The Yale Institute for

Biospheric Studies

YIBS 1997-1998 Annual Report

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I. PERSONNEL APPOINTMENTS

Joseph Kiesecker, Gaylord Donnelley Environmental Fellow
School of Forestry and Environmental Studies

Frederick Myerson, Lecturer
Department of Biology

James Hill, Director of Undergraduate Studies
Program in Organismal Biology

II. STUDENT PROGRAMS

A. Studies in the Environment Program
Mary Helen Goldsmith, Chair
Professor, Molecular, Cellular and Developmental Biology
Studies in the Environment in Yale College offers a program for students interested in acquiring a more comprehensive understanding of complex environmental processes and issues than afforded by any single major in the natural or social sciences or the humanities. The program is offered only as a second major and provides students with both the skills and depth of knowledge required to pursue an environmental career in government or the private sector. It also prepares them to continue their education in graduate and professional programs in business, law, or management of natural resources, and to become effective, informed citizens and stewards of the environment in their communities. Studies in the Environment emphasizes an interdisciplinary approach built on a strong foundation in the natural sciences, especially geology and ecology, subjects that also require a basic background in chemistry, physics, and biology. In the social sciences, courses in economics, political science and policy analysis, and in the humanities, history and literature, are essential components of our core curriculum. Regardless of their primary major, students in the program acquire basic scientific knowledge and practical skills. They become aware, inquiring, and observant, capable of formulating hypotheses, designing experiments,

analyzing data, determining its statistical significance, analyzing risk, coming to decisions on the basis of present knowledge, monitoring and adjusting course in response to unanticipated outcomes. Students in the program who are majoring in one of the humanities or social sciences clearly get a better education in natural sciences than do most of their peers.

An Advisory Committee composed of faculty drawn from various participating departments discusses the development of the program and its curriculum. They also provide a resource of information about the program for students with primary majors in their respective departments. The faculty for the program consists of a DUS (currently in the History Department) and a Chair (currently in Molecular, Cellular and Developmental Biology). To satisfy all requirements, except the new junior seminar and the senior colloquium, the program relies on courses taught by participating departments that have been designed to satisfy their curricular goals, not the curricular of Studies in the Environment. In designing their majors and courses, departments do not consult the program about the needs of our students.

During the past two years, the program has undertaken a major discussion and revamping of its requirements. We reviewed the contribution to the environmental literacy of Yale undergraduates made by F&ES 199 introduction

to Environmental Studies which is taught by Gordon Geballe. The enrollment was 152 students last year. While this course is attractive to freshmen and sophomores who are considering the second major, we decided not to require it of all majors. If they have not already taken F&ES 199 by the time they are juniors, our majors frequently find they have already covered much of this material in other Yale courses. In the future, students will be required to take a course on the stresses imposed by the explosive growth of human population, such as Global Problems of Population Growth, Studies in the Environment 205b, taught by Robert Wyman, as well as a course in statistical analysis and probability.

An innovation this past year was the introduction of a junior seminar, offered to eleven juniors jointly by DUS Steven Stoll and Chair Mary Helen Goldsmith. The purpose is to prepare students for their senior research projects early enough so they can seek an internship with an environmental organization or other relevant experience in the field or research laboratory over the summer. This course covered historical, social, economic, and scientific perspectives on environmental problems in New England and featured readings and discussions with the students led by experts with interdisciplinary research interests. The problems included land use, agriculture, forests, watersheds, marine fisheries, and urban impacts on regional ecology -- all problems with global dimensions. One goal of the seminar was to encourage students from different disciplines to work in groups and share knowledge across disciplinary boundaries. This was prologue to each student doing a preliminary study in preparation for their senior research, selecting a faculty advisor, and presenting their ideas orally for critique by their peers. Each student also submitted a written prospectus of their research plans for comment by the faculty. We encourage our students to consult with their research advisor and to select an environmental problem for their senior research that can be the subject of a rigorous analysis using the techniques of their primary major, but also one that lends itself well to an interdisciplinary approach.

Because of the introduction of the Junior Seminar, this year we added Lecturer Frederick Meyerson to help monitor the progress of the seniors with their research projects and to run the Senior Colloquium. Meyerson is also responsible for keeping in close contact with each student's research advisor in order that the expectations of both majors are fulfilled. He has a law degree and is a PhD candidate in F&ES. His expertise in environmental policy, including human population, conservation, and climate change, complements that of the DUS and Chair and adds a further dimension to our guidance of the students in the Senior Colloquium.

Despite these positive developments the program remains small. Because of the extra demands of a second major, more students consistently participate in the program than finally complete all its requirements. Although attrition is high, even students who do not complete the major benefit from its existence and the interdisciplinary interactions that the program and its seminar offerings foster between students and faculty. On the other hand, by acquiring depth of knowledge in the field of their primary major and mastering the skills and techniques necessary to do a rigorous research project, we feel that our students avoid the common pitfall of "multidisciplinary illiteracy."

An important strength is that the program provides greater exposure to disciplines relevant to environmental issues than students can achieve in any single major. The program also emphasizes practical experience through its summer internships. This year Ecology and Evolutionary Biology as well as Environmental Engineering have created, and Geology and Geophysics has substantially improved, departmentally based options for students interested in environmental sciences. These initiatives, which are intended to attract students to various departmental majors, raise concern for the survival of an interdisciplinary second major. The intellectual vitality that comes from the interaction among both students and faculty across disciplinary boundaries that has always characterized the major in Studies in the Environment will be seriously undermined if most of the students in natural and applied sciences opt for the new environmental concentrations within individual science departments.

Following demolition of Bingham Laboratory to make way for the new Environmental Sciences building next year, there will be an urgent need for both interim and long-term space for the program. We need administrative and faculty offices where the DUS and Chair can meet with students, and also

well equipped classrooms and laboratory space for the program. Ideally, the space designated for the program should be integrated with environmental sciences and in an area that is both accessible and highly visible to undergraduates. An ideal location for the program would be in the new Environmental Sciences building.

By far our most critical need is intellectual: a cadre of committed Yale College faculty need to engage in the design and teaching of a more effective curriculum in Environmental Studies. We need dedicated faculty who see the continuing impoverishment of the earth's land, water, air and biological diversity as a major intellectual challenge facing humans, their social institutions, and security. This faculty needs to initiate ongoing interdisciplinary discussions towards the goal of replacing the current hodge-podge of courses designed by the departments for their own restricted disciplinary purposes, with a better integrated and more coherent, comprehensive, and efficient curriculum in Environmental Studies. The Dean of Yale College recognizes the challenge of meeting the aspirations of many present and potential Yale undergraduates for an excellent program in environmental sciences and studies and has taken the lead by convening a committee of faculty to consider the future shape of environmental education in Yale College.

B. 1997 Hitachi America Summer Undergraduate Internships

Program in Organismal Biology	*Studies in the Environment*
Zina Deretsky	Rebecca Birch
Lorky Libaridian	Leanna Hicks
Kristen Vose Michaelides	Everett Meyer
Hanna Norfleet	Robert Trostle
Gabriela Redwine	
Kara Rodgers	
David Seelig	
John Sykes	

C. 1997 Summer Internship Grants for Studies in the Environment Rising Seniors

Henry Kessler
Internship with INFORM in New York City

Rachel Brakeman
The Environment of the Olympic Peninsula

Susan Brown
Connecting Ecological and Social Systems: Watershed Research Relating Ecosystem Structure and Function to Human Values and Socioeconomic Behavior

Sarah Hollinshead
A Study of Ground Water Contamination at Otis Air Force Base on Cape Cod, MA

Lise Johnson
Internship with the Wilderness Society in Washington, DC

Amardip Mann
Fire in the Great Basin

Sarah Reed
Film documentary - *Suburbanization in Front Range CO*

Joanna Schwartz
Earthwatch expedition on Shenandoah wildlife

Kathrine Spector
Southern African environment project in Capetown, South Africa

D. 1997 G. Evelyn Hutchinson Prize - Graduate Students

Department of Ecology & Evolutionary Biology	*School of Forestry & Environmental Studies*
Homayoun Bagheri	Karen Beard
Luis Cadavid	Victoria Derr
Max Shpak	Bronson Griscom
Michel Slotman	Sushila Kanoida
Pamela McElwee	Susan Koenig

Ragnihildur Siguroardottir

Department of Geology & Geophysics
Jessica Maisano
Cynthia Marshall

E. 1997 YIBS Additional Funding - Summer Internships

Ecology & Evolutionary Biology

Kristen Saltonstall
Max Shpak

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III. GAYLORD DONNELLEY ENVIRONMENTAL FELLOWSHIP

1997 -1999 Gaylord Donnelley Environmental Fellow
Joseph Kiesecker, Ph.D

Activities
- Collaborated with several scientists including both graduate students and faculty.

- Examined the effects of pathogenic infection on behavioral interactions.

- Investigated how infection with pathogens may influence social interactions between larval amphibians, which resulted in his laboratory experiments demonstrating how tadpoles avoid associating with conspecifics infected with intestinal pathogens. This is one of the first demonstrations that animals can recognize and use behavior to avoid pathogenic infection and these results will have important ramifications for the understanding of disease transmission.

- Learned techniques that will enable him to identify, isolate and manipulate pathogens in field experiments to be conducted in the spring of 1998.

- Has written and submitted results of research conducted during his Ph.D. studies.

- Submitted five manuscripts, two of which have been accepted for publication.
- Guest lecturer in the Conservation Biology course at the Yale School of Forestry and Environmental Studies.

- Instructor at the Society for Conservation Biology's Weekend Methods Retreat at the Great Mountain Field Station.

- Attended talks and seminars presented by Yale's School of Forestry and Environmental Studies and the Department of Biology.

- Presented results of research at the University of Connecticut, Department of Ecology and Evolutionary Biology, in November 1997.

- Presented results of research at the University of Maine, Department of Biological Sciences, in December 1997.

- Attended seminar at the University of Colorado, Department of Biology, in March 1998.

- Attended seminar at Hardwick College, Department of Biology, in May 1998.

- Presented at the American Association for the Advancement of Science 150th Anniversary Meeting, Philadelphia, PA. Development in a Volatile World: How Embryos Cope With Environmental Stress; Amphibian embryo mortality: The consequences of exposure to ambient ultraviolet radiation.

- Presented at the Society for Conservation Biology Annual Meeting, Sydney, Australia. Amphibian Declines: The Role of Environmental Stress and Disease.

Manuscripts in press or recently submitted

Blaustein, A.R., Kiesecker, J.M., Chivers, D.P. and R.G. Anthony. Ambient

UV-B radiation causes deformities in amphibian embryos. Proceedings of the National Academy of Science. 94:13735-137-37.

Chivers, D. P., Kiesecker, J.M., Wildy, E. T., Kats, L. and A.R. Blaustein. Avoidance response of juvenile anurans to cues of injured conspecifics and predators. Journal of Herpetology. In Press.

Kiesecker, J.M. and A. R. Blaustein. Pathogen reverses competition between larval amphibians. Submitted to Ecology. 29 pages.

Kiesecker, J.M., Chivers, D.P., Marco, A., and A.R. Blaustein. Identification of a non-damage alarm pheromone in larval red-legged frogs (Rana aurora). Submitted to Animal Behaviour. 31 pages.

Blaustein, A.R., Kiesecker, J.M., Belden, L. K. and D.H. Olson. Amphibian breeding and climate. Submitted to Conservation Biology. 7 pages.

Wildy, E.L., Chivers, D.P., Kiesecker, J. M. and A.R. Blaustein. 1998. The effects of intraspecific predation on growth in larval long-toed salamanders, Ambystoma macrodactylum. Journal of Herpetology. 32:286-289.

Kiesecker, J. M. and A.R. Blaustein. 1998. Effects of introduced bullfrogs and smallmouth bass on the microhabitat use, growth and survival of native red-legged frogs. Conservation Biology. 12:776-787.

Devito, J., Chivers, D.P., Kiesecker, J.M., Marco, A., Wildy, E.L. and Blaustein, A.R. 1998. The effects of snake predation on metamorphosis of western toads, Bufo boreas (Amphibia, Bufonidae). Ethology, 104:185-193.

Marco, A., Kiesecker, J.M., Chivers, D.P., and Blaustein, A.R. 1998. Sex recognition and mate choice by male western toads (Bufo boreas). Animal Behaviour, 55:1631-1635.

Blaustein, A.R. Hoffman, P., Hayes, J.B., Chivers, D.P., Kiesecker, J.M., et al. The influence of ambient UV-B on embryos of the spotted frog (Rana pretiosa) across an elevation gradient. Ecological Applications. In Press.

Kiesecker, J.M., Chivers, D. P., Marco, A., Quilchano, C., Anderson, M.T. and A.R. Blaustein. Identification of a disturbance signal in larval and red-legged frogs (Rana aurora). In Review for Animal Behavior. 25 pages.

Blaustein, A.R., Kiesecker, J.M., Belden, L.K. and D.H. Olson. Amphibian Breeding and Climate. In Review for Conservation Biology. 9 pages.

Devito, J., Chivers, D.P., Kiesecker, J.M., Belden, L.K. and A.R. Blaustein. Effects of snake predation on aggregation and metamorphosis of pacific tree frogs (Hyla regilla) larvae. In Review for Copeia. 21 pages.

Kiesecker, J.M., Skelly, D. K., Beard, K. and E. Pressier. Behavioral Reduction of Infection Risk. In Review for Proceedings of the National Academy of Sciences. 18 pages.

Plan for Future Activities

Research

- Follow up on work involving behavioral resistance to pathogenic infection.

- Examine the role that disease plays in structuring communities.

- Construct artificial larval amphibian communities and manipulate the presence of snail borne trematode pathogens.

- Examine how trematode infection can affect performance of amphibian larvae and the conditions that result in trematode outbreaks with a goal to understand how environmental change can influence disease outbreaks and ultimately community structure.

- Work closely with Dr. David Skelly examining the role of food resource gradients and the ecology of larval amphibian communities

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IV. RESEARCH CENTERS

A. Center for Computational Ecology
Oswald J. Schmitz, Director
Associate Professor, Ecology & Evolutionary Biology and
The School of Forestry and Environmental Studies

Publications

Baatz, M. and G. P. Wagner 1997. Adaptive inertia caused by hidden pleiotroic effects. Theor. Population Biology, 51, 49-66.

Baily, W., J. Kim, G. P. Wagner, and F. Ruddle 1997: Phylgenetic reconstruction of Hox Cluster duplications. Molecular Biology and Evolution, 14, 843-853.

Booth, G. 1997. Swarm Gecko: A 2-D world for ecological modeling. Artificial Life

Calabretta, R. C., G. P. Wagner, S. Nolfi, and D. Parisi 1997: Evolutionary mechanisms for the origin of modular design in artificial neural networks. Proceedings of the International Conference on Complex Systems, Nashua, NH 21-26 September 1997

Johnston, K.M. and O.J. Schmitz. 1997. Influence of climate change on the distribution of selected wildlife species within the continental USA. Global Change Biology 3: 531-544

Schmitz, O.J., A.P. Beckerman and S.Litman. 1997. Functional responses of adaptive consumers and community stability with emphasis on the dynamics of plant-herbivore systems. Evolutionary Ecology 11:773-784.

Schmitz, O.J. and G. Booth. 1997. Modeling food web complexity: the consequences of individual-based, spatially explicit behavioral ecology on trophic interactions. Evolutionary Ecology 11:379-398.

Karieva, P., D.K. Skelly and M. Ruckelshaus. 1997. Reevaluating the use of models to predict the consequences of habitat loss and fragmentation. Pages 156-166 in (S.T.A. Picket, R. Ostfeld, M. Shachak and K.E. Likens, Editors) Enhancing the ecological basis of conservation: heterogeneity, ecosystem function, and biodiversity. Chapman and Hall, New York.

Abrams, P.A. and O.J. Schmitz. 1998. The effect of risk of mortality on the foraging behavior of animals faced with time- and gut-capacity constraints. Evolutionary Ecology (in press).

Wagner, G. P., G. Booth and H. Homayoun-Chaichian 1997. A Population Genetic Theory of Canalization. Evolution, 51, 329-347.

Dudgeon, S., A. Wagner, J.R. Vaisnys, L. Buss 1998. Dynamics of gastrovascular circulation in the colonial hydroid, Podocoryne carnea. The one-polyp case. Invertebrate Biology

Mokady, O. Dick, M. H., Lackschewitz, D., Schiewater, B., and L. W. Buss 1998. Over one-half billion years of head conservation: Expression of an ems class gene in Hydractinia symbiolongicarpus (Cnidaria:Hydrozoa). PNAS 95:

3673-3678.

Schmitz, O.J., J.L. Cohon, K.D. Rothley and A.P. Beckerman. 1998. Reconciling variability and optimal behavior using multiple criteria in optimality models. Evolutionary Ecology 12: 73-94.

Stadler, P. and G.P. Wagner. 1997. The algebraic theory of recombination spaces. Evolutionary Computation

Wagner, A., Dudgeon, S., J. R. Vaisnys, and L. W. Buss 1998. Non-linear oscillations in polyps of the colonial hydroid Podocoryne carnea. Naturwiss. 85:117

Kreft, J.-U., G. Booth and J. Wimpenny 1998. Bacsim, a simulator for individual-based modeling of bacterial colony growth. Microbiology (In Press)

Beard, K.H., N. Hengartner and D.K. Skelly. Predicting bird distributions using probabilistic models. Conservation Biology. (Submitted)

Luttbeg, B. and O.J. Schmitz. Dynamics of predator-prey models with flexible prey behavior and imperfect information. American Naturalist. (Submitted)

Schmitz O.J. From individuals to communities: identifying the dynamically-relevant organizational scales. Ecology. (Submitted)

Sponsored Programs and Seminars

Seminar by O. Schmitz, CCE, at the Department of Zoology, University of Toronto

Seminar by D. Skelly, CCE, at the Department of Zoology, University of Oklahoma

Seminar by D. Skelly, CCE, at the Division of Biological Science, University of Missouri

Seminar by D. Skelly, CCE, at the Mountain Lake Biological Station, University of Montana

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Honors and Awards

Oswald Schmitz, CCE - Yale University Library and ITS Grant: Using CourseWare to develop a self-directed, computational teaching environment for community ecology.

Oswald Schmitz, CCE - National Science Foundation (with T. Graedel and L. Bennet). Indeco: development of an individual-based simulator to model the evolution and dynamics of industrial ecosystems.

Gunter Wagner, CCE, NECUSE: Development of CourseWare, a software framework for developing and deploying custom science labs via the Web.

International Seminars, Conferences

International Society for Behavioral Ecology, Monterey, CA (July 1998) attended by Oswald Schmitz, CCE

Ecological Society of America, Baltimore, MD (August 1998) attended by David Skelly, CCE

B. Center for Earth Observation
Ronald Smith, Director
Professor, Department of Geology and Geophysics

Publications

Kouhouchos, N., R.B. Smith, A. Gleason, P.S. Thenkabail, F. Hole, Y. Barkoudah, J. Albert, P. Gluhosky, and J. Foster. 1998. Monitoring the Distribution, Use, and Regeneration of Natural Resources in Semi-Arid South West Asia, To appear in Transformations of Middle Eastern Natural Environments, Proceedings of an International Conference held at Yale University 29-31 October, 1997, Yale School of Forestry & Environmental Studies Bulletin.

Kouhouchos, N. 1998. Landscape and Social Change in Late Prehistoric Mesopotamia, Doctoral dissertation, Department of Anthropology, Yale University.

Pan, F. and R.B. Smith. 1998. Gap Winds and Wakes: SAR observations and numerical solutions, Journal of Atmospheric Sciences, 55.

Thenkabail, P.S. 1998. Characterization of the Alternative to Slash-and-Burn Benchmark Research area representing the Congolese rainforests of Africa using Near-Real-Time SPOT HRV Data, International Journal of Remote Sensing, Accepted for publication as Ref # RES120835.

Thenkabail, P.S. and R.B. Smith. 1998. Crop Growth and Yield Studies Using a 512-Band Spectrometer in the Semi-Arid Environments of Syria, Proceedings of the First International Conference on Geospatial Information in Agriculture.

Thenkabail, P.S., R.B. Smith, and E. DePauw. 1998. Hyperspectral Vegetation Indices for Determining Agricultural Crop Characteristics, Remote Sensing of the Environment, Submitted

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Visitors

Dr. K. D. Singh - FAO Forestry Department, United Nations. The purpose of this visit was to explore opportunities to develop land cover maps of South West Asia which could be integrated into existing global forest mapping efforts of the UN.

Eddy De Pauw - International Center for Agricultural Research in Dry Areas (ICARDA). The purpose of this visit was to coordinate collaborative research in South West Asia between ICARDA and CEO.

Khaldoun Rishmawi - Applied Research Institute of Jerusalem. The purpose of this visit was to use the expertise and facilities of CEO to develop detailed vegetation classification maps of the West Bank. This will be used to assist in developing a water budget for the area.

Jack Mustard - Geology Department, Brown University. Professor Mustard and one of his students visited CEO to begin collaboration concerning the use of a statistical mixing model to determine the percent coverage of vegetation in arid region.

Ani Balikian - ICARDA. Ms. Balikian used the facilities and datasets at CEO to develop a large-scale vegetation analysis of the Middle East and Central Asia.

Jiaguo Qi - Michigan State University. Professor Qi visited us to begin collaboration using Bidirectional Reflectance data to analysis vegetation in arid regions

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Sponsored Programs and Seminars

October 1997 - Speakers from the Center for Earth Observation participated in the Yale Symposium on Changing Environments in the Middle East at Luce Hall.

November 1997 - Professor Ronald Smith presented results from the South West Asia Project to the NASA Workshop, Global Land Use/Land Cover

Analysis, in Warrenton, Virginia.

April 1998 - Professor Ronald Smith lectured on Middle East climate and vegetation in Aleppo, Syria at the International Center for Agricultural Research in Dry Areas (ICARDA).

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C. Center for Ecology and Systematics of Animals on the Verge of Extinction (ECOSAVE)
Elisabeth Vrba, Director
Professor, Department of Geology and Geophysics

In our desire to preserve the broadest possible segments of earth's vast biodiversity, scientists must constantly ask themselves and one another which ecosystems should be conserved, and where? Which are the endangered species and which species require priority attention? What sort of habitat does a species require and how do habitats relate to species' life cycles and behaviors? The Center for the Study of Ecology and Systematics of Animals on the Verge of Extinction (ECOSAVE) focuses specifically on providing the vital scientific basis for conservation strategies to help diminish the loss of threatened species. ECOSAVE concentrates research efforts in two major areas: analyses of ecosystem changes found in fossil records, and understanding a species' family trees by combining the traditional method of analyzing physical form and function with new techniques to analyze underlying genetic similarities. This information is essential for creating animal and plant reserves and for developing effective management strategies for the future.

The ECOSAVE Center currently has two major subsections:

1. The ECOSAVE Conservation Genetics Laboratory, and
2. ECOSAVE Faculty Research.

ECOSAVE Conservation Genetics Laboratory

The YIBS ECOSAVE Conservation Genetics Laboratory was established this year to service all YIBS-associated faculty and students. It will accommodate the needs in environmental sciences at Yale for undergraduate and graduate teaching of the laboratory procedures involving evolutionary genetic analyses on all types of organisms. The larger focus of this teaching effort includes the relationships of such genetic patterns to systematics and biology of organisms as a whole, and to the understanding of their evolution and conservation.

The "molecular revolution" in systematic and conservation studies began in the 1960's when methods for examining the molecular structure of proteins and nucleic acids were adopted by evolutionary biologists. The past ten years have witnessed a quantum leap in the number and scope of applications of molecular methods to evolutionary genetics and systematics. Central to this increase is the development of new applications of the polymerase chain reaction, PCR, for investigating variation in DNA on a large scale.

In parallel with the biotechnological advances, improvements have been made in the statistical analysis of molecular variation spurred by the availability of large data sets on the molecular variation within and between species. Examples of such improvements are the development of coalescence theory, the analysis of phylogeography, and rigorous methods of inferring phylogenetic trees. The wide availability of increasingly powerful computers is key in many of these advances. These new analytical methods allow use of molecular approaches to test hypothesis in almost every evolutionary biology and ecology, from biogeography to behavior, physiology, development, and epidemiology.

The role of molecular genetic approaches in conservation biology has expanded dramatically in the last decade. These techniques have been used to measure genetic variation of dwindling populations, to understand the genetic structuring of populations of endangered species, and to define "genetic units" as targets of conservation of threatened species.

Considering the increasing number of potentially useful molecular tools to address questions in evolution, ecology, and conservation biology, it is imperative to provide students with formal training in these techniques. This training will enable students without a strong molecular background to make informed decisions on the best molecular tools to use for their questions and to acquire the necessary laboratory skills in which to use these techniques. While molecular methods offer important insights, it is also extremely important not to oversell them and to have a clear understanding of their merits and limits. The fact that sophisticated molecular techniques are available does not mean a recommendation based on molecular genetics is not correct, a wrong recommendation could contribute to the extinction of a species.

Considering the above issues, there is an urgent need for basic training in molecular laboratory techniques of students that want to take an integrative approach to systematics and conservation. Although there are excellent molecular laboratories at Yale in the Departments of Ecology and Evolutionary Biology (EEB), Molecular, Cellular and Developmental Biology (MCDB), and Molecular Biophysics and Biochemistry (MB&B), the research and teaching emphasis of these departments lie elsewhere. Thus, the ECOSAVE Conservation Genetics Laboratory represents efforts and a mission that are distinct and complementary to those of the above departments.

The ECOSAVE Conservation Genetics Laboratory will accomplish its research and teaching mission by offering undergraduate and graduate students training. The Center is a University-wide facility and is not limited to the faculty of Arts and Sciences, and it will be used as a resource by other units such as the School of Forestry and Environmental Studies and the School of Epidemiology and Public Health. The Center will sponsor an undergraduate level laboratory course for 10 to 20 students on "Molecular approaches to systematic, conservation genetics, and ecology.î

ECOSAVE will organize an advanced seminar for graduate students on the merits and limits of molecular techniques in systematics and conservation genetics. Graduate students will receive one-on-one training by having three to six months research stages in the laboratory (five to ten graduate students per semester). ECOSAVE will provide some preliminary support for graduate students who do not have access to a molecular lab to learn the techniques and produce sufficient preliminary data to obtain their own funding.

Ongoing projects will include studies on the systematics and conservation genetics of the giant Galapagos tortoises, paternity analyses of Madagascar lemurs, and extraction of DNA from bones of extinct dwarf elephants inhabiting Mediterranean islands. Biogeographical studies include salamanders and cave beetles inhabiting the Mediterranean region. One project involves studies on the major vector of malaria in the world, the mosquitoes belonging to the Anopheles gambiae complex in sub-saharan Africa.

ECOSAVE Faculty Research

Under the leadership of Yale paleontologist Elisabeth Vrba, ECOSAVE has entered into collaborations with scientists from the New York Zoological Society and the American Museum of Natural History (principally George Schaller, Director, Wildlife Conservation International, and also George Amato, New York Zoological Society, Rob DeSalle, American Museum of Natural History, John Gatesy, a former graduate student now doing postdoctoral research in Wisconsin). These collaborations currently include basic systematic, behavioral and field ecological studies of mammals that today are precariously surviving in various parts of the world including Tibet, Laos and Vietnam, and analysis of the evolutionary histories of the animals by study of their fossil records. The publications from this group over 1997-1998

include studies based on gene sequences, analyses of morphology and behaviour, and analyses of new fossil species within joint cladistic analyses of extinct and extant species (see publication list below).

Ethiopian project on new antelope fossils from Late Neogene strata, Middle Awash, and Hadar, Ethiopia: Elisabeth Vrba continues as a member of the Middle Awash Research Program (MARP), the members of which are conducting annual field trips to find new fossil sites in the eastern African Rift in Ethiopia and to excavate and study the stratigraphy and fossil contents of the most promising strata. The antelope fossils comprise some 70-80% of all the large mammal fossils found. Fortunately, a strong chronometric framework based on radiometric dates is being developed to set into context the hundreds of new hominid and other mammalian fossils from strata dating from Late Miocene to Late Pleistocene. Dr. Vrba's role includes basic description and analysis of the antelope fossils which include many new species and new genera, and to use these analyses to help in stratigraphic correlation, in preliminary assessments of which fossil assemblages should be excavated further, paleoecological analyses, and in establishing the context of hominid evolution in this stratigraphic succession (see publication list). Dr. Vrba plans to go to Ethiopia again during the summer of 1999.

Special interests continue to be how evolution occurs, tests of evolutionary hypotheses using phylogenetic and paleontological data, and how organisms grow and what growth processes have to do with macroevolution. The publication in the Journal of Theoretical Biology presents a new quantitative growth model, and its application to data on brain growth and evolution in living chimpanzees and humans.

Under the leadership of Professor Jeffrey Powell, Department of Ecology and Evolutionary Biology, two relevant projects have been ongoing. One concerns the conservation genetics and phylogenetics of Giant Galapagos Tortoises. To date we have collected over 1,700 blood samples from several subspecies of these tortoises. We are pursuing two levels of investigation. One is to determine the phylogenetic relationships of the subspecies as well as their relationship to other tortoises; the data are DNA sequences. We have identified the likely closest living relative of the Galapagos tortoises; it is the Chaco tortoise of mainland South America. It is not the largest mainland tortoise, but its ecology is much more similar to the islands than are other mainland tortoises. The second level of investigation is population genetics. For this we are developing microsatellites, a form of DNA fingerprinting. In addition to studying the population genetics of the subspecies, we are also using these tools to assist in a repatriation program of one subspecies that was nearly extinct. Finally, we have already determined that we can determine the island origin of tortoises based on DNA data. This will be useful in determining the origin of captive animals of unknown origin that then might be placed back into the wild if the subspecies is threatened.

A second project in our laboratory concerns an invasive plant, Phragmites, that has recently undergone a large range expansion in both freshwater and brackish wetlands. It is threatening native biodiversity. Why this species is suddenly spreading is not clear; one hypothesis is that a new genotype has colonized the US. Genetic studies of modern populations compared to herbarium specimens and old core samples will determine if there has been a genetic shift. The data we are collecting are a combination of DNA sequences, microsatellites, and karyotypes.

Publications:

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Vrba, E.S. 1997. Species' habitats in relation to climate, evolution, migration and conservation. In B. Huntley, W. Cramer, A.V. Morgan, H.C. Prentice and J.R.M. Allen (eds), Past and Future Rapid Environmental Changes: Spatial and Evolutionary Responses of Terrestrial Biota. NATO Advanced Research Workshop on the Science of Global Environmental Change, Crieff, Scotland, June 1995, pp. 275-286. NATO ASI Series 1, Vol. 47, Springer-Verlag, Heidelberg, Germany.

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Visitors:

William Harris, Executive Director of Biosphere 2, Tucson, Arizona
Richard Estes, currently in Arusha, Tanzania, specialist on African mammals and savanna ecology several vi

Andrew Sillen, University of Cape Town, South Africa, specialist on geochemical analyses of paleodiets

George Schaller, introduced above, several visits for research collaborations
Joao Munoz, student associate of ECOSAVE, graduate student at UCLA
Nelson (Bud) Talbott, Yale Institute for Biospheric Studies' External Advisory Board Member

Lawrence Mitchell, Addison-Wesley Publishers, for interviews with Elisabeth and a contribution from her to a Biology textbook.

Matthias von Gunten, Swiss Television, Zurich, Switzerland, making an educational film of the evolution of humans and other mammals in Africa

John Bermingham, Yale Institute for Biospheric Studies' External Advisory Board Member

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Honors and Awards:

Elisabeth Vrba was elected to the Smithsonian Council, Smithsonian Institution, Washington D.C.

Seminars, Conferences:

International conference held by Elisabeth Vrba and George Schaller with participants from Europe, Africa, Australia and America on Deer, Antelopes, Giraffes, and Relatives: Past, Present and Future. The conference was held at the Airlie Conference Center, Virginia, and was sponsored by the ECOSAVE Center, by the Division of Vertebrate Zoology of the Yale Peabody Museum

Center, by the Division of Vertebrate Zoology of the Yale Peabody Museum, and by Wildlife Conservation International, a division of the New York

Zoological Society. The following topics on ruminants were discussed: their fossil record, origins, evolution, diversification, systematics; palaeobiogeography including major migrations; past tectonic and palaeoclimatic changes associated with ruminant evolution; causes of major speciation and extinction episodes; ecology and behaviour in the past; systematics of living species based on gene sequences, hard and soft anatomy and behaviour; ecology, behavior and evolution; present biogeography; what the past and present information indicates for conservation : population conservation genetics; which taxonomic level and which taxa and ecosystems merit conservation priority; implications of greenhouse warming; management and role of zoos, national parks, etc.; sustainable use on game ranches and by local peoples; reintroductions. A book by the same title as the conference was edited by Vrba and Schaller during 1997-1998, and is now in press with Yale University Press.

Courses:

Fall 1997 G&G 250a "Paleontology and Evolutionary Theory
Spring 1998 G&G489b Advanced Topics in Evolutionary Theory

D. Center for the Study of Global Change
Karl K. Turekian, Director
Professor, Department of Geology and Geophysics

The Center for the Study of Global Changes offered a fall seminar series, "Topics in Global Change" from September through December 1997. In the place of the spring 1998 seminar series, candidates for a position in environmental fluid dynamics made presentations.

The Director of the Center for the Study of Global Change, Professor Karl K. Turekian, is a member of the Committee on Global Change Research of the National Research Council. He was recently asked to offer advice in structuring a program on Global Change, similar to the one at Yale, for Tulane University. Professor Turekian is also a member of MEDEA, a governmental organization to advise on classified matters and the environment.

Awards

Karl K. Turekian, the Benjamin Silliman Professor of Geology and Geophysics at Yale, was awarded the The Wollaston Medal, the major award of the Geological Society of London at Yale University.

The Geological Society of London was founded in 1807, and the medal has been awarded annually since 1831 "...to promote research concerning the mineral structure of the Earth..." This statement has a broad interpretation since one of the early recipients was Charles Darwin in 1859. In 1872, James

Dwight Dana, the first Benjamin Silliman Professor at Yale, was also a recipient of this medal, which is struck from palladium, an element discovered by Wollaston in 1802.

Professor Turekian's citation begins "In more than forty years of research, over 200 papers and six books, Karl Turekian has laid the foundations of a vast array of geochemical solutions to problems in the earth and ocean sciences." It concludes, "Karl Turekian, as one of the giants of modern earth and environmental sciences, you richly merit the major award of the Geological Society, the Wollaston Medal."

Seminar Series - Fall 1997

September 8, 1997
K. K. Turekian - Department of Geology and Geophysics, Yale University:
"Strontium and its isotopes-tools of global environmental change studies."

September 15, 1997
S. Krishnaswami - Physical Research Laboratory: *"Sr isotopes and silicate weathering in the Himalayas."*

September 22, 1997
E. Thomas ñ Department of Geology and Geophysics, Yale University and Wesleyan University: *"Productivity control of fine particle transport to equatorial Pacific sediments and its relation to climatic cycles."*

September 29, 1997
S. Hart ñ Woods Hole Oceanographic Institution: *"Sr/Ca and other trace element proxies of the changing ocean environment in corals."*

October 13, 1997
A. Sillen - University of Cape Town: *"Sr isotopes in modern and fossil foodwebs:*
Implications for early hominid habitat preference."

October 27, 1997
D. Shrag- Harvard University: *"The dynamics of strontium in seawater."*

November 3, 1997
F. Richter ñ University of Chicago: *"Three stories of strontium in sea water."*

November 10, 1997
L. Edwards ñ University of Minnesota: *"234U/230Th and 235U/231Pa dating of carbonate deposits and Quaternary climate change."*

November 17, 1997
R. Anderson - Lamont-Doherty Earth Observatory, Columbia University:
"Records of abrupt climate change in Southern Ocean sediments."

December 1, 1997
J. D. Blum ñ Dartmouth College: *"Links between soil weathering processes and the marine Sr isotope record"*

Seminar Series - Spring 1998

Yakov Afanasyev - *"Vortex Structures in the Environment and in the Laboratory"*

Judah Cohen - *"Snow Cover and Northern Hemisphere Climate Variability"*

David Hill - *"A Day in the Life of An Internal Wave"*

Wendell Welch - *"Heat Transport, Vavenumber Selection, and Baroclinic Equilibration in the Midaltitude Troposphere"*

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V. SPONSORED PROGRAMS AND SEMINARS

Dr. Prasad Thenkabail presented his work on Syrian agriculture at the First International Conference on Geospatial Information in Agriculture and Forestry in Lake Buena Vista, Florida.

Mr. Jeff Albert presented work on water resources and remote sensing at Tel Aviv University in Israel.

Global Change Symposium ñ Global Change, the Broad View, sponsored by the Yale Institute for Biospheric Studies and the Department of Geology and Geophysics in honor of Professor Karl Turekian's 70th birthday.

Climate Change Conference - Strategic Opportunities Post-Kyoto: Business and Global Climate Change, sponsored by the Yale Institute for Biospheric Studies, the Yale School of Forestry and Environmental Studies, the Environmental Protection Agency, and the Climate Institute of Washington, D.C.

Distinguished Guest Lecture Series - New Directions for Conservation Biology, presented by the Yale Student Chapter of the Society for Conservation Biology and sponsored by the Yale Institute for Biospheric Studies, the Yale School of Forestry and Environmental Studies, and the Society for Conservation Biology.

Conservation of Biological Diversity in Tibet - Dr. Reed Noss, Society for Conservation Biology.
Conservation Biology and Planning on a Regional Scale - Dr. Reed Noss, Society for Conservation Biology.

Beyond Platitudes: What Can Science Really Do for Conservation Biology? - Dr. Peter Karevia, University of Washington.

When Ecological Theory Bumps Against Public Policy and Politics - Dr. Joy Belsky, Oregon Natural Desert Association.

How Can Field Research Merge with Models to Illuminate the Effects of Forest Fragmentation? - Dr. Scott Mills, University of Montana.

The Future of Biodiversity in Madagascar - Dr. Pat Wright, Institute for the Conservation of Tropical Environments, State University of New York.

What is Environmental Studies? - Dr. Michael Soule, University of California at Santa Cruz.

Population Seminar Series, Fall 1997

The Size of Humanity - Jessie Ansubel, Director, Program for the Human Environment, Rockefeller University.

Population Policy Options in the Developing World - John Bongaarts, Vice President, Policy Research Division, and The Population Council.

Fresh Water in the 21st Century - Peter Cleick, Pacific Institute for Studies in Development, Environment, and Security.

Climate, Disease, and Security: Some Connections - Donald Kennedy, Co-Director, Institute for International Studies, Stanford University.

Human Fertility in Africa: The Mismatch Between Theory and Current Observations - Allan Hill, Department of Population and International Health, Harvard School of Public Health.

The Demographeris Perspective on the Next Century - John Cleland, Professor, London School of Hygiene and Tropical Medicine, University of London.

African-American Mortality - Samuel Preston, Director, Population Studies Center, University of Pennsylvania.

VI. COURSES

Introduction to Environmental Studies (F&ES 199a)

Senior Project and Colloquium (Studies in the Environment 496a)

Global Problems of Population Growth (Studies in the Environment 205b/Biology 205b)

Interdisciplinary Approaches to Managing Earth and its Resources (Studies in the Env 466b)

Plant Ecology w/laboratory (Organismal Biology 455b/456Lb)

Senior Project and Colloquium (Organismal Biology 491b)

World Populations and Environmental Issues (F&ES 504b)

Observing Earth From Space (OEFS) - G&G 362b/562b or F&ES 506b

Evolution, Ecology and Behavior II: Bio 242a

Intensive Research: Bio 595 - L. Buss

Community Ecology: FES 563b

Seminar on the Design of Bioreserves and Bioreserve Networks: FES - O. Schmitz

Landscape Ecology: FES - D. Skelly

VII. MEMBERS OF THE FACULTY COUNCIL

Elisabeth S. Vrba - Director, Yale Institute for Biospheric Studies
Director, Center for Ecology and Systematics of Animals on the Verge of Extinction (ECOSAVE); Professor, Department of Geology and Geophysics

D. Allan Bromley - Dean of Engineering

Richard L. Burger - Director, Peabody Museum of Natural History

Mary Helen Goldsmith - Chair, Studies in the Environment; Professor, Department of Molecular, Cellular and Developmental Biology; Director, Marsh Botanical Gardens

John C. Gordon - Acting Dean, Yale School of Forestry and Environmental Studies

Pierre C. Hohenberg - Deputy Provost, Science and Technology

Douglas R. Kankel - Chair, Department of Molecular, Cellular, and Developmental Biology

Michael H. Merson - Chair, Epidemiology and Public Health

Jeffrey R. Powell - Chair, Program in Organismal Biology; Professor and Director of Undergraduate Studies, Department of Ecology and Evolutionary Biology

Gustav Ranis - Director, Center for International and Area Studies

Ronald Smith - Director, Center for Earth Observation; Professor, Department of Geology and Geophysics

Karl K. Turekian - Director, Center for Global Change; Professor, Department

of Geology and Geophysics

J. Rimas Vaisnys - Professor, Electrical Engineering

Günter P. Wagner - Director, Center for Computational Ecology; Chair, Department of Ecology and Evolutionary Biology

Robert J. Wyman - Department of Molecular, Cellular, and Developmental Biology

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VIII. MEMBERS OF THE EXTERNAL ADVISORY BOARD

Chair: Edward P. Bass -Fort Worth, Texas

Edward A. Adelberg - New Haven, Connecticut

Frances Beinecke - New York, New York

Coleman P. Burke - New York, New York

John R. Bermingham - Denver, Colorado

William J. Cronon - Madison, Wisconsin

Duane Dickson - Chicago, Illinois

Strachan Donnelley - Garrison, New York

Michael J. Donoghue - Cambridge, Massachusetts

W. Daniel Hillis - Glendale, California

Donald Hudson - Boston, Massachusetts

Thomas E. Lovejoy - Washington, D.C.

George G. Montgomery, Jr. - San Francisco, California

Michael J. Novacek - New York, New York

Nicholas Pappas - Wilmington, Delaware

William K. Reilly - Washington, D. C.

Ralph C. Schmidt - New York, New York

Nelson S. Talbott - Cleveland, Ohio

Joseph H. Williams - Tulsa, Oklahoma

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1997 - 1998 G. EVELYN HUTCHINSON PRIZE GRADUATE STUDENT ABSTRACTS

Index

Regulatory Self Maintenance in Metabolic Pathways and Evolutionary Strategies for Forming Physiological Adaptations

Homayoun Bagheri
Department of Ecology and Evolutionary Biology

In previous stages of my research it had been concluded that in order to address the evolution of metabolic pathways, a model is required which includes a causal understanding of enzyme kinetics at the single enzyme level. Subsequently this understanding has to be incorporated into a multi-enzyme pathway. I have successfully implemented the afore mentioned steps and have developed a model which captures metabolic pathways at the physiological level. In doing so I have also encountered and addressed several serious problems associated with metabolic control theory that relates to both physiology and evolution. Metabolic control theory has been used in its present format since 1973. Addressing these problems has opened the possibility for me to address metabolic evolution at a much deeper level than has been possible so far.

The above mentioned model of metabolic physiology has to be now introduced into an evolutionary context so that we may study different physiological architectures in terms of three evolutionary properties: I) physiological performance (fitness), ii) adaptability (fitness in different environments) and iii) evolvability (mutational properties of particular architectures). Physiological architecture refers to differences in terms of a) pathway structure, b) kinetic properties of the enzymes

and c) regulatory relations within the pathway.

Genetic and Molecular Characterization of Hydractinia Symbiolongicarpus Allorecognition Locus

Luis F. Cadavid
Department of Ecology and Evolutionary Biology

Colonial invertebrates typically discern between self-tissues and those from unrelated individuals of the same species. These allorecognition phenomena have played a significant role in several biological questions such as the origin and maintenance of genetic variation, the problem of units of selection in evolutionary theory, and the evolution of the vertebrate immune system. Despite the ubiquity of invertebrate allorecognition events and its prominence in biological thought, the responsible molecules and the encoding genes remain unknown.

Hydractinia symbiolongicarpus (Cnidaria: Hydrozoa) displays an unequivocal allorecognition response involving either fusion or rejection of conspecific tissues. The latter outcome involves an effector response characterized by site-specific differentiation, transport, and triggering of nematocysts, the stinging organelles. The allorecognition response in H. symbiolongicarpus segregates as a single co-dominant Mendelian trait. Colonies sharing one or both alleles fuse and those lacking shared alleles reject.

This study proposes a genetic and molecular characterization of the allorecognition locus (arl) in Hydractinia symbiolongicarpus, employing chromosome landing strategies. The approach involves the use of Amplified Fragment Length Polymorphisms (AFLPs) to generate large numbers of markers linked to arl. We are using near-isogeneic lines, previously established in our laboratory, to generate offspring pools of homozygotes for arl; AFLP markers that are linked to the locus of interest are identified by presence in one pool and absence in the other. Using the correct number of offspring in each pool, we will identify markers lying in a 1 cM arl-spanning interval. After a high-resolution mapping of the AFLP markers using a large F2 mapping population, the markers most tightly linked flanking arl will be detected. These markers, in turn, will serve to screen a BAC library, generating thus a small collection of contiguous positive BAC clones. The arl-containing clones will be used as probes to screen a ectodermal-enriched cDNA library and candidate genes showing appropriate expression patterns and polymorphic domains that co-segregate with fusibility, will be selected for further functional analysis.

At this point, we have generated the homozygous pools and are actively searching for co-segregating markers.

Algebraic and Probabilistic Properties of a Model of Random Unequal Crossing Over

Maxim Shpak
Department of Ecology and Evolutionary Biology

In collaboration with Gunter P. Wagner and Kevin Atteson, I have investigated the algebraic and probabilistic properties of a model of random unequal crossing over. The research was motivated by the idea of gene duplication by unequal recombination being a source of evolutionary innovation, i.e. a process which generates new dimensions of evolutionary space rather than simply changing frequencies within fixed state spaces. The evolutionary implications of this model, along with a formal algebraic treatment of the structure of the configuration spaces induced by unequal crossover are treated in a paper in preparation with G. P. Wagner, while the treatment of the special type of reversible stochastic process representing this recombination scheme is to appear in a work in progress with Kevin Atteson. I hope to include some of this material in my doctoral thesis, in which I hope to treat the question of how symmetric recombination and hence well defined "alleles" and "loci" evolved from more primitive and less controlled genetic systems.

I spent the summer of 1998 collaborating with N. H. Barton at the University of Edinburgh on several problems in theoretical quantitative genetics. Principally, we investigated two problems: the accuracy of linkage-equilibrium models of cline shape represented by diffusion approximations, and the stability of concordant solutions to multilocus clines (i.e. solutions to selection/migration regimes which give equal allele frequencies across all loci).

Hutchinson Award Abstract

Michel Slotman
Department of Ecology and Evolutionary Biology

The Anopheles gambiae complex consists of six closely related species that were only fairly recently found out as being distinct species. Several of these, especially A. gambiae and A. arabiensis, are among the most important vectors of malaria in Africa, where about 90% of the world's yearly 200 to 300 million cases of malaria occur. In trying to resolve the phylogenetic relationships among these taxa using mitochondrial, as well as different nuclear genes, several incongruencies have been observed. The most parsimonious explanation for the current data is that introgression of nuclear DNA is occurring between A. arabiensis and A. gambiae.

In order to investigate to what extent different regions of the genome can actually introgress between these two species, we are analyzing the genetic structure of backcrosses between A. gambiae and A. arabiensis. At this point a collaborator in Rome provides these crosses. These crosses were (or will be) made according to the following scheme: A. arabiensis is crossed with A. gambiae, which yields the F1 generation. F1 males are sterile, whereas the females are fertile. The F1 females are backcrossed with both A. gambiae and A. arabiensis males. This results in the F2 generation. The F2 generation is then analyzed with respect to fertility by dissection of the reproductive organs.

This F2 generation is subsequently analyzed genetically, i.e. we are using microsatellite markers to analyze the genetic make-up of these specimens. L. Zheng has published about 130 microsatellite loci, mapped on the A. gambiae genome. We are using a large number of these loci to distinguish which parental strain a particular portion of the genome comes from. This should not only provide us with information as to what extent introgression is actually possible, but also if introgression of some chromosomal regions is easier than others and if introgression can go in both directions. However, it will also shed some light on some of the underlying genetic processes of speciation in these mosquitoes. That is, it will allow us to say something about the number as well as the location of genes that are involved in causing sterility.

An Assessment of the Accuracy of the Wildlife Habitat Relations Model for Amphibian Species in California Using Methods of Species Distributions from Field Data

Karen H. Beard
School of Forestry and Environmental Studies

The California Department of Fish and Game created Wildlife Habitat Relation (WHR) models to predict areas of suitable habitat for 630 species in California based on known habitat requirements for the species. These models are created with the intention of pinpointing areas of high conservation concern. The habitat requirements for the species taken into consideration include: vegetation cover type, feeding requirements and reproductive need. It is often difficult to assess the accuracy of these models based on limited databases available for many wildlife species and therefore the resultant models are rarely tested with actual field data. Amphibian species, in particular, have been difficult to model using WHR models because of their preferences for microhabitat parameters, the resolution of which are often not included in the models, and because of the common fluctuating nature of population occurrences. Finally, unlike for the avian and mammalian community, there does not exist a statewide compilation of amphibian survey data which makes the overall testing of the predict power of these models nearly impossible.

I propose to compile, using available survey data, the best possible map of amphibian distributions in California. Using the compiled sitting database, I propose to first develop logistic regression models using the available environmental and biological parameters to determine which factors best predict species presence and absence. These parameters will be from readily accessible databases and could include: the presence and absence of other species, topography, soil type, elevation, vegetation cover type from the national GAP Analysis program, potential evapotranspiration, insolation, air and water temperature, precipitation, pond permanence level, and land-use type. By using a regression tree analysis to analyze the logistic regression models, I will pinpoint the available parameters that best predict potential habitat for each species.

I will then assess the accuracy of the WHR models by determining how well the model predicts the field data. I will determine the accuracy by calculating the number of presence's predicted as presence's, the number of absences predicted as absences, the number of commission errors and the number of omission errors. I will also determine the probabilities and confidence intervals of observing the species areas described by the WHR parameters. I will assess the predictive power of the models by assessing the performance of the models while varying proportions of the

data set are deleted to fit the model and then the model is used to predict species presence and absence in the proportion deleted. This type of assessment will provide me with an assessment of how well the model will work in areas where data was not collected. I will then use other parameters with high predictive power to assess the accuracy of using these parameters to predict species presence. I will determine through this process what parameters and models should be used to discern areas of high conservation concern and with what accuracy levels these models should be expected to predict. The purpose of this study is to determine areas of potential habitat and for future protection of all amphibian species in California.

Cultivating Connections in Childhood: An Evaluation of Experience, Attachment, and Environmental Values

Victoria L. Derr
School of Forestry and Environmental Studies

If we are to educate future generations to care about the environment, and to work to protect and preserve it, we also need to determine effective ways to cultivate caring connections between children and their environments. These connections are necessary, not only to promote healthy ecosystems and environments, but also to promote future generations of healthy children and adults who obtain the diversity of benefits that can come from a positive relationship with the environment.

My research will contribute to an understanding of the relationship between children's experiences and their environmental knowledge and values. In particular, it will evaluate the ways that direct and narrative experiences contribute to a child's development of these values in a contemporary context. For example, how are changes in society and technology affecting children's connections to the physical landscape and the biota that reside within it? What does this mean in terms of their human development and identity and their values and knowledge?

This research will build on previous work by Nabhan and St. Antoine (1993), who found that as direct and story-telling experiences with the environment diminish, so too does knowledge about the flora and fauna contained in that environment. Through a combination of semi-structured interviews, narrative analysis, surveys, and ethnographic methods, the proposed research will evaluate children's experience, values, and knowledge of places within communities of southern Arizona. Comparisons will be made between children of middle childhood (ages 6-11) and early adolescence (ages 12-13). It will focus on the types of experiences that children have with places, the cultural knowledge and values that relate to these places, and how these factors contribute to children's development of personal identity and connection to their local environment.

It is hoped that a better understanding of these questions will assist in the development of education that can meet children's needs and cultivate positive and lasting connections to the environment.

Tropical Tree Distribution Patterns as Scales Relevant to Silviculture and Ecosystem Management

Bronson Griscom
School of Forestry and Environmental Studies

The science of ecology becomes applied when the burning theoretical questions of the field are brought to species and spatial scales relevant to the management of ecosystems. The research proposed here addresses a central question in tropical ecology: what (if any) structure exists in the distribution patterns of trees within moist tropical plant communities? The innovation of this research lies in addressing this question at the two spatial scales most relevant to silviculture and ecosystem management: the cohort and the forest type. In doing so, this research is intended to provide information about the distribution of useful plants to local families and clarify the critical scales of analysis for management of tropical moist forests of the region. Research will be conducted in the western Amazonian state of Acre, Brazil where the social and biological context is particularly appropriate for these questions.

Role of Materials Accounting in Achieving Resource Efficiency: Resolution of Toxic Release Inventory Phase-3 Expansion Debate

Sushila Kanoida
School of Forestry and Environmental Studies

The EPA Office of Pollution Prevention and Toxics (OPPT) recently announced an advance notice of the proposed rule related to the possible addition of chemical "use" data to the existing information collection requirement under the Toxic Release Inventory. The expansion initiative is widely known as "TRI-Phase 3: Use Expansion" (TRI-P3). The purpose of the proposed research is to evaluate the wisdom and effectiveness of the chemical use data elements to be added under the TRI reporting requirements.

The Toxic Release Inventory (TRI) is the centerpiece of Emergency Planning and Community Right-to-Know Act (EPCRA). The TRI is the most comprehensive and publicly reported database in the United States of hazardous emissions and discharges to the environment of some 340 chemicals and chemical categories. Under TRI policy, manufacturing facilities covered under standard industrial classification (SIC) code 20 through 39, are required to report estimated annual release of chemicals into air, water land undend, and waste transfer information to the EPA and State Environmental Agencies. Easy access to TRI information is perceived to promote and empower initiatives at all levels from facility teams, to local environmental groups, to trade associations, to state and federal agencies.

The conventional US command and control regulations for toxic chemicals changed with the implementation of the TRI policy. The national experience with TRI has led to increased appreciation of information dissemination. OPPT is interested in the appropriate expansion of informational tools to further promote pollution prevention activities nationwide. In many respects, the TRI-P3 issue is linked to the nature and type of information most useful for sustaining pollution prevention efforts. EPA proposes to seek CUI information through materials accounting data.

A current topic of national interest, especially in the environmental community, is the wisdom and effectiveness of materials accounting reporting and its public dissemination through the expanded TRI database for reducing the toxic chemical use for tracking the toxic chemical flow through facilities and communities. Also questioning is the measuring of the progress of pollution prevention. These topics are both questioned by various stakeholders.

The proposed research will examine and assess the role of materials accounting as an initiator of paradigm shift from pollution control to pollution prevention at the source, in achieving material resource efficiency, and as a measure of pollution prevention at the source. These will be accomplished by analyzing and evaluating the available databases requiring materials accounting information under the pollution prevention legislation in the states of New Jersey and Massachusetts.

The study will clarify how materials accounting information, when publicly disseminated, may empower industries as well as public and regulatory agencies to work together towards developing a policy for safe and effective chemical management to attain sustainability in resource use.

Reproductive Performance of Jamaica's Amazona Parrots Along A Habitat Gradient: Identifying Minimal and Optimal Nesting Conditions To Ensure Reproductive Success

Susan E. Koenig
School of Forestry and Environmental Studies

Low annual reproductive performance in medium and larger psittacines is often attributed to poor quality of food resources and/or poor availability of suitable nesting cavities. Yet, this trait is inherent in the taxon and is observed in species that vary considerably in foraging ecology and specialization to nest cavity characteristics. The relative importance of these two classes of resources as they relate to nestling growth and fledging success has not been quantified for any species of parrot under natural conditions. Without an understanding of the relationship between resource and habitat quality and inherent traits of parrots, it is difficult to identify minimal critical habitat, and, in particular, critical nesting substrates.

Jamaica is unique among the islands of the Greater Antilles in that it hosts two endemic species of Amazona parrot: the Black-billed Parrot (Amazona agills) and the Yellow-billed Parrot (Amazona collaria). Although unique, neither has been the subject of a systematic biological research program and hence little is known of basic ecology or factors limiting the populations. What is known is that Jamaica currently has one of the highest rates of deforestation in the world (World Resources Institute, 1994), and the largest tract of remaining primary forest is still under threat from exploitation of timber products and bauxite mining. This habitat also represents the only stronghold where Jamaica's two Amazona parrots occur sympatrically on the Island.

Parrots are secondary cavity nesters and are thus dependent upon suitably large trees to ensure reproduction. Deforestation removes nesting substrates, food resources,

and shelter from adverse weather. Degradation can alter the quality of habitat by altering availability of native food resources, altering thermal properties of the environment, or facilitating the expansion or reduction of species that occur in balance in undisturbed habitats. Few studies exist of wild parrot populations that examine the effects of differing cavity qualities on reproductive success. Even fewer incorporate an assessment of diet quality. Without an understanding of the effects of resource quality on reproductive performance, it is difficult to determine to what extent parrots can tolerate anthropogenic disturbance. The research proposed here is designed to quantify the quality of nesting cavities and diet of nestlings to better understand what factors may affect reproductive performance in the medium-sized parrots of Jamaica. Once identified, this will enable Jamaica's resource managers to better identify and protect critical parrot habitat.

Property Rights and Forest Protection in National Parks in Vietnam: Understanding Local and National Claims to Land and Trees

Pam McElwee
School of Forestry and Environmental Studies

Conservation groups as the key to their protection have often promoted establishing secure tenure to forested lands, particularly in the tropics. But still little is known about how tenure rights affect forest stand dynamics, and how property rights change and come into conflict around protected areas and parks. For my dissertation, I will be exploring the effects of varying property rights regimes on the conservation and management of protected forests and surrounding areas in upland north Vietnam. This study will look at use rights and property conflicts over one genus of economically valuable trees, Cinnamomum spp., from which cinnamon powder is derived, on lands ranging between state, common, and on private property. I will use an interdisciplinary approach combining local fieldwork on cultural, social and historical rights to forests with ecological surveys of cinnamon stands in order to formulate ideas about competing meanings of property and resource allocation and the effect of these social processes on the health of populations of cinnamon in Vietnam.

This case study has implications far beyond Vietnam's borders as well. Vietnam is a particularly appropriate place for an exploration of the effectiveness of different property designations for parks and forest protection, as Vietnam has a long and unusual history of changing property rights, from pre-colonial days to the present de-collectivizing Vietnamese state. Furthermore, Vietnam is a highly centralized government with significant state influence even in smaller, more isolated villages through local communist party committees and other state-planned projects. However, if local people in Vietnam, as accustomed to this state influence as they are, continue to contest the rule of the state in managing resources, as preliminary accounts suggest they do, what are the implications of this for national park management in countries with less monolithic states? Understanding these local struggles over coercive state managed parks is essential to answering this question for other areas of the world, which may hopefully shed light on better ways to protect the diversity and health of tropical forests.

Effects of Different Forest Types on Total Ecosystem Carbon Sequestration in Iceland

Ragnhildur Siguroardottir
School of Forestry and Environmental Studies

Today, people throughout the world are concerned about the increasing atmospheric concentration of various gasses, which could result in an increase of the mean temperature on earth, accompanied by climatic change and disrupt ecological conditions. Carbon dioxide is the most common of these anthropogenic gases, and the danger of global warming effect is to a considerable extent attributed to the substantial and steady increase of anthropogenic emissions of carbon dioxide. This has driven an interest in studying how ecosystems accumulate carbon and what controls C efflux from different ecosystems in an attempt to put human generation of CO2 in perspective, and to attempt to manage C budgets.

In this study I propose that mixed stands of spruce and birch, and stands of Larix sp. (deciduous conifer), when compared to stands dominated either of deciduous broad-leaved species or evergreen conifers, are able to increase the carbon sequestration of the ecosystem by increasing the cycling of nutrients that contribute to the formation of humus in the soil.

My research will be conducted in Iceland, which is the second largest island in Europe, 103,000 km2 in area, and lies in the North Atlantic with the most northerly

extremes bounding on the Arctic Circle. Located at the junction of warm and cold ocean and atmospheric currents, the biosphere is extremely sensitive to any changes in the global meteorological and oceanographic systems. This, in addition to the volcanic properties of Iceland's soils and the fact that Icelandic ecosystems have been severely degraded throughout the 1100 years of human settlement, make the country an ideal setting for studying carbon accumulation and carbon dynamics in maritime boreal/subarctic. My hypotheses will be tested by developing complete carbon and nutrient budgets for 4 different vegetative community types at Hallormssta_ur Forest in eastern Iceland. This area is where monocultural plantations of exotic tree species in the native birch forests provide an understory and overstory species and species compositions on carbon accumulations, nutrient cycling, and tree growth under rigorous climatic conditions.

Traditionally, soil carbon has been considered to be a stable resource, or changing very slowly through time. Once lost through erosion or other forms of ecosystem degradation, the common perception has been that it is almost an unrenewable resource, especially in northern systems like those in Iceland. Recent research however has shown that this is not necessarily the case. Various plant species, or plant types, seem to have different inherent characteristics in affecting carbon sequestration in the soil (Vogt et al 1995).

An understanding on how carbon accumulation may be manipulated by selecting for certain conditions and strong abiotic constraints limit plant growth. By increasing carbon accumulation in the soil, and the diversity of carbon compounds in the soil, these systems may be enhanced above the current threshold levels for plant growth and provide an important level of resistance to soils that are extremely prone to erosion (Arnolds 1990).

Evolving Complexity In An In Vitro Ribozyme System

Martin Hansczyc
Department of Genetics

Using an in vitro mimic of the Darwinian process, a population of molecules can be mutated, amplified and selected for multiple generations, giving rise to a descended population of evolved molecules with enhanced, selected activity. While selecting the group I ribozyme (an RNA enzyme) from Tetrahymena thermophila for improved DNA cleavage activity, I observe an unexpected bifurcation resulting in active ribozymes that effect DNA cleavage and inactive ribozyme variants that act as trans substrates for the active ribozymes in the population. This intermolecular interaction ensures the propagation of both the active and inactive molecular species in the population. I show the specific nucleotide changes that have evolved to promote this intermolecular reaction and explore the mechanism of the interaction revealing the source of the nucleophile and the electrophile.

Kinetic analyses suggest that these inactive ribozymes are not parasites since there is no detrimental effect of the inactive variants on the action of the evolving ribozymes. I conclude from these studies that complex molecular roles have evolved in a few generations in a system that was initially designed to produce a singular, selected outcome.

Patterns of Postnatal Ossification in Squamates:
Their Phylogenetic Informativeness and Relationship to Life History Characters

Jessica A. Maisano
Department of Geology and Geophysics

This is the first systematic survey of postnatal ossification patterns throughout any major vertebrate group, and the first to attempt to discern the relationship between these patterns and life history characters. The group of interest is the Squamata, the clade comprised of lizards (including snakes). This project focuses on the development of the skeleton from birth or hatching to maximum size, and the relationship of that development to life history characters such as growth rate and sexual maturity. This approach will help to elucidate the degree of complexity of developmental processes and thus the number of discrete developmental units upon which evolution can act. It will also reveal the amount of phylogenetic information contained in these patterns, at least for the squamate clade. Finally, the documentation of the timing and sequence of these ossification events will greatly aid in the interpretation of the fossil record in terms of the biological age of individual specimens. This should help alleviate the general problem of taxonomic oversplitting due to the naming of different stages of the same ontogeny as different species. That, in turn, will provide a more accurate picture of vertebrate diversity through time, so that its relationship to changing environmental factors can be

better ascertained.

This project includes 27 species representing 12 major squamate clades. Its basic framework consists of the detailed description of postnatal skeletal ossification in each of these species. From these descriptions will follow the comparative component. First, the ossification patterns will be coded as characters and mapped onto a phylogenetic hypothesis independently derived from morphological and molecular data. The degree of congruence between the ossification character set and the other character sets will indicate the quality of phylogenetic information in the ossification data. This component of the project has the potential not only to improve hypotheses of squamate relationships, but also to provide all systematists working on vertebrates with an additional line of evidence: ossification sequences.

The second set of comparisons will consider ossification patterns in light of life history characters such as size at birth, size at sexual maturity, maximum size, growth rate, and age at sexual maturity. A wide variety of questions will be addressed, including the following: Do ossification patterns support the theory that the skeleton, from an evolutionary standpoint, is compartmentalized into major integrated regions? How closely do patterns of ossification recapitulate patterns of morphogenesis? What fusions, if any, are consistently reliable indicators of sexual maturity? Are terminal fusions really terminal, that is, do they truly mark the cessation of further significant growth? What is the relationship between ossification rate and growth rate?

In lizards, because they are ectotherms, changes in life history strategies are logically attributable to changes in climate. For example, climatic cooling is considered causal to a longer retention of eggs by the female, which is generally considered to be how viviparity evolves. The shift from oviparity to viviparity has occurred many times in squamate history, yet we currently have no concept of how this affects ossification patterns and, by extension, morphology. This project will provide an important first step toward understanding this link between climate, life history strategy, and morphology.

In summary, the postnatal ossification of the skeleton is an area ripe for inquiry. Not only is it relatively untouched territory, but it also holds much potential for elucidating answers to the some of the most pressing questions in paleobiology today, namely, how does the vertebrate skeleton evolve, and how is this evolution related to environmental changes in the earth's history? Squamates are an ideal group for the first systematic investigation of these patterns because they have a rich fossil history, a large number of extant representatives, and their phylogenetic relationships are reasonably well established. It is expected that this study will prove rewarding enough to spur similar investigations in other vertebrate groups.

Comparative Analysis of Developmental Anatomy and Growth Patterns inEmbryonic Paleognathes; With Comparisons to Embryonic Neognathes,Archosaurs and Non-Avian Theropods

Cynthia Marshall
Department of Geology & Geophysics

The question of ratite affinities is of classic and enduring interest, but little is known about their growth. Comparative patterns of ratite growth and development are poorly documented. The purpose of this study is to describe and quantify general skeletal growth patterns within ratites focusing on the comparative developmental anatomy of the embryonic skeleton. Using established vertebrate clearing and staining techniques, a pre-hatching, skeletal developmental series is being analyzed. The growth and shape information will be of interest to those studying comparative evolutionary patterns and processes such as heterochrony, as well as those investigating development and growth in either modern or extinct taxa. This information can subsequently be applied to larger questions such as those involving exploration of how these growth patterns may possibly correlate to the ecological adaptive strategies of these birds, or of evolution as it relates to heterochrony, biogeography, and continental movements.