

**Note: This is just a proposal for informational purposes; the program does not yet exist.**

## **Graduate Program in Forest Canopy Studies: Integration of an Emerging and Multidisciplinary Field**

Principal Investigators:

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### **Project Summary**

The Evergreen State College and the University of Washington propose the world's first graduate training program in the study of forest canopies. This international collaborative program addresses critical issues identified in a recent NSF-sponsored survey: the emerging field of canopy science is fragmented into separate disciplines and lacks any formal graduate training program. Students need a program that trains them in a variety of disciplines, effectively crosses disciplines, and provides contact with the worldwide community of canopy scientists.

Our goals are to train scientists who can work across traditional disciplinary fields to understand the complex factors that explain forest canopies and their associated abiotic and biotic attributes. With an innovative two-tiered institutional structure, trainees will matriculate at one of the two resident institutions and have periodic, structured access to ca. 25 "Canopy Research Advisors" at other institutions around the world. The program has three parts: coursework, research training at field sites associated with the resident institutions, and the "canopy walkabout". During the summer walkabout, trainees will work directly with a subset of Canopy Research Advisors to broaden their research experiences.

Both resident institutions have a history of research in canopy studies and have well-developed canopy access and laboratory facilities for student research. Evergreen, which grants a Masters degree, will serve as a feeder school to University of Washington. Both schools support programs to recruit and retain under-represented ethnic groups, women, and disabled persons.

Three factors come together to make our request an extremely timely one for the GRT program in environmental biology and plant biology: the results of the NSF-

sponsored canopy science survey that showed a critical need for a graduate program; the establishment of major facilities for the study of canopies at the resident institutions; and the emergence of canopy research initiatives around the world.

## **I. Project Description**

### **I.A. Project Background**

We propose the world's first graduate training program in the study of forest canopies. The forest canopy has been termed "the last biological frontier" and is one of the richest but most poorly studied habitats in the biosphere (Erwin 1983). Members of canopy communities are essential to maintain the diversity and resilience of the forests they inhabit. Canopy-dwelling plants (epiphytes) constitute up to half of the total plant diversity of some wet tropical forests (Gentry & Dodson 1987) and provide crucial resources for a host of arboreal birds and mammals (Nadkarni & Matelson 1988). Canopy structural elements such as foliage and twigs account for a tremendous "sieving" effect of fog in some forests, causing wind-borne precipitation and its accompanying nutrients and pollutants to be deposited locally (Veneklaas & Ek 1990). Because canopy organisms dwell at the atmosphere-forest interface, they can serve as indicator organisms to monitor changes in global climate and atmospheric conditions (Lugo & Scatena 1992).

The forest canopy is defined as "the aggregate of all crowns in a stand of vegetation, which is the combination of foliage, twigs, branches, epiphytes and the interstices (air) in a forest". The nature of canopy studies is multidisciplinary; it includes such diverse fields as environmental biology, plant biology, forest ecology, meteorology, computer science, atmospheric science, statistics, and zoology. Although most canopy research has been conducted by scientists who work singly or in small groups, interdisciplinary research groups are just now coalescing to approach canopy questions from different perspectives and spatial scales, using a wide array of access and analytical tools.

In the last decade, a remarkable burgeoning of scientific interest in the canopy has occurred (Lowman & Nadkarni 1995). The number of scientific publications on canopy structure has grown at a disproportionately rapid pace relative to the general field of biology (Fig. 1). New methods of low-impact access to tree crowns with ropes, cranes, and remote sensing technology have enabled scientists to directly study the canopy. Heightened public interest in biodiversity, global climate change, and tropical deforestation has generated books, symposia, popular articles, and films about the canopy. Thus, canopy researchers are poised to incorporate an unprecedented amount of information and interest in this long-overlooked field.

### **I.B. Project Justification**

In 1994, we conducted a survey of canopy scientists to identify the current state of the discipline (Nadkarni & Parker 1994), funded by an NSF planning grant

(Database Activities Program, BIR 93-07771). The survey indicated that the field is developing rapidly but is fragmented, due to the multidisciplinary nature of the field and the historically isolated nature of the researchers. Two major obstacles were identified: dearth of communication networks among canopy researchers, and lack of formal training for future canopy researchers.

We responded to the first obstacle, the communication vacuum, by establishing a highly successful electronic mail bulletin board (canopy@lternet.edu) in 1994, which now has over 300 subscribers and supports weekly traffic of ca. 20 messages per week. We also began a quarterly newsletter ("What's Up?") which is distributed to 650 readers in 27 countries. We have assembled a canopy researcher directory, compiled a growing bibliography of canopy references (ca. 700 to date), and entered them in a bibliographic database. In 1995 we formalized the International Canopy Network (ICAN) as a non-profit organization to bring together people interested in forest canopy research, education, and conservation. This association enables us to perpetuate the network beyond the life of the supporting NSF grant. These actions have enhanced communication and promoted the efficiency of canopy research and thus largely solved the first impediment identified in the survey.

The second obstacle that has not yet been filled is the lack of any formal program in canopy studies at the graduate level. Because of the relative youth of canopy studies, canopy researchers are often isolated in their institutions. This contrasts to colleagues in more established disciplines (e.g., marine biology, soil science), who have colleagues down the hall with whom to confer and collaborate. Thus, a student wishing to gather the tools to become a successful researcher in forest canopy science must either rely upon a single mentor who works on the canopy or jump from one institution to another to gain his/her background. The result is a background that is either too narrow for the breadth of background that canopy studies demands, or a program that is fragmented and inefficient. The timing is perfect for the creation of a structured and efficient training program for students in the emerging and multidisciplinary field of canopy studies.

## **I.C. Program Structure and Characteristics**

### **I.C.1. Overall Program Design**

We have designed a program in forest canopy studies with many innovative structural characteristics. This novel two-tiered institutional program consists of three component activities (Fig. 2). The first institutional tier is composed of two "resident institutions", The Evergreen State College (TESC) and the University of Washington (UW) Graduate School. Prospective students will enroll and receive their degrees at either of these institutions, both of which have faculty with active canopy research programs. Trainees may take courses at the other institution as needed, with credits transferred to the student's home institution. Administrative agreements between the two institutions are already in place (Appendix 1). TESC offers a Masters in Environmental Studies (MES) degree, with a focus on

policy and environmental science. Although some students will opt for a terminal MES degree, TESC will undoubtedly function as a "feeder" institution to the UW PhD program. UW offers both MS and PhD degrees from the College of Forest Resources, the Department of Botany, and the Department of Zoology.

The second tier of institutions are the universities and laboratories of a cadre of "Canopy Research Advisors" we have engaged for this program. We invited an international group of senior faculty and researchers who have published extensively in disciplines that represent as many aspects of canopy studies as possible. At the time of proposal submission, 25 researchers have committed themselves to being advisors to this program (Appendix 2); we anticipate others will join this group in the future. Our trainees will approach them for guidance and advice on research ideas. Advisors will place a set of their reprints and grant proposals on file at the two resident institutions.

The proposed program consists of three components: coursework, resident institution research training, and the "canopy walkabout" (see below). Coursework will take place at the two resident institutions. Students will matriculate at one or the other school, and take courses at the other institution as needed. For the second component, research training at resident institutions, trainees will participate in ongoing canopy research programs of faculty at the two resident institutions and their associated field stations. The third part of this program is an innovative activity, the canopy walkabout, during which trainees contact Canopy Research Advisors and arrange to visit their field site or institution. The proposed graduate study timetable (Appendix 3) can be altered to suit the individual needs of the student.

### **I.C.2. Component 1: Coursework**

Emphasis in this program is on the environment and organisms that dwell in the forest canopy, which relate directly to the broader fields of environmental biology and plant biology. Academic training will also emphasize basic scientific knowledge, and application of that knowledge for solving a broad range of environmental and ecological problems. Below we describe the existing degree programs and courses that are currently offered which would fit our vision of a program in canopy studies.

#### **I.C.2.A. The Evergreen State College**

The Graduate Program in Environmental Studies opened in 1984, and has reached its steady state capacity of ca. 80 students. Our first graduates are now in public and private sector jobs or continuing graduate studies in related fields. The program is integrated and interdisciplinary. A primary objective is a deep understanding of environmental policy development and implementation. Study focuses on the relationship between science and policy. Students are presented with a balanced curriculum which seeks creative solutions to contemporary environmental issues.

The MES program is open to part-time and full-time students. The 72-quarter-hour completion requirement can be met in as few as six full-time quarters. Students are expected to have recent coursework in the social and natural sciences and in statistics. The MES program consists of three parts: 1) a required core taken by all students (32 quarter hours, qh); 2) electives (24 qh), and 3) a thesis or essay of distinction (16 qh). Core is taught by an interdisciplinary team, usually a social scientist and a natural scientist. Electives are subjects that are treated in greater depth, and vary depending on faculty. Students are required to complete an original thesis or essay of distinction with the guidance of a faculty committee. GRT trainees will fulfill all standard MES requirements, and take electives (at TESC and/or UW) that relate to canopy studies.

Courses relating to canopy studies at TESC:

Core courses:

1. Political, Economic and Environmental Processes
2. Population, Energy and Resources
3. Quantitative Analysis for Environmental Studies
4. Case Studies: Environmental Assessment, Policy, and Management

Elective Courses (available 1994-1995):

1. Land Resources
2. Natural Resource Economics
3. Ecological Principles
4. Environmental Philosophy and Ethics
5. Hydrology
6. Forest Ecology

### **I.C.2.B. University of Washington**

The Graduate School was created in 1899 to foster research by students and faculty, and to integrate education and research to the benefit of both. The Graduate Faculty has over 2500 members, with ca. 8000 graduate students working towards masters and doctoral degrees in 84 areas, as well as 9 interdisciplinary degree programs. Relevant degrees for canopy studies are from the College of Forest Resources (MFR, MS, PhD) and the College of Arts and Sciences (Botany, MS, PhD; and Zoology, MS, PhD).

Courses relating to canopy studies at UW:

College of Forest Resources:

- ESC 501: Forest Ecosystems: Community Ecology
- ESC 502: Structure and Function of Forest Ecosystems
- ESC 509: Review of Forest Autecology
- ESC 524/525: Tree Physiology
- ESC 441: Landscape Ecology
- ESC 442: Geographic Information System Applications to Forest Resources
- ESC 450: Wildlife Ecology and Conservation
- ESC 451: Biology and Conservation of Birds

ESC 453: Biology and Conservation of Mammals

Atmospheric Sciences:

ATM 501: Fundamentals of Physical Meteorology

ATM 502: Introduction to Dynamic Meteorology

ATM 524: Seminar in Clouds and Precipitation

ATM 534: Remote Sensing of the Atmosphere and Climate System

Botany:

BOT 525: Topics in Plant Ecology

BOT 551: Plant Population Biology

BOT 575: Transport Processes in Plants

BOT 577: Plant Growth and Development

BOT 579: Environmental Control of Plant Growth

Statistics:

STAT 503: Practical Methods for Data Analysis

STAT 516/517: Stochastic Modeling of Scientific Data

STAT 520: Time Series Analysis

STAT 534: Statistical Computing

STAT 577: Advanced Design and Analysis of Experiments

Zoology:

ZOO 570: Evolutionary Physiological Ecology

ZOO 573: Physiological Ecology

ZOO 578: Advanced Ecology

ZOO 506: Topics in Vertebrate Biology

### **I.C.3. Component 2. Resident Institution Research Training**

Resident institution research training is the participation of trainees in ongoing canopy research programs by faculty at the two resident institutions and their associated field sites. Current field projects include canopy work in Monteverde, Costa Rica (see Results of Prior Support), Wind River (Franklin, Nadkarni, and Hinckley) (App. 5), and Findley Lake (Hinckley) (see IV. Research and Teaching Excellence).

Nadkarni's long-term canopy research in Monteverde has focused on the ecological role of epiphytes, with a focus on ecosystem nutrient cycling. The Wind River Crane Facility is a new U.S. Forest Service-funded research site dedicated to the study of the forest canopy in the context of old-growth forest ecosystem ecology. A giant construction crane is being installed to enable scientists to study the forests in three dimensions. It has attracted an international cadre of canopy scientists, with facilities for staff and visiting scientists (App. 5). The Findley Lake site, located in the Cascade Mountains, supports an international research program focused on tree physiology; researchers gain access to the canopy with a unique system of interlocking metal towers and catwalks.

In resident institution research training, GRT trainees will participate as field assistants and gain direct experience with safe and non-destructive canopy

access techniques, observation and experimental procedures, and data analysis. This work will take place primarily during the summers, but may also occur during the academic year, with credit awarded as thesis or independent study units.

#### **I.C.4. Component 3. Canopy Walkabout**

An exciting and innovative part of this program is the creation of the "canopy walkabout". The walkabout is a concept borrowed from the culture of Australian aborigines, in which individuals of a tribal group journey to the outback on an odyssey to learn skills for living with the environment and to seek spiritual connections. In the case of this program, trainees (singly or in small groups) will contact Canopy Research Advisors (3-5 in the summer of the first year, and probably fewer during the summer of the second year) and arrange to visit their field site or institution. Trainees will serve as short-term field assistants to the Advisors, and in doing so, learn canopy research techniques, theory, and practices and broaden their experiences and perspectives. They would simultaneously develop ideas for their own canopy research projects. A trainee could choose to stay on with a particular Advisor for his/her thesis research, or the trainee could initiate an independent thesis project elsewhere.

We anticipate that this geographical walkabout will be followed and amplified by "electronic walkabouts" for the duration of their graduate programs and beyond. Building upon the personal contacts that the trainees make with their Advisors, they will use our newly-established e-mail canopy network for efficient communication among members of the extended canopy community.

Thus, we envision that these trainee journeys will serve not only to further the graduate careers of five trainees, but also to more tightly knit together the entire canopy researcher community, which is now scattered geographically. The presence of trainees will also be enormously effective to recruit new students to the program. The traveling trainees could provide such services as safety training courses for canopy access, seminars for undergraduates, and interpretive talks about the canopy for high school students and other audiences.

#### **I.C.5. Summary**

We emphasize the pioneering nature of this program, which provides combined access to both resident and non-resident institutional resources. The coursework and resident institution research training provides stability, quality control, and continuity for the trainees, while the walkabout allows them to learn and conduct research with the input of widely scattered Research Advisors, thus transcending the bricks and mortar of a single university. Other emerging fields of science whose researchers are similarly geographically scattered might follow this novel model.

#### **I.D. Administration of the Traineeship Program**

Although NSF funds will be administered through TESC, we consider the two resident institutions, UW and TESC, to be co-equal partners in terms of

intellectual and academic input and responsibilities. We have existing agreements concerning transfer of academic credit between the two institutions (Appendix 1). Student stipends will be paid through the MES program at TESC and The Graduate School at UW.

Trainee applications will be considered jointly by the three co-PIs. We have agreed that each institution will receive two traineeships/year with the fifth going to the school with the most qualified candidate. Staff support for assisting with mailings and other recruitment activities, payroll, registration, and evaluation will be easily provided by existing administrative staff.

We anticipate that funds for the canopy walkabout travel and other research expenses will be derived from the educational allowances of the trainees. We will actively seek supplementary funds within and outside the institutions, particularly from the forestry and timber industry, which dominates the local economy. Out-of-state tuition waivers will be available from UW and may be available from TESC (Appendix 1) to help reduce tuition costs and increase the amount of funds for student research activities and travel.

#### **I.E. Trainee Retention Plan**

In addition to the incentive of continuing financial support, we will foster a strong sense of community among trainees by facilitating formal and informal communication among them by three mechanisms: 1) participation at a required bi-weekly seminar at the home institution, in which scientific papers on the canopy (many from Advisors) are read and discussed; 2) one half-day meeting per quarter among all GRT students and faculty (alternating host institution), to present progress, provide feedback, and resolve problems; 3) an annual meeting for all participants at resident institutions, with as many Research Advisors as possible. This may coincide with the annual scientific meetings at the Wind River Canopy Research Facility, which are funded by the U.S. Forest Service. These meetings will provide opportunities to reinforce a sense of unity among trainees and faculty and thereby foster retention in the program.

#### **I.F. Traineeship Evaluation Plan**

We will evaluate the program each year. During summer quarter of each year, trainees will be asked to prepare a summary of their activities and to self-evaluate and group-evaluate the program (typical activities for TESC students). Resident faculty will gather transcripts and written self- and faculty evaluations of all trainees and involved faculty, including those Canopy Research Advisors who had substantial contact with a trainee. Conferences will be conducted with each trainee to identify the positive and negative experiences for that year. Resident faculty will make recommendations for further coursework, resident institution research experiences, and Advisory Researchers to contact. These recommendations will become part of the trainee's record.

At the mid-point and at the end of the program (Spring Quarter, 1997 and 2000),

resident faculty will set up an advisory team to evaluate the program. The team will consist of the two deans of the resident institutional programs, the resident canopy faculty, a subset of the Advisory Researchers, and at least two outside evaluators (e.g., NSF administrators, deans of other graduate schools). The reports will be circulated among all participants and recommendations will be implemented to the fullest extent possible.

### **I.G. Long-term Future of the Canopy Studies Traineeship Program**

We envision at least three scenarios evolving while the GRT funds are in place. First, the structure could remain the same as at the outset throughout the funding cycle. Second, some Advisors may become more major players in the program; we could explore the idea of expanding the number of resident institutions to include them. Third, the group of advisory institutions may evolve to a more formal consortium, following the model of the Organization for Tropical Studies, in which nearly 50 universities pay an annual fee so that their students can participate in intensive tropical field biology courses. We are open to any of these (or other) developments.

We also envision positive scenarios when NSF funding ends. We anticipate that the five years of funding will produce high-quality and high-visibility education and research in this emerging area of environmental biology and plant biology. This lends itself to continuing institutional support in the future, either directly (e.g., by tuition waivers and fellowships) or indirectly (by allowing faculty the administrative time to pursue funding for these students in the future). We will actively pursue other funds from industry (e.g., forestry companies), agencies (e.g., U.S. Forest Service), and other research grants.

## **II. Trainee Recruitment Plan**

Because of the unique and compelling subject matter, and the high interest in canopy biology, we anticipate a large response to our call for trainees. We have the a remarkable opportunity to recruit excellent candidates through the International Canopy Network (ICAN), the network focused on canopy science. Of the over 300 electronic bulletin board subscribers, ca. 35% are graduate students. In November, 1994, we "floated a message" that we were considering a possible program in canopy studies; within the first three days, ten students expressed sincere interest. Four of these sought training at the Masters level. We are confident that the e-mail bulletin board will be an excellent medium for recruiting trainees. An announcement in our quarterly newsletter, which is targeted at canopy researchers and educators, will also reach a large number of potential recruits.

The resident institutions enjoy a high level of interest in their graduate programs due to their reputation and excellent location. To attract a broad array of outstanding trainee candidates, advertisements will be placed in forest ecology journals and bulletins, including: Ecological Bulletin, Plant Sciences Journal, The Liana, and Tropinet. All advertisements will include appropriate affirmative action language and will encourage participation of women, minorities, and those with

disabilities. Personal contacts will also be made with university colleagues, industrial and consulting organizations, and government agencies. Similar efforts in the past have attracted superior students. We will also tap our Advisors to actively identify and recruit students. During their canopy walkabouts, students will serve as "ambassadors" for this program.

Trainee applicants will initially be screened by participating faculty members to identify top candidates. These individuals will be interviewed personally or by phone to assess their level of enthusiasm, to ensure their commitment to a career in the field, and references will be verified. Prospective women, minority, and disabled trainees from outside the area will be invited to visit the campuses for personal interviews. Selection of trainees will be made by consensus of the resident faculty.

### **III. Commitment to Minorities Recruitment**

TESC has a long tradition of recruiting minorities. Our First People's Coalition is funded with student activity fees, and includes an active recruitment effort through visits, letters of invitation from faculty, a mentorship program, and social activities to build a supportive atmosphere. There are several other ethnic organizations on campus (Women of Color, Native American groups, Latin American Coalition). All have offices for regular meetings, access to funds, and regular social events. These students help identify other minority students to join TESC. Specific efforts targeted at the graduate level are actively being developed (Appendix 4).

The Graduate School of UW has committed itself to promote greater access to advanced study by women and members of ethnic minority groups. Within the Graduate School, the Minority Education Division activity solicits applications for admission, facilitates their review, and helps with procedures related to the enrollment of minority graduate students. The Division offers financial aid to students who need such help. In addition to a special appropriation of funds by the Washington State Legislature to encourage the recruitment and retention of ethnic minority students in areas of underrepresentation, the Division administers several federal and private scholarship programs which provide financial aid and contribute to the overall environment of support for minority graduate students. Nadkarni was herself the recipient of the above funds when she was a PhD student at the College of Forest Resources (1979-1980), as a woman in a field underrepresented in her area of study (forestry). That support was critical for her to pursue graduate opportunities at UW.

### **IV. Research and Teaching Excellence**

The individual teaching and research programs of all three of the co-PIs are congruent with this proposal. Nadkarni has been conducting research on forest canopy ecology in tropical and temperate rainforests since her graduate program in 1983, supported by NSF, Man and the Biosphere, the National Geographic Society, and the Whitehall Foundation. She has incorporated descriptive,

experimental, and modelling approaches to understand the ecological role of epiphytes in whole-forest interactions, particularly nutrient cycling. More recently, she has explored methods to sample and analyze three-dimensional spatial data, collaborating with computer scientists, database specialists, spatial information specialists in other fields.

Nadkarni has had six graduate students, five of whom carried out research on canopy biology. She teaches an interdisciplinary upper-division undergraduate program in "Temperate and Tropical Rainforests". The first quarter focuses on the ecology and geology of temperate rainforests; the second quarter is held in Monteverde, Costa Rica, on tropical forest ecology, geology, and agroecology. Nadkarni is slated to teach in the MES program in 1995-1997, and will offer elective courses that pertain to canopy studies, including forest ecology, ecosystem ecology, and biogeochemistry. In all her courses, she exposes students to active processes of field research. Nadkarni holds a 0.5 FTE appointment (she splits a faculty position with her husband), and so she is available for the research training component during the academic year and summer over the course of the grant.

Nadkarni has received several Research Experiences for Undergraduates (REU) grant supplements, and has another REU supplement pending with NSF to fund two undergraduates to participate in her current research. She also has a pending application for a Research Assistantship for Minority High School Students (RAMHSS), which would be another link in the chain of research training in her laboratory. The GRT trainees would be a welcome part of this system.

The atmosphere at TESC provides the freedom to help develop the "whole student". In 1994, Nadkarni initiated regular meetings with students who dream of going to graduate school in ecology. This group, called "GRAF" (Greeners with an Academic Future), meets every week to discuss aspects of graduate school, careers in science, pitfalls in applying to graduate school, and special problems for women and minorities. Students run workshops, choose articles and topics for discussion, and provide a support system for each other.

Current grants to Hinckley from the EPA and the USFS are specific to canopy research. A system of catwalks and towers has been erected in an old-growth forest of Pacific silver fir and Mountain hemlock near Findley Lake, Washington. Faculty from UW, research scientists from a set of international institutions (e.g., University of Hawaii; University of Antwerp, The Netherlands; University of Prague, Czech Republic), and graduate and undergraduate students regularly use this facility.

Hinckley currently has five graduate students, three of whom are conducting research in canopy processes. Over a 27-yr period, he, his colleagues, and his students have conducted research on canopy processes. Many of his former

students are recognized for their work on canopies. Hinckley also teaches high school minority students (with G. Kalongi and P. MacGown in College of Engineering, NSF sponsored), undergraduate (e.g., Forest Biology and Global Change), graduate (e.g., Topics in Forest Physiology, Stress Physiology) and professional students (e.g., Review of Forest Autecology) at UW. In all of his courses, field sessions and experiences are emphasized. His teaching was recognized in 1988 with a Burlington Northern Teaching Award. He has also taught researchers and professional foresters in Finland (1991) and Austria (1994), and undergraduate and graduate students in Austria (1978, 1988-89, 1994).

Franklin has been intensively involved in research and teaching on the structure and function of forest ecosystems since the late 1960's when he helped organize the International Biological Program's Coniferous Forest project. Since that time, Franklin and his students have conducted research on the structural characteristics of natural forests (including the definitive work on old-growth coniferous forests), responses to natural and experimentally-created forest gaps, vertebrate responses to canopy and other structural features of forest stands, and snag and log decay processes. He has particularly emphasized the relationships between stand structural features and ecological processes, including productivity, nutrient cycling, and provision of habitat for birds and mammals. A particular current interest is the relationship between ground- and stream-dwelling invertebrates and high canopy habitat. Much of this work has been in collaboration with the research group at the H.J. Andrews Experimental Forest, which he led for over 10 years.

Franklin's current teaching includes courses in the structure and function of forest ecosystems and on applications of ecosystem knowledge in the development of forest management practices. Franklin teaches primarily at the graduate level. His courses include Landscape Ecology, Structure and Function of Forest Ecosystems, and numerous seminars. He currently advises 8-10 graduate students, about half of whom are women, and one of which is an Asian-American. Franklin also teaches a high-enrollment undergraduate course, Ecological Basis for Forest Management.

Franklin's research and teaching is a major underpinning of the ecosystem management strategies adopted for federal timberlands in the Pacific Northwest. His broad interests and contacts among the ecosystem research community should also prove valuable in this program; Franklin was Program Officer for Ecosystem Studies in the National Science Foundation (1973-1975) and served as the national leader of the Long-Term Ecological Research (LTER) program for 12 years (1983-1994). He is also the Project Leader for the Wind River Canopy Crane Facility in Wind River (App. 5).

## **V. Institutional Accommodation of Trainees**

At both of the resident institutions, competitive, financially supported graduate

students face no enrollment limitations. Discussions with deans and other administrators assure us that the addition of 2-3 students per institution will not pose a problem. Staff support for assisting with mailings, recruitment, registration, and evaluation will be provided by existing program staff.

The requested trainee support is a truly new effort, and does not simply replace other support by NSF funds. Trainees may be eligible for out-of-state tuition waivers which will allow them to use part of their educational allowance for travel and research expenses.

### **Literature Cited**

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### **A. Summary of Institutional Record for Producing Degrees**

At TESC, the average length of time enrolled to complete the program is approximately 3.2 years, based on records from the past five years. We anticipate that the expected time for GRT trainees to complete their programs will be three years. Since trainees have full support from their stipends, they can take a full-time course load. Both summers and the third year will be used to carry out their research and complete their thesis or essay of distinction (Appendix 3).

At UW, the average length of time enrolled to complete the MS degree is ca. 3.3 yr for the College of Forest Resources, 3.2 for the Department of Botany, and 3.6 for the Department of Zoology. The average time to obtain the PhD is 6.2 for the College of Forest Resources, 5.7 for the Department of Botany, and 5.7 for the Department of Zoology.

### **Canopy Research Advisors for Canopy Graduate Program**

#### Researcher Name/Institution/Area of Interest

**Dennis Baldocchi**/Oak Ridge National Laboratory/atmospheric science

**Bradley Bennett**/Florida International University, Department of Biological Science/ethnobotany

**Jiquan Chen**/Michigan Technical University/forest structure

**Darwyn Coxson**/University of N. British Columbia, Department of Biology/  
nutrient cycling

**D.A. Crossley, Jr.**/University of Georgia, Institute of Ecology/canopy  
arthropods

**Roman Dial**/Alaska Pacific University, Department of Environmental  
Science/ lizard ecology

**Terry Erwin**/Smithsonian Institution, Department of Entomology/canopy  
arthropods

**Dave Fitzjarrald**/SUNY, Albany, Atmospheric Science Resource Center/  
microclimatology

**Jerry Franklin**/University of Washington, College of Forest Resources/  
forest ecology

**I.A. Gunatilleke**/University of Peradeniya/plant biology (Sri Lanka)

**Tom Hinckley**/University of Washington, College of Forest Resources/  
tree physiology

**Robert Lawton**/University of Alabama, Department of Biological Sciences/  
forest dynamics

**Bette Loiselle**/University of Missouri, St. Louis, Department of Biology/  
bird ecology

**Meg Lowman**/The Marie Selby Botanical Gardens/canopy herbivory

**Bruce McCune**/Oregon State University, Department of Botany and Plant  
Pathology/lichen ecology

**Steve Mulkey**/University of Missouri, St. Louis, Department of Biology/  
ecophysiology

**Nalini Nadkarni**/The Evergreen State College, Environmental Studies/  
ecosystem ecology

**Howard Neufeld**/Appalachian State University, Department of Biology/  
ecophysiology

**Geoffrey Parker**/Smithsonian Environmental Research Center/  
forest structure

**Richard Ring**/University of Victoria, Department of Biology/  
canopy arthropods

**Doug Schaefer**/University of Puerto Rico, Terrestrial Ecology Division/  
nutrient cycling

**Tim Schowalter**/Oregon State University, Department of Entomology/  
canopy arthropods

**Nigel Stork**/British Museum, Entomology Division/canopy arthropods

**David Vieglais**/Kennedy Space Center, NASA/forest structure

**David Walter**/University of Queensland/canopy mite biology