessions (such training sessions are required for continued certification to teach in NC). This educational outreach will be supported at no cost to this project, by using internship funds available to professional master's students in Duke's Nicholas School of the Environment. For example, a student of co-PI Urban is currently working with Duke Forest staff to create a self-guided walking tour to highlight ecosystem services (e.g., watershed protection, wildlife habitat) provided by urban forests. We will continue to work with the Duke Forest and Garden staff on outreach opportunities for local schools and the public that will serve to illustrate not only natural ecosystems, but also the many and varied impacts of humans on the natural landscape.

7. Results of Prior NSF Support.

NSF 0737466 to J. Greenberg and A. Weakley: BOT 2.0: Botany through Web 2.0, Memex and Social Learning. We developed an innovative curriculum for teaching botany (taxonomy, classification, plant descriptive terminology, and plant recognition) to underserved student populations, using social media, collaborative learning, and hands-on experiences, and studied the benefits of applying these techniques to recruiting students into STEM fields.

ITR-0225635 subaward to R. Peet (from U. Kansas). Enabling the Science Environment for Ecological Knowledge; UNC portion $351,104, 2002-2008. We developed and deployed cyberinfrastructure needed to use taxon concepts for annotating and merging organism occurrence records. This included development of TCS, an international exchange standard for taxon concept data now adopted by TDWG (Franz 2005, Franz et al 2008, Franz and Peet 2009, Franz and Thau 2010). We worked with A. Weakley to develop the first large-scale set of taxon concept relationships (~70,000 taxon concepts from ~800 taxonomic treatments of Southeastern flora), and developed a data system for integrating taxon observations from divergent sources using mapped-concept relationships, including the Atlas of the Flora of the Southeastern United States where we merge >2,000,000 taxon observations to generate regional occurrence maps. We built a software tool (ConceptMapper) for creation and management of concept relationships. Finally, we worked with Vegetation Scientists to incorporate TCS as part of a broader international schema for vegetation plot data (see Wiser et al. 2011).

BCS-0948047 to Urban. This is an Urban Long-Term Research Area planning grant (ULTRA-ex), *Collaborative research: Reconciling human and natural systems for the equitable provision of ecosystem services in the Triangle of North Carolina* (with 6 co-PIs at Duke, UNC-Chapel Hill, NCSU, and the Triangle Council of Governments (10/2009-9/2011, Duke portion $80,645). The Duke component of this collaborative project has provided partial support for 1 PhD student, 2 master's students, and an undergraduate graduate (3 manuscripts are in preparation). The project proposed here bolsters the foundation of the broader and longer-term ULTRA program, which includes a focus on the role of forests in urban ecosystems.

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GIVD: Global Index of Vegetation-plot Databases. http://www.givd.info/

LTREB Project website. http://www.bio.unc.edu/faculty/peet/lab/PEL/df.htm

North Carolina Botanical Garden website. http://www.ncbg.unc.edu/

PRISM Climate Group, Oregon State University. http://www.prismclimate.org

USDA Plants. http://plants.usda.gov/

VegBank. The Vegetation plot archive of the Ecological Society of America. http://vegbank.org

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Philippi, T.E., R.K. Peet, & N.L. Christensen. 1993. Tree seedling demography in old-field Pinus taeda and mature mixed hardwoods stands in a Piedmont forest. Bull. Ecol. Soc. Amer. 74(Suppl.):393.

Philippi, T.E. & R.K. Peet 1994. A model of optimal life-histories for tree seedlings: allocation to growth vs belowground reserves. Bull. Ecol. Soc. Amer. 75(Suppl):180.

Reed, R.A., R.K. Peet, M.W. Palmer and P.S. White. 1993. Scale dependence of vegetation-environment correlations in a Piedmont woodland, North Carolina, USA. Journal of Vegetation Science 4: 329-340.

Riitters, K.H., J.D. Wickham, R.V. O'Neill, K.B. Jones, E.R. Smith, J.W. Coulston, T.G. Wade, & J.H. Smith. 2002. Fragmentation of continental United States forests. Ecosystems 5:815-822.

Rooney, T.P. 2001. Deer impacts on forest ecosystems: a North American perspective. Forestry 74:201-208.

Rooney, T.P. & D.M. Waller. 2003. Direct and indirect effects of white-tailed deer in forest ecosystems. For. Ecol. and Management 181:165-176.

Russell, C.R., B. Gorsira & S. Patch. 2005. Effects of white-tailed deer on vegetation structure and woody seedling composition in three forest types on the Piedmont plateau. For. Ecol. Manage. 210:415-424.

Schwartz, M. 2007. Vegetation community change over decadal and century scales in the North Carolina piedmont. PhD dissertation, Duke University, Durham, NC.

Sexton, J.O., D.L. Urban, M.J. Donahue, & C. Song. Landcover dynamics by multi-temporal classification across the Landsat-5 record. Remote Sensing of Environment (*in review*).

Taverna, K. 2004. Mature hardwood forests of the central Piedmont of North Carolina: landscape distribution and understory change. M.S.thesis, University of North Carolina, Chapel Hill, NC.

Taverna, K., D.L. Urban, & R.I. McDonald. 2005a. Modeling landscape vegetation pattern in response to historic land-use: a hypothesis-driven approach for the North Carolina Piedmont, USA. Landscape Ecology 20:689-702.

Taverna, K., R.K. Peet, & L. Phillips. 2005b. Long-term change in ground-layer vegetation of deciduous forests of the North Carolina Piedmont, USA. *Journal of Ecology* 93:202-213.

Urban, D.L. 2002. Tactical monitoring of landscapes. Pages 294-311 in J.L. Liu and W.W. Taylor (eds.), *Integrating landscape ecology into natural resource management.* Cambridge Univ. Press, Cambridge.

Urban, D.L. 2006. A modeling framework for ecological restoration. Pages 238-256 in D. Falk, M. Palmer, and J. Zedler (eds.), *Foundations of restoration ecology*. Island Press, Washington, DC.

Urban, D.L, S. Goslee, K.B. Pierce, & T.R. Lookingbill. 2002. Extending community ecology to landscapes. Ecoscience 9:200-212.

Urban, D.L., C. Miller, N.L. Stephenson, & P.N. Halpin. 2000. Forest pattern in Sierran landscapes: the physical template. Landscape Ecol. 15:603-620.

White, M.A., R.R. Nemani, P.E. Thornton, & S.W. Running. 2002. Satellite evidence of phenological differences between urbanized and rural areas of the eastern United State deciduous broadleaf forest. Ecosystems 5:260–77.

White, R. 1999. The impacts of Hurricane Fran on a North Carolina Piedmont woodland. Masters Thesis, University of North Carolina, Chapel Hill, NC.

Wiser, S.K., N. Spencer, M. De Caceres, M. Kleikamp, B. Boyle, & R.K. Peet. 2011. Veg-X -- An international exchange standard for plot-based vegetation data. Journal of Vegetation Science 22:598-609.

Xi, W. & R.K. Peet. 2008a. Hurricane effects on the Piedmont forests: patterns and implications. Ecological Restoration 26:295-298.

Xi, W. & R.K.Peet. 2008b . Long-term studies of forest dynamics in the Duke Forest, southeastern United States: A synthesis. Journal of Plant Ecology 32:299-318.

Xi, W. & R. K. Peet. 2010. The complexity of catastrophic wind disturbance on temperate forests. Hurricane Research. ISBN 978-953-7619-X-X. IN-TECH, Vienna, Austria*.*

Xi, W., R.K. Peet, J.K. DeCoster & D.L. Urban.2008. Tree damage risk factors associated with large, infrequent wind disturbances of Carolina forests. Forestry 81:317-334.

Xi, W., R.K. Peet & D.L. Urban. 2008. Changes in forest structure, species diversity, and spatial pattern following hurricane disturbance in a Piedmont North Carolina forest, USA. Journal of Plant Ecology 1: 43-57.

Biographical Sketch - Robert K. Peet

Address: Department of Biology, CB#3280, University of North Carolina
Chapel Hill, NC 27599-3280
Email: peet@unc.edu, Phone: 919-962-6942
Web: http://www.bio.unc.edu/faculty/peet

Education:

Univ. Wisconsin Madison	Botany, honors	B.A.	1970
Univ. Wisconsin Madison	Botany	M.S.	1971
Cornell University	Ecology	Ph.D.	1975

Appointments:

2008-09	Fellow, National Evolutionary Synthesis Center
2008	Interim Director, Institute for the Environment, UNC-CH
2003-08	Chairman, Curriculum in Ecology, UNC-CH
2001-02	Fellow, National Center for Ecological Analysis and Synthesis
1988 -	Professor, University of North Carolina at Chapel Hill
1980-88	Associate Professor, University of North Carolina at Chapel Hill
1975-80	Assistant Professor, University of North Carolina, Chapel Hill

Honors: AAAS, Elected Fellow 1984; Author of a Citation Classic; 1995 Distinguished Service Award - Ecological Society of America 1995; Phi Beta Kappa; Phi Eta Sigma; Phi Kappa Phi; Sigma Xi; President, International Association for Vegetation Science, 2007-2011; Secretary, Ecological Society of America, 2002-2005; Editor-in-Chief, *Ecology* & *Ecological Monographs*, 1995-2000. Co-founder and Chief Editor *Journal of Vegetation Science*, 1990-1995.

Five relevant publications:

1. Matthews, E.M., R.K. Peet & A.S. Weakley. 2011. Classification and description of alluvial plant communities of the Piedmont region. North Carolina, .U.S.A. Applied Vegetation Science (invited submission).
2. Wiser, S.K., N. Spencer, M. De Caceres, M. Kleikamp, B. Boyle, & R.K. Peet. 2011. Veg-X -- An international exchange standard for plot-based vegetation data. Journal of Vegetation Science (in press).
3. Xi, W., R.K. Peet and D.L. Urban. 2008. Changes in forest structure, species diversity, and spatial pattern following hurricane disturbance in a Piedmont North Carolina forest, USA. *Journal of Plant Ecology* 1: 43-57.
4. Xi, W., R.K. Peet, J.K. DeCoster and D.L. Urban.2008. Tree damage risk factors associated with large, infrequent wind disturbances of Carolina forests. Forestry 81:317-334.
5. McDonald, R.I., R.K. Peet and D.L. Urban. 2002. Environmental correlates of oak decline and red maple increase in the North Carolina Piedmont. Castanea 67:84-95.

Five additional publications:

1. Manthey M., J.D. Fridley & R.K. Peet. 2011. Niche expansion from past species extinctions? A comparative assessment of habitat generalists and specialists in the tree floras of Southeastern North America and Southeastern Europe. *Journal of Biogeography* (in press).
2. Franz, N.M. and R.K. Peet. 2009. Towards a language for mapping relationships among taxonomic concepts. Systematics and Biodiversity 7:5-20.
3. Jennings, M.D., D. Faber-Langendoen, O.L. Loucks, R.K. Peet, & D. Roberts. 2009. Characterizing Associations and Alliances of the U.S. National Vegetation Classification. Ecological Monographs 79:173-199.
4. Carr, S.C.,K.M. Robertson,W.J.Platt & R.K.Peet. 2009. A model of geographic, environmental and regional variation in vegetation composition of pyrogenic pinelands of Florida. *Journal of Biogeography* 36:1600-1612.

5. Fridley, J.D., R.K. Peet, E. van der Maarel, and J.H. Willems. 2006. Integration of local and regional species-area relationships from space-time species accumulation. *American Naturalist* 168:133-143.

Synergistic Activities:

1. 2006-present: I organized a set of international workshops and then worked with the core participants to develop VegX, an international XML data exchange standard for vegetation plot data. (http://wiki.tdwg.org/Vegetation/).
2. 2004-2007: My colleagues and I collaboratively designed, reviewed and submitted for approval as an international data standard the Taxon Concept Schema (TCS). TCS is an XML schema for data exchange, now approved by TDWG as an international standard (http://www.tdwg.org/standards/117/).
3. 1998-present: Organizer and principal investigator of a collaborative program of the Ecological Society of America, USGS-NBII, NatureServe, FGDC, and the National Center for Ecological Analysis and Synthesis to develop the information system and database architecture to support a US National Vegetation Classification (http://VegBank.org).
4. 1996-2000: While Editor-in-Chief of *Ecology* and *Ecological Monographs*, conceived, designed and implemented *Ecological Archives* (http://www.esapubs.org/Archive/), a new digital publication for electronic appendices, supplements and data papers.
5. 1994- present: Proposed and organized the Ecological Society Vegetation Panel to provide professional oversight, review, evaluation and standardization of the US National Vegetation Classification. I continue to serve on the Executive Committee of the Panel. (http://www.esa.org/vegweb/)

Recent Collaborators & Coauthors: Marc Abrams (Penn. State U), Tom Albright (U Wisc), Dean Anderson (Landcare New Zealand), Michael Barbour (UC Davis), Brad Boyle (U AZ), Forbes Boyle (UNC), Rebecca Brown (Eastern Wash U), Susan Carr (Denver, CO), Norman Christensen (Duke U), Milan Chytrý (Masaryk U), Rick Condit (CTFS), Miquel De Cáceres (Centre Tecnològic Forestal, Solsona), Alessandro Chiarucci(U Sienna), Jenifer Costanza (NCSU),James DeCoster (US Nat Park Serv), Jürgen Dengler (U Hamburg), Georg Ewald (U. Appl. Sci. Weihenstephan-Triesdorf), Brian Enquist (U AZ), D. Faber-Langendoen (NatureServe), Manfred Finckh (U Hamburg), Nico Franz (U Puerto Rico), Jason Fridley (Syracuse U), Frank Gilliam (Marshall), Falko Glöckler (U Greifswald), Cliff Hupp (USGS), Lee Anne Jacobs Reilly (Duke U), Florian Jansen (U Greifswald), Michael Jennings (TNC), Matt Jones (NCEAS), Martin Kleikamp (Bergisch-Gladbach, DE), Dane Kuppinger (Salem College), Xianhua Liu (NESCent), Orie Loucks (Miami U), Eddy van der Maarel (U. Groenigen), Elizabeth Matthews (UNC-CH),Michael Manthey (Ernst-Moritz-Arndt U), Alexa McKerrow (NCSU), Aaron Moody (UNC), Ladislav Mucina (Curtin U), Jens Oldeland (U Hamburg), Michael Palmer (Oklahoma St Univ), Meelis Pärtel (Tartu U), Scott Pearson (Mars Hill College), William Platt (Lousiana St. U), Marcel Rejmank (U Cal Davis), David Roberts (Montana St.), Kevin Robertson (Tall Timbers, FL), Michael Schafale (NC Heritage), Joop Schaminée (U Nijmegen), Edward Schenk (USGS),Mark Schildhauer (NCEAS), Amanda Senft (Seattle WA), Nick Spencer (Landcare New Zealand), Stephen Talbot (US Fish Wildlife Serv), Dave Tart (USFS), Barbara Thiers (NYBG), Phil Townsend (U. Wisc), Monica Turner (U. Wisc), Dean Urban (Duke U), David Vandermast (Elon College), Joan Walker (US Forest Service), Alan Weakley (UNC), Thomas Wentworth (NCSU), Peter White (UNC), Deborah Willard (USGS), Jo Willems (U Utrecht), Bastow Wilson (Otaga U.), Susan Wiser (Landcare New Zealand), Weimin Xi (U Wisc).

Graduate Advisors: Orie L. Loucks (MS), Robert H. Whittaker (Ph.D)

Graduate Students (47) and Postdoctoral Scholars (9): Nick Adams, Dorothy Allard, Robert Allen, Peter Avis, William Baker, Forbes Boyle, Kathleen Baker-Brosh, Rebecca Brown, Jeffrey Corbin, Patricia Corry, Phillip Coulling, Orin Pete Council, James DeCoster, James Doyle, Nico Franz, Jason Fridley, Cecil Frost, Joel Gramling, James Graves, Rachel Hochman, Lee Anne Jacobs Reilly, Mark Knott, Robert Knox, Xianhua Liu, Lauro Lopez-Mata, Elizabeth Matthews, Mary Lou May, Jasper McChesney, Claire Newell, Timothy Nifong, Jeffrey Ott, Kyle Palmquist, Anne Richards, Janette Schue, Amanda Senft, Stephanie Seymour, Sonja Stiefel, Gary Thorburn, Joan Walker, Brooke Wheeler, Jacqueline White, Susan Wiser, Weimin Xi

Alan S. Weakley
Department of Biology / UNC Herbarium / University of North Carolina at Chapel Hill
Campus Box 3280, Chapel Hill, NC 27517 / (919) 962-0578 / weakley@email.unc.edu

Professional Preparation

University of North Carolina at Chapel Hill	Botany / Comparative Literature	B.A., with highest honors, 1974-1978
Duke University, Nicholas School of the Environment and Earth Sciences	Environmental Sciences and Policy	Ph.D., 2003-2005

Appointments

2002 – present	*Curator,* University of North Carolina Herbarium / North Carolina Botanical Garden, and *Adjunct Assistant Professor*, UNC-Chapel Hill
1999 – 2002	*Chief Ecologist*, The Nature Conservancy, later NatureServe
1994 – 1999	*Deputy Director* (International Ecology Program) and *Senior Regional Ecologist* (Southern Resource Office), Association for Biodiversity Information / The Nature Conservancy
1984 – 1994	*Assistant Coordinator for Natural Heritage Inventory/Botanist/Community Ecologist*, North Carolina Natural Heritage Program
1978 – 1984	*Consulting Ecologist/Botanist*, Coastal Zone Resources, Inc.

Publications – 5 most relevant:

- **Weakley, A.S.** 2010. Flora of the southern and mid-Atlantic states. Working draft of 8 March 2010. UNC Herbarium, North Carolina Botanical Garden, Chapel Hill, NC. http://www.herbarium.unc.edu/flora.htm
- Franz, N. M., R. K. Peet, and **A. S. Weakley**. 2006. On the use of taxonomic concepts in support of biodiversity research and taxonomy. Proceedings of the New Taxonomy Symposium. http://208.110.170.18/pdf2html/pdf2html.php?url=http%3A%2F%2Fwww.bio.unc.edu%2FFaculty%2Fpeet%2Fpubs%2FCardiff.pdf&images=yes
- Greenberg, J.A., B. Heidorn, S. Seiberling, and **A.S. Weakley**. 2006. Growing vocabularies for plant identification and scientific learning. Bulletin of the American Society for Information Science and Technology. http://www.asis.org/Bulletin/Jun-06/greenberg_heidorn_sieberling_weakley.html
- **Weakley, A.S**. 2005. Why are plant names changing so much? Native Plants Journal 6: 52-58. http://muse.jhu.edu/journals/native_plants_journal/v006/6.1weakley.html
- **Weakley, A.S.** 2005. Change over time in our understanding of the flora of the southeastern United States: implications for plant systematics, bioinformatics, and conservation. Ph.D. dissertation, Duke University, Nicholas School of the Environment and Earth Sciences. 3240 pp.

Publications – 5 other significant publications:

- **Weakley, A.S.**, and others (compilers). 2000. International classification of ecological communities: terrestrial vegetation of the southeastern United States. Working draft of September 2000. Association for Biodiversity Information/The Nature Conservancy, Southern Resource Office, Durham, NC. [also available electronically in an updated form at www.natureserve.org]
- Kauffman, G.E., G.L. Nesom, **A.S. Weakley**, T.E. Govus, and L.M. Cotterman. 2004. A new species of *Symphyotrichum* (Asteraceae: Astereae) from a serpentine barren in western North Carolina. Sida 21: 827-839.
- **Weakley, A.S.**, and G.L. Nesom. 2004. A new species of *Ptilimnium* (Apiaceae) from the Atlantic coast. Sida 21: 743-752.
- Sorrie, B.A., and **A.S. Weakley**. 2001. Coastal Plain vascular plant endemics: phytogeographic patterns. Castanea 66: 50-82.
- **Weakley, A.S.**, and P.M. Peterson. 1998. Taxonomy of the *Sporobolus floridanus* complex (Poaceae: Sporobolinae). Sida 18: 247-270.

Selected Synergistic and Leadership Activities

- I have been a major participant in the development of Biotics 4, the state-of-the-art biodiversity data management system developed by NatureServe for standard use by the international Network of Natural Heritage Programs and Conservation Data Centres.
- I serve as a member of the Board of Directors, a contributor, and a regional reviewer on the Flora of North America project, an ambitious effort to create a new flora for North America north of Mexico in a projected 30 volumes (of which 16 have been published).
- I am the lead author or co-author on three projects to develop new state and regional floras in the Southeastern United States aimed at serving broad constituencies. My regional flora is available online prior to publication at www.herbarium.unc.edu
- I serve on the Executive Board of the Society of Herbarium Curators, on the Editorial Board of the Southern Appalachian Botanical Society, on the board of trustees of the N.C. Natural Area Trust Fund, as Chair of the N.C. Plant Conservation Program Scientific Committee, as Chair of the N.C. Natural Heritage Program Advisory Committee, as member of the Ecological Society of America Vegetation Panel, and member of the Federal Geographic Data Committee, Vegetation Classification Hierarchy Revisions Working Group.

Collaborators & Co-Editors

William R. Burk, Univ. of NC at Chapel Hill, NC; **Gregory T. Chandler**, Univ. of NC at Wilmington; **Lynn G. Clark**, IA State Univ.; **Patricia B. Cox**, Tennessee Valley Authority; **Juliana de Paula-Souza**, Universidade de São Paulo; **Don Faber-Langendoen**, NatureServe; **Nico M. Franz**, Univ. of Puerto Rico, Mayagüez; **Kanchi N. Gandhi**, Harvard Univ; **Thomas E. Govus**, Ellijay, GA ; **Jane A. Greenberg**, Univ. of NC at Chapel Hill; **Dennis H. Grossman**, NatureServe; **Stephan J. Hatch**, TX A. & M. Univ.; **Brian A. Heidorn**, Univ. of IL, Urbana; **James Henrickson**, Univ. of TX, Austin; **Gary E. Kauffman**, U.S. Forest Service; **Alexander Krings**, NC State Univ.; **Richard J. LeBlond**, NC Natural Heritage Program; **Xianhua Liu**, National Evolutionary Synthesis Center; **J. Christopher Ludwig**, VA Div. of Natural Heritage; **Patrick D. McMillan**, Clemson Univ.; **Zack Murrell**, Appalachian State Univ.; **Guy L. Nesom**, Botanical Research Inst. of TX; **Susana S. Neves**, Instituto de Tecnologia Quimica e Biologica; Universidade Nova de Lisboa; **Robert K. Peet**, Univ. of NC at Chapel Hill; **Paul M. Peterson**, Smithsonian Institution; **Richard D. Porcher**, The Citadel; **James S. Pringle**, Royal Botanic Gardens, Hamilton, Ontario; **Michael P. Schafale**, NC Natural Heritage Program; **Edward E. Schilling**, Univ. of TN; **Stephen Seiberling**, Univ. of NC at Chapel Hill; **Bruce A. Sorrie**, North Carolina Natural Heritage Program; **Shannon C.K. Straub**, Cornell University; **Herwig Teppner**, Institute of Systematic Botany, Univ. of Graz; **John F. Townsend**, VA Div. of Natural Heritage; **Jimmy K. Triplett**, IA State Univ.; **Gordon C. Tucker**, Eastern Illinois Univ.; **Allison E. Weakley**, Chapel Hill, NC; **Thomas P. Wentworth**, NC State Univ.; **Peter A. White**, Univ. of NC at Chapel Hill; **B. Eugene Wofford**, Univ. of TN; **Robert A.S. Wright**, EEE Consultants, Inc., Blacksburg, VA.

Ph.D. Advisor: Dr. Norman L. Christensen, Duke University, Nicholas School of the Environment and Earth Sciences; Honor's Thesis Advisor: Dr. Albert E. Radford, UNC-CH, Botany Department

Graduate students: Emily Bidgood, Megan Faestel, Liz Matthews, Kyle Palmquist, Stephanie Seymour, Kristie Wendelberger.

Peter S. White
Biographical Sketch

a. Education

Bennington College	Biology	BA	1971
Dartmouth College	Plant Ecology	PhD	1976
Missouri Botanical Garden	Systematics	Postdoc	1977-1978

b. Appointments

1986-	Professor, University of North Carolina
1986-	Director, North Carolina Botanical Garden
1985-1986	Leader, Cooperative Park Studies Unit, University of Tennessee
1978-1985	Research biologist, Great Smoky Mountains National Park

c. Publications

5 relevant to this proposal

Kuppinger, D.M., M.A. Jenkins, and P.S. White. 2010. Predicting post-fire establishment and persistence of an invasive tree species across a complex gradient. Biological Invasions, in press.

Thiemann, JA, Webster, CR, Jenkins, MA, Hurley, PM, Rock, JH, White, PS. 2009. Herbaceous layer impoverisment in a post-agricultural southern Appalachian landscape. American Midland Naturalist 162:148-168.

Jobe, R. Todd, and P. S. White. 2009. A new cost-distance model for human accessibility and an evaluation of accessibility bias in permanent vegetation plots of Great Smoky Mountains National Park, USA. Journal of Vegetation Science 20: 1099-1109.

Busing, RT, White, RD, Harmon, ME, and White, PS. 2009. Hurricane disturbance in a temperate deciduous forest: patch dynamics, tree mortality, and coarse woody debris. Plant Ecology 201:351-363.

Jenkins, M.A., S. Jose, and P. S. White. 2007. Impacts of a forest fungal disease on forest community composition and structure and the resulting effects on foliar calcium cycling. Ecological Applications 17:869-881.

5 other publications

White, P.S., L. Yung, D.N. Cole, and R. J. Hobbs. 2010. Conservation at large scales: systems of protected areas and protected areas in the matrix. Chapter 12, pp. 197-212, in Beyond Naturalness. Island Press, Washington, DC.

Palmer, M.A., E.S. Bernhardt, W.H. Schlessinger, K.N. Eshleman, E. Foufoula-Georgiou, M.S. Hendryx, A.D. Lemly, G.E. Likens, O.L. Loucks, M.E. Power, P.S. White, and P.R. Wilcock. 2010. Mountaintop Mining Consequences. Science 327: 148-149.

McKnight, M, P. S. White, R. I. McDonald, J. F. Lamoreux, W. Sechrest, R. S. Ridgely, S. N. Stuart. 2007. Putting Beta-Diversity on the Map: Broad-Scale Congruence and Coincidence in the Extremes. PLoS Biology 5(10):002-009.

White, P. S., and A. Jentsch. 2001. The search for generality in studies of disturbance and ecosystem dynamics. Progress in Botany 62:399-450.

Palmer, M. W., and P. S. White. 1994. Scale dependence and the species-area relationship. Amer. Nat. 144:717-740.

d. Service activities

Board of Directors, Center for Plant Conservation; Plant Conservation Board, North Carolina Department of Agriculture; Conservation Committee, American Public Garden Association

e. Collaborations and other affiliations

R. J. Hobbs (University of Western Australia), D. N. Cole (USDS Forest Service), L. Yung (University of Montana), A. Jentsch (University of Beyreuth), R. T. Busing (Ecological Engineering), R. D. White (Nature Serve), M. E. Harmon (Oregon State University), B. Collins (Western Carolina University), X. P. Wang (Peking University), J. Y. Fang (Peking University), H. Qian (Illinois Natural History Survey), J. D. Fridley (Syracuse University), D. Urban (Duke University), M. Palmer (Oklahoma State University), T. Wentworth (North Carolina State University), M. A. Jenkins (Purdue University), K. Langdon (Great Smoky Mountains National Park), J. Nekola (University of New Mexico), A. Moody (University of North Carolina), M. Hayes (University of North Carolina), J. H. Graves (Green Mountain College), R. T. Jobe (University of North Carolina), J. L. Constanza (University of North Carolina), D. M. Kuppinger (Salem College), R. E. Ricklefs (University of Missouri, St. Louis), A. Barros (Duke University), M. A. Palmer (University of Maryland), Jennifer Gruhn (Washington University), A. Meyn (UFZ Leipzig)

Graduate advisor, William A. Reiners (University of Wyoming)
Postdoctoral supervisor, Peter A. Raven (Missouri Botanical Garden)

Students last five years: Todd Jobe, Megan McKnight, Dane Kuppinger, David Vandermast, Sam Tessell, Julie Tuttle

Students graduated: 11 PhDs, 11 MS students, 17 undergraduate students mentored

Dean L. Urban

Nicholas School of the Environment, Duke University, Durham, NC 27708

Professional Preparation:

B.A., Botany/Zoology, Southern Illinois University, 1978; University honors;
M.A., Zoology (Wildlife Ecology), Southern Illinois University, 1981;
Ph.D., Ecology, University of Tennessee, December 1986

Appointments:

Current: Professor of Landscape Ecology, Nicholas School of the Environment, Duke University (Assistant Professor, 1994-2000, Associate Professor 2001-2006); Director, Landscape Ecology Laboratory; Faculty member, Duke's University Program in Ecology; Program Chair for Ecosystem Science and Conservation (Master of Environmental Management), and Forestry (Master of Forestry) tracks (2002-2007, 2011); Chair, Division of Environmental Sciences and Policy (2010-2013)

Associate Professor in Forest Science, and Research Scientist in Range Science, Colorado State University (1991-1994); Research Faculty (1988-1990), Environmental Sciences, University of Virginia (Postdoctoral Research Associate, 1986-1988).

Publications Relevant to Proposal:

Minor, E.S., and D.L. Urban. 2010. Forest bird communities across a gradient of urban development. Urban Ecosystems 13:51-71

Urban, D., E. Minor, E.Treml, and R. Schick. 2009. Graph models of habitat mosaics. Ecology Letters 12:260-273.

Xi, Weimin, R.K. Peet and D.L. Urban. 2008. Changes in forest structure, species diversity, and spatial pattern following hurricane disturbance in a Piedmont North Carolina forest, USA. Journal of Plant Ecology 1:43-57.

McDonald, R.I., and D.L. Urban. 2006. Spatially varying rules of landscape change: lessons from a case study. Landscape and Urban Planning B 74:7-20.

Taverna, K., D.L. Urban, and R.I. McDonald. 2005. Modeling landscape vegetation pattern in response to historic land use: a hypothesis-driven approach for the North Carolina Piedmont. Landscape Ecology 20:689-702.

Other Significant Publications:

McDonald, R.I., P.N. Halpin, and D.L. Urban. 2007. Monitoring succession from space: a case study from the North Carolina Piedmont. Applied Vegetation Science 10:193-203.

Urban, D.L. 2005. Modeling ecological processes across scales. Ecology 86:1996-2006.

Gardner, R.H., and D.L. Urban. 2003. Model testing and validation: past lessons and present challenges. Pages 184-203 in C.D. Canham, J.J. Cole, and W.K. Lauenroth (eds.), *Models in ecosystem science*. Princeton University Press, Princeton.

Urban, D.L. 2002. Tactical monitoring of landscapes. Pages 294-311 in J. L. Liu and W. W. Taylor (eds.), *Integrating landscape ecology into natural resource management*. Cambridge University Press, Cambridge.

Urban, D.L. 2000. Using model analysis to design monitoring programs for landscape management and impact assessment. Ecological Applications 10:1820-1832.

Synergistic Activities:

Integration of research and teaching: I use examples from my own research as case studies in my classes. Models used in my research were initially developed as teaching tools, and models developed as research tools are now provided to teachers.

Research tools, computational methods and algorithms: Development of forest gap models and landscape simulators, including meta-models using advanced computational algorithms; development of new algorithms for analysis of huge digital data sets; development of decision support system for conservation planning with The Nature Conservancy.

Outside service: Associate Editor, *Ecology* and *Ecological Monographs* (2002-2005), *Landscape Ecology* (2002-2005). Member, NEON Land Use and National Network Design Committees (2005-2006). Participation as volunteer on federal Recovery Team for threatened Mexican spotted owl (1995-2005). On-going *pro bono* development of conservation planning tools for The Nature Conservancy, and *pro bono* land use change assessment and greenspace planning with local city and regional planners. Current participation with NC Department of Environment and Natural Resources in developing *One NC Naturally*, an integrated conservation plan encompassing biodiversity, watershed services, open space, and working lands. President, US Chapter, International Association for Landscape Ecology (2009-2011).

Collaborators:

H. Shugart (U. Virginia, *PhD and postdoc advisor*); N.L. Christensen, P.N. Halpin, C.R. Richardson, E. Bernhardt (Duke University); R. Gardner (Maryland, Appalachian Environmental Lab); T.H. Keitt (Univ. Texas); L. Band, A. Moody, R.K. Peet, P.S. White, A. Weakley (U. North Carolina-Chapel Hill).

Graduate Students (Duke University except as noted; total = 9 Ph.D + ~80 MEM advisees):

List includes PhD's advised (in bold), and all graduates with whom I have published …
C. Miller (Colorado State University); F. Biasi, K. Bickel, A. Bunn, L. Hierl, N.Cagle, **C. Chang**, S. Goslee, J. Kintsch, **T. Lookingbill**, R. King, E. Treml, R. Schick, **R. McDonald**, **E. Minor**, **K. Pierce**, **M. Rocca**, **J. Sexton**, **K. Somers**

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **University of North Carolina at Chapel Hill**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Robert K Peet**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Robert K Peet - none	0.00	0.00	0.00	$ 0	$
2. Alan S Weakley - none	0.00	0.00	0.00	0	
3. Peter S White - none	0.00	0.00	0.00	0	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	20,143	
3. (0) GRADUATE STUDENTS				0	
4. (2) UNDERGRADUATE STUDENTS				11,520	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				31,663	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,485	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				39,148	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,200	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				1,200	
H. TOTAL DIRECT COSTS (A THROUGH G)				41,848	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 48.0000, Base: 41848)					
TOTAL INDIRECT COSTS (F&A)				20,087	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				61,935	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 61,935	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Robert K Peet**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Martha Martin**	Date Checked	Date Of Rate Sheet	Initials - ORG

1 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

1147391

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY			
PROPOSAL NO.	DURATION (months)		
	Proposed	Granted	
AWARD NO.			

ORGANIZATION
University of North Carolina at Chapel Hill

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Robert K Peet

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Robert K Peet - none**	0.00	0.00	0.00	$ **0**	$
2. **Alan S Weakley - none**	0.00	0.00	0.00	**0**	
3. **Peter S White - none**	0.00	0.00	0.00	**0**	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	**20,747**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**2**) UNDERGRADUATE STUDENTS				**11,520**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**32,267**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**7,607**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**39,874**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,500**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,200**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**1,200**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**42,574**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 48.0000, Base: 42574)**					
TOTAL INDIRECT COSTS (F&A)				**20,436**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**63,010**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **63,010**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME **Robert K Peet**	**FOR NSF USE ONLY**		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Martha Martin**	Date Checked	Date Of Rate Sheet	Initials - ORG

2 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION **University of North Carolina at Chapel Hill**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Robert K Peet**				AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Robert K Peet - none**	0.00	0.00	0.00	$ **0**	$
2. **Alan S Weakley - none**	0.00	0.00	0.00	**0**	
3. **Peter S White - none**	0.00	0.00	0.00	**0**	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	**21,369**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**2**) UNDERGRADUATE STUDENTS				**11,520**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**32,889**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**7,733**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**40,622**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,500**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,200**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**1,200**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**43,322**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 48.0000, Base: 43322)**					
TOTAL INDIRECT COSTS (F&A)				**20,795**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**64,117**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **64,117**	$
M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Robert K Peet**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Martha Martin**	Date Checked	Date Of Rate Sheet	Initials - ORG

3 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

1147391

SUMMARY PROPOSAL BUDGET

YEAR 4

ORGANIZATION: **University of North Carolina at Chapel Hill**				FOR NSF USE ONLY	
				PROPOSAL NO.	DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Robert K Peet**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Robert K Peet - none**	0.00	0.00	0.00	$ **0**	$
2. **Alan S Weakley - none**	0.00	0.00	0.00	**0**	
3. **Peter S White - none**	0.00	0.00	0.00	**0**	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	**22,010**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**2**) UNDERGRADUATE STUDENTS				**11,520**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**33,530**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**7,862**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**41,392**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,500**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,200**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**1,200**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**44,092**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 48.0000, Base: 44092)**					
TOTAL INDIRECT COSTS (F&A)				**21,164**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**65,256**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **65,256**	$
M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: **Robert K Peet**	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: **Martha Martin**	Date Checked	Date Of Rate Sheet	Initials - ORG

4 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 5

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of North Carolina at Chapel Hill

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Robert K Peet

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Robert K Peet - none	0.00	0.00	0.00	$ 0	$
2. Alan S Weakley - none	0.00	0.00	0.00	0	
3. Peter S White - none	0.00	0.00	0.00	0	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	6.00	0.00	0.00	22,671	
3. (0) GRADUATE STUDENTS				0	
4. (2) UNDERGRADUATE STUDENTS				11,520	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				34,191	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,996	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				42,187	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,200	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				1,200	
H. TOTAL DIRECT COSTS (A THROUGH G)				44,887	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 48.0000, Base: 44887)					
TOTAL INDIRECT COSTS (F&A)				21,546	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				66,433	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 66,433	$

M. COST SHARING PROPOSED LEVEL $ 0 | AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Robert K Peet

ORG. REP. NAME*
Martha Martin

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

1147391

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of North Carolina at Chapel Hill

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Robert K Peet

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Robert K Peet - none	0.00	0.00	0.00	$ 0	$
2. Alan S Weakley - none	0.00	0.00	0.00	0	
3. Peter S White - none	0.00	0.00	0.00	0	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (5) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	30.00	0.00	0.00	106,940	
3. (0) GRADUATE STUDENTS				0	
4. (10) UNDERGRADUATE STUDENTS				57,600	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				164,540	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				38,683	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				203,223	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				7,500	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				6,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				6,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				216,723	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				104,028	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				320,751	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 320,751	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Robert K Peet

ORG. REP. NAME*
Martha Martin

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

1147391

Budget Justification Page

Budget Justification - UNC

The budget is aimed at annual data collection and data processing. Toward this end we will employ 4 undergraduates (typically for 12 weeks) each summer, two on the UNC budget and 2 on the Duke budget. The field teams will be directed by a research specialist who will commit 50% of his time to the project on an annual basis and who will process the data during the remainder of the year. We anticipate using the services of Dr. Forbes Boyle who obtained his PhD in 2010 from Clemson and who is employed by our research group at UNC. The only other anticipated expenses are local travel ($1500/yr), annual supplies ($1200/yr).

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Duke University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Dean L Urban

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Dean L Urban - PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (2) OTHER				11,520	
TOTAL SALARIES AND WAGES (A + B)				11,520	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				2,802	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				14,322	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				1,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				16,322	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 57.0000, Base: 16322)					
TOTAL INDIRECT COSTS (F&A)				9,304	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				25,626	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 25,626	$

M. COST SHARING PROPOSED LEVEL $ 0 | AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Dean L Urban

ORG. REP. NAME*
Kenneth Macdonald

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Duke University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Dean L Urban

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Dean L Urban - none	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (2) OTHER				11,520	
TOTAL SALARIES AND WAGES (A + B)				11,520	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				2,856	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				14,376	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				1,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				16,376	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 57.0000, Base: 16376)					
TOTAL INDIRECT COSTS (F&A)				9,334	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				25,710	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 25,710	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Dean L Urban

ORG. REP. NAME*
Kenneth Macdonald

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

2 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Duke University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Dean L Urban

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Dean L Urban - none	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (2) OTHER				11,520	
TOTAL SALARIES AND WAGES (A + B)				11,520	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				2,868	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				14,388	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				1,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				16,388	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 57.0000, Base: 16388)					
TOTAL INDIRECT COSTS (F&A)				9,341	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				25,729	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 25,729	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Dean L Urban

ORG. REP. NAME*
Kenneth Macdonald

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

3 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 4

ORGANIZATION **Duke University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Dean L Urban**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Dean L Urban - none**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**2**) OTHER				**11,520**	
TOTAL SALARIES AND WAGES (A + B)				**11,520**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**2,868**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**14,388**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**1,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**16,388**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 57.0000, Base: 16388)**					
TOTAL INDIRECT COSTS (F&A)				**9,341**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**25,729**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **25,729**	$
M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Dean L Urban**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Kenneth Macdonald**	Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

1147362

SUMMARY PROPOSAL BUDGET

YEAR 5

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Duke University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Dean L Urban

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Dean L Urban - none	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (2) OTHER				11,520	
TOTAL SALARIES AND WAGES (A + B)				11,520	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				2,868	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				14,388	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				1,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				16,388	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 57.0000, Base: 16388)					
TOTAL INDIRECT COSTS (F&A)				9,341	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				25,729	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 25,729	$

M. COST SHARING PROPOSED LEVEL $ 0 | AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Dean L Urban

ORG. REP. NAME*
Kenneth Macdonald

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

1147362

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION Duke University			FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Dean L Urban			AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Dean L Urban - PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (10) OTHER				57,600	
TOTAL SALARIES AND WAGES (A + B)				57,600	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				14,262	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				71,862	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				5,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				5,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				5,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				81,862	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				46,661	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				128,523	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 128,523	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME Dean L Urban	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* Kenneth Macdonald	Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Duke Budget Justification

The Duke budget includes salary support for two students as summer field crew. Summer crew are budgeted at $12/hr for 40 hr/wk for 12 weeks in years 1-5. To stay within budget constraints, we will rely on volunteers to erect deer fences in year 1. Fringe rates on summer field technicians is assessed at 24.33, 24.8, 24.9, 24.9, and 24.9% for yrs 1-5, respectively. PI Urban will supervise the field technicians and help manage the project (with the co-PIs at UNC-Chapel Hill), at no cost to this project.

Modest domestic travel support ($1000 in yrs 1-5) is budgeted to support field crews during the summers; rates are based on a recent (2009) field season in the study area as part of another project.

Other direct costs support purchase, repair, and replacement of field gear (reel tapes, diameter tapes, etc.), at $1000 in yrs 1-5. Expenses for erecting deer exclosures are included in the budget for UNC-Chapel Hill.

Indirect costs are calculated at Duke's federal rate of 57% of total direct costs. As we have not requested any major equipment, this applies to the full direct cost of the project.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Robert Peet

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Vegetation documentation for restoration design and monitoring

Source of Support: NC Dept. Env & Natural Resources, Ecosystem Enhancement Prog

Total Award Amount: $ 1,669,138 Total Award Period Covered: 08/01/10 - 11/30/11

Location of Project: University of North Carolina at Chapel Hill

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Establishment & Survival of Floodplain Tree Seedlings: Roanoke River

Source of Support: Dominion Power

Total Award Amount: $ 425,000 Total Award Period Covered: 07/01/06 - 12/31/11

Location of Project: University of North Carolina at Chapel Hill

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: LTREB: Collaborative Research: Long-term dynamics of Piedmont forests in a changing world

Source of Support: NSF

Total Award Amount: $ 320,747 Total Award Period Covered: 01/01/12 - 12/31/16

Location of Project: UNC Chapel Hill

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Alan Weakley

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: LTREB: Collaborative Research: Long-term dynamics of Piedmont forests in a changing world

Source of Support: NSF

Total Award Amount: $ 320,747 Total Award Period Covered: 01/01/12 - 12/31/16

Location of Project: UNC Chapel Hill

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

 USE ADDITIONAL SHEETS AS NECESSARY

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Peter White

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: LTREB: Collaborative Research: Long-term dynamics of Piedmont forests in a changing world

Source of Support: NSF
Total Award Amount: $ 320,747 Total Award Period Covered: 01/01/12 - 12/31/16
Location of Project: UNC Chapel Hill
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Linking across scales to predict climate change effects in Great Smoky Mountains National Park, North Carolina and Tennessee

Source of Support: NASA
Total Award Amount: $ 1,400,000 Total Award Period Covered: 04/01/11 - 03/31/15
Location of Project: University of North Carolina
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support
Dean Urban

Title: Collaborative research, LTREB: Long-term forest dynamics in a changing world

Source of Support: NSF/LTREB
Project Location: Durham, NC (Duke) *Status:* (this proposal)
Project Duration: 6/2012 – 5/2017
Amount: $128,523 (Duke share) *Commitment:* student support only

Title: Collaborative research: Reconciling human and natural systems for the equitable provision of ecosystem services in the Triangle of North Carolina (G. Hess, M. McHale, E. Bernhardt, L. Band, P. Berke, & S. Bruce)

Source of Support: NSF/ULTRA-ex
Project Location: Durham, NC (Duke) *Status:* current
Project Duration: 1/2010 – 12/2011
Amount: $80,645 (Duke share) *Commitment:* student support only

Title: Doris Duke Conservation Fellows Program *(w*ith Bill Chameides, Karen Kirchof)

So*urce:* Doris Duke Charitable Foundation
Project Location: Durham, NC *Status:* current
Project Duration: 2005-2009 (extended)
Amount: $275,000 *Commitment:* student support only

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. USE additional pages as necessary.

Laboratory: NA

Clinical: NA

Animal: NA

Computer: Labtop and desktop computers are provided by UNC. Data are stored on a central server with routine backup. The website will be maintained on the Biology department webserver, again with routine backup.

Office: Office space is available for project personnel in Coker Hall and assigned to R.K. Peet

Other: Duke Forest field sites are made available by the Office of Duke Forest at Duke University. We have an excellent relationship with them dating from 1975. North Carolina Botanical Garden sites are under the control of NCBG Director Peter White, a Co-PI on this project.

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate identifying the location and pertinent capabilities of each.

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual arrangements with other organizations.

Facilities, Equipment, and Other Resources

The Landscape Ecology Lab is a NASA Center of Excellence in Remote Sensing and is well equipped with computers and other equipment to complete this project. Our project is computer-intensive, as we will be analyzing large volumes of data as well as performing computer simulations. The Landscape Ecology Lab is superbly equipped with a dedicated high-performance data server (1 TB RAID storage) on which we have already collated all the geospatial data needed for this project, as part of other projects. The lab also has a full range of input/output devices (DVDs, printers, plotters) and networked software for GIS (ARC/INFO), remote sensing (ERDAS IMAGINE, ENVI/IDL), and computer-intensive simulations (in fortran and C). The Lab uses the R package for statistics, and we have written a number of custom routines for spatial and multivariate statistical analysis. As a lab specializing in spatial applications, we also have high-precision global positioning satellite receivers (Trimble ProXR and GeoXT, Trimble Juno) and supporting software (Pathfinder Office) for georeferencing field data. The Lab houses and maintains mirrored copies of the Duke Forest archives, a rich legacy of historical and monitoring data dating from the 1930's. In support of field studies, we also maintain an inventory of surveying tools (Laser Tech Impulse lasers and software support) and field sampling tools (reel tapes, diameter tapes, soil probes, etc.).

Data Management Plan

Data collected as part of this LTREB research program will be promptly documented, archived, and made available to the scientific community and the general public. Data from our previous LTREB grants are currently available at http://www.bio.unc.edu/faculty/peet/lab/PEL/df.htm. Those data take the form of spreadsheets sorted by sample plot ID and date of survey, followed by standard measures of abundance for all species recorded on the sample (e.g., basal area, m^2ha^{-1}; percent cover). For some samples, the data also include spatial coordinates of each tree stem. Ancillary data include full species names (with taxonomic reconciliation of older data following Weakley (2011; http://herbarium.unc.edu/flora.htm).

Discovery. All data collected from our research plots since inception, including all data collected with NSF support, will be stored physically on the UNC biology department server where data from our previous LTREB grant are currently available (http://www.bio.unc.edu/faculty/peet/lab/PEL/df.htm). But data are of little use if they are not known or discoverable. To facilitate discovery, we will advertise the data via annotated links on intuitive websites including the Duke Forest (http://www.dukeforest.duke.edu/), the North Carolina Botanical Garden (http://www.ncbg.unc.edu/), and the Landscape Ecology Laboratory at Duke (http://www.nicholas.duke.edu/landscape). In addition, scientific publications that use the data will provide links to permanent archives. The dataset will be announced in appropriate international registries of ecological data, such as GIVD, the Global Index of Vegetation-Plot Databases (Dengler et al. 2011; http://www.givd.info/).

Documentation, metadata and format. Data will be carefully described with complete metadata files. Inevitably, there is a tradeoff in selection of file format between immediate functionality, simplicity of immediate use, and long-term access. We will compromise by providing key files in three formats. (1) csv text files afford the greatest possible future usability as they are likely to be readable by all future software. (2) Excel files will provide maximum immediate usability for most potential users. (3) XML files conforming to the VegX vegetation plot data international exchange standard (Wiser et al 2011) will maximize future ease of integration with other datasets and data systems. Plant taxa will be mapped to taxonomic concepts as described in the TDWG TCS standard, already a component part of the VegX standard) so as to allow future integration with other databases that were based on potentially different taxon concepts.

Documentation associated with data currently archived conform to metadata standards in place at the time they were collected (~10 years ago). During this project, we will augment the metadata to conform to current standards.

Archiving strategies. To assure both maximum efficiency in immediately access as well as assurance of data longevity, data will be accessible from several places. (1) Data in all three formats will be served from the UNC Biology Department LTREB site, and links to this site will be provided on the Duke Forest website, the NC Botanical Garden, and the Landscape Ecology Laboratory at Duke. Copies of core data sets also will archived in the Landscape Ecology Lab as back-ups. These sites will provide immediately, high-efficiency downloads, though we are not in a position to assure long-term maintenance. (2) Data will be periodically deposited in the Carolina Digital Repository, which, being a component of the UNC library system, is our best bet for preservation in perpetuity, though discoverability maybe somewhat lower. (3) Plot data for taxon cover values (and possibly also tree stem maps) will be archived in VegBank, the plot archive of the Ecological Society of America and a component of the U.S. National Vegetation Classification. As this site is expected to be maintained by the U.S. Forest Service, acting on behalf of the U.S. Federal Geographic Data Committee Vegetation Subcommittee, the prospects for long-term preservation are good. (4) As we publish on datasets, we will attempt to include the data as digital supplements directly or by deposit in the NESCent-sponsored Dryad repository. Finally, (5) as datasets are completed, and if they are not otherwise deposited as supplements to papers, we will submit them as data papers to *Ecology* with linked datasets in *Ecological Archives*, a process we have already started with one dataset published (Palmer et al. 2007).

Versioning. Datasets evolve and need to be updated. However, once data have been used in the scientific process, it is necessary to maintain the data unmodified so that future scholars will be in a position to replicate the work and build on it. In short, the problem we confront is the need to perfectly archive versions of the data, but to also allow updates. In the case of the Duke Forest website and the Carolina Digital Repository, we will simply add new versions of the data on an annual basis while retaining the old versions. VegBank already has a continuous versioning system, so we can simply upload new versions as needed. In theory, *Ecological Archives* of the Ecological Society of America (for supplements and data papers) allows submission of new versions as needed. We are not sure how easy this is, but it is ESA policy.

Geospatial data. Spatial databases will be maintained in GIS format (currently ArcGIS version 2.10). , and documented according to FGDC standards. As spatial data, some of these files will comprise little more than the location of the plots, yet in this format the permanent plots can be overlaid readily with other geographic data maintained for the Duke Forest and surrounding area. Currently these data include digital terrain data, hydrography, roads, built structures, and soils (NRCS Soil Survey data as represented in SSURGO). In addition, stand maps (dominant species by age class) for all management compartments in Duke Forest are revised every 10 years (since 1934). Finally, Duke Forest is a NASA SuperSite and we maintain a wealth of remotely-sensed data ranging from digital orthophotos (1-m resolution) to Landsat TM (30 m) and MSS (80 m), to AVHRR imagery (1 km). The georeferencing of all Duke Forest data allows us to reconcile these different data within a common spatial framework so we can address questions such as whether Hurricane Fran affected stands differentially with respect to soil type or topographic position, or to pinpoint permanent sample plots that have been damaged as evidenced in airphotos acquired within weeks after the storm. The georeferencing of permanent sample plots also allows us to use the plots as ground truth for various remote sensing campaigns.

Policies for data sharing. Previously, these core data sets have been available on a “collaborator” basis, i.e., by direct communication with PI Peet. This simplified some issues (metadata and documentation were simpler because Peet knew the data) but limited general access. As part of this project, we will make core data sets freely available to any and all interested parties via anonymous download from the UNC Biology server. For research applications that generate publications, we will request authors’ acknowledgement of the provenance of the data as well as the original NSF grants that have supported the data collection (appropriate wording will be suggested on the website). We will make no claims concerning intellectual property rights for research using these data, beyond our own primary use of the data.

Rights and obligations of co-investigators. All co-investigators will share responsibility in developing and maintaining the documentation of the core data sets. PI Peet will have primary responsibility for archiving and documenting the core data sets from this project. Co-PI Urban will mirror the datasets off-line at Duke University, primarily as a secure back-up of the primary archive. If needed, this mirror can be made an active server of the data (the Landscape Ecology Lab hosts a public-access data server, but it does not currently serve these data). Over time, the project will migrate to Duke (see our Decadal Research Plan) and the Landscape Ecology Lab will become the primary server, with UNC’s server shifting to a mirror and back-up. Duke’s Nicholas School provides full IT support and ‘cold’ (i.e., read-only) storage capacity for archival data sets and metadata.