1. Participants

O.J. Reichman, Director PI

Sandy J. Andelman, Deputy Director Co-PI

Mark Schildhauer, Director of Computing

Partner Organizations

Matching funds have been provided by the University of California ($500,000) and by the University of California, Santa Barbara.

The Andrew W. Mellon Foundation has provided funding to support three postdoctoral researchers: Sarah Gergel, Helene Muller-Landau and Diego Vazquez. Their research activities are described in the following section. In addition, the Mellon Foundation has made awards to NCEAS totaling approximately $1,150,000 to support informatics research at NCEAS.

The David and Lucille Packard Foundation has provided funding to conduct a distributed graduate seminar focused on a critical review of ecosystem-based management (EBM) efforts relevant to coastal-marine ecosystems and to design a longer-term program of activities to develop the scientific foundations for EBM in coastal marine systems.

Vulcan, Inc. has provided $350,000 to support working groups and to initiate planning for a UCSB Center focused on scientific solutions to important environmental problems.

Other Collaborators

Ben Halpern and Christopher Pyke are postdoctoral fellows at NCEAS, supported by David Hamilton Smith Fellowships from The Nature Conservancy.

To facilitate informatics research and to support the informatics needs of the ecological community, NCEAS has formed a research partnership with three other organizations: San Diego Super Computer Center, University of Kansas and University of New Mexico (LTER Network Office).

2. Activities and Findings

Science Advisory Board

For our August, 2003 deadline, we received 43 proposals for 45 activities: 15 postdoctoral fellowships; 5 sabbatical fellowships; and 25 working groups. We have made decisions to support 3 postdoctoral fellowships; 3 Center Fellows (sabbaticals); and
9 working groups. The Science Advisory Board met September 10-11, 2003, to review these proposals and based on their recommendations, decisions to support 3 postdoctoral fellowships; 3 Center Fellows (sabbaticals); and 9 working groups.

For our January, 2004 deadline, we received 46 proposals for 48 activities: 21 postdoctoral fellowships; 4 sabbatical fellowships; and 25 working groups. The Science Advisory Board met March 3-4, 2004, to review these proposals and based on their recommendations, decisions were made to support 3 postdoctoral fellowships; 2 Center Fellows (sabbaticals); and 5 working groups. A list of Science Advisory Board members is available on the NCEAS web site: www.nceas.ucsb.edu.

**Major Research Activities**

During the reporting period, May 1, 2003 through April 30, 2004, NCEAS supported 12 sabbatical visitors and 23 postdoctoral researchers. Of these, 3 postdoctoral researchers were supported with funding from the Andrew W. Mellon Foundation, three postdocs were supported with funds from NSF’s Knowledge and Distributed Intelligence Program for the Knowledge Network for Biocomplexity, two postdocs were funded by fellowships from the David Hamilton Smith Fellowship Program of The Nature Conservancy and one was funded by the Norwegian National Research Council. A list of sabbatical and postdoctoral researchers, including descriptions of their projects is provided below. During the past year, NCEAS postdoctoral scientists have accepted faculty positions at East Carolina University, Oregon State University (2), University of British Columbia (2), University of Minnesota, University of Wisconsin, Yale University, and Washington University. One postdoc was offered a AAAS Science and Environment Fellowship, one accepted a research position at the Smithsonian Tropical Research Institute in Panama, one was offered a position as a scientist with World Wildlife Fund, and one was offered a research position with CONICET, the Argentine National Science Council.

During the reporting period, 661 different scientists participated in activities at NCEAS (858 total visits). NCEAS supported 59 working group meetings, representing the activities of 43 different working groups, and 7 meetings. Thirteen of these working groups focus on issues of immediate relevance to resource managers and policy makers, and these are highlighted in a separate section below.

**Sabbatical Fellows**

Mark Burgman  
07/01/2002-06/30/2003  
**Sabbatical Fellow**

Setting priorities and making decisions for conservation risk management

Risk-based decisions are made routinely in medicine, toxicology, engineering, psychology, insurance and finance. The development of methods in these fields has been rapid but the paths followed and the tools developed have been different. To some extent the differences reflect the kinds of data and the range of problems people need to solve. In part, the differences are because methods have grown in relative isolation. A common problem facing practitioners in conservation biology is to identify priorities that
discriminate among a suite of alternative actions. Biologists make decisions on a routine basis, but with little understanding of the techniques for decisions involving risk. The kinds of questions conservation biologists are obliged to answer will benefit substantially from advances in decision analysis and risk assessment made in other disciplines. This project will develop and expand the toolkit for problem solving available to conservation biologists by reviewing risk-based, priority setting methods in different fields, and bringing together people from different disciplines to examine the problems confronting conservation biologists, resulting in new approaches to finding solutions to priority setting and decision making problems.

Cliff Cunningham    Sabbatical Fellow
09/01/2002-06/30/2003

The North Atlantic Project: Comparative ecology of the temperate Northwestern and Northeastern Atlantic benthic communities
Although it is one of the best-studied oceans in the world, many aspects of temperate North Atlantic marine community ecology await synthesis and research coordination. During a fellowship year at NCEAS I will work to: (1) Synthesize available information on the distribution and abundance of closely related populations that exist on both sides of the temperate North Atlantic (trans-Atlantic species). This will include compiling a list of temperate trans-Atlantic species, along with all available information on their life history. (2) Synthesize available information comparing the ecology and relative species abundance of the temperate NW and NE Atlantic nearshore communities. (3) Encourage American and European field ecologists to design and carry out coordinated experiments on both coasts of the temperate North Atlantic.

Larry Crowder    Sabbatical Fellow
01/01/2004-06/30/2004

Marine conservation: Integrating science and policy
Marine conservation requires not only an understanding of the biological, physical, and ecological science, but it also requires a mature understanding of the socio-political process. Poor science can doom the implementation of wise marine conservation practices, but naiveté among scientists regarding the policymaking process also can slow the application of good science. I propose two major goals for my time as a Center Fellow on sabbatical at NCEAS during 2003-2004. First, I will write a book tentatively titled, Marine Conservation: Integrating Science and Policy. This book will follow on the heels of another book on Marine Conservation Biology: The Science of Sustaining the Seas, Island Press, 2003, which I am co-editing with Elliott Norse of MCBI. The new book will be co-authored by Mike Orbach and derives from the Conservation Biology and Policy Course we have taught at the Duke University Marine Laboratory since 1997. Second, I plan to learn more about the science/policy integration process by working with an interdisciplinary group of people who deal with marine conservation from disciplines other than my own including anthropologists, economists, lawyers, journalists, marketing people, governance experts, fishermen, and environmentalists. The current working group on Marine Management (Francis and Kitchell), of which I am a member, is holding its first meeting with people from this broader interdisciplinary group in December 2002. One lesson from previous NCEAS syntheses, like the one on Marine Reserves (Lubchenco
et al.), is that even after the science is synthesized, there is much new interdisciplinary work required to implement a marine reserve. The current working group on Practical Design of Marine Reserves (Hastings and Botsford) is addressing these issues relative to marine reserves. The purpose of my sabbatical will be to provide a roadmap for ecologists orienteering through the policy landscape.

Kay Gross
Sabbatical Fellow
11/01/2002-06/30/2003
**Developing a predictive framework for the maintenance and restoration of native plant diversity in grasslands**
As a sabbatical fellow at NCEAS I plan to work on the synthesis and integration of data from several field projects in which I have been examining the factors that influence the composition and diversity of plant species in grassland-savanna communities in SW Michigan. My goal is to determine how spatial patterns of heterogeneity in resources and species pools influence these patterns and how to translate these results into an understanding of determinants of species diversity across communities and environmental gradients.

Michael Hochberg
Sabbatical Fellow
07/01/2003-08/31/2003
**Patterns in social behavior and cultural diversity**
The 'tragedy of the commons' describes how individualism can result in hardship to a population as a whole. In an alternative scenario --'collective action'-- potential competitors are better-off cooperating for a common good, even if it is not obviously in their short-term individual interests. What can shift a tragedy of the commons scenario to one of collective action in human societies? Given complex social environments influenced by governments and media, migrations of peoples over different scales, and interactions among individuals who may be family, friends or perfect strangers, how can we ever hope to understand cooperation and attempt to nurture the factors promoting it? Despite a blossoming interest in theories of human cooperation, surprisingly, there has been no serious assessment of whether human societies should show characteristic patterns in social behavior and cultural diversity. I plan to spend a sabbatical year (June 2003-4) addressing this question, capitalizing on the fact that community ecology provides us with the necessary tools. Concretely, my project shall provide: 1) new models of human social change and 2) predictive equations and graphs of social behavior and cultural diversity. I will be doing one or more stays at NCEAS to carry out parts of this project.

Margaret Kinnaird
Sabbatical Fellow
Timothy O'Brien
09/01/2003-08/31/2004
**Functional relationships of Asian Hornbills in changing forest landscapes**
Birds and mammals are important seed dispersers and pollinators in tropical rainforests and are increasingly threatened by deforestation and hunting. The use of minimum viable populations as targets for conservation may be insufficient to assure the delivery of ecological services such as seed dispersal. Hornbills (Family Bucerotidae) are a
distinctive African and Asian bird family, inhabiting savannahs, dry forests and rainforests of Sub-Saharan Africa, and India eastward to the Solomon Islands. In Asia, hornbills are largely frugivorous forest birds and important dispersers of seeds of rainforest trees. Despite more than two decades of research, there has not been an attempt to synthesize and extend knowledge about this family. We propose to collate, analyze and synthesize data that will explore the ecology and behavior of these important birds, demonstrate their functional role in forest ecosystems, highlight keystone interactions with fruit resources, and examine the conservation impact of forest loss and fragmentation for hornbills and their function in the ecosystem.

James F. Kitchell
Sabbatical Fellow
10/01/2003-04/30/2004

Food web models for aquatic ecosystems
I have three goals for my time as a Center Fellow on sabbatical at NCEAS during 2003-2004. First, I will develop a synthesis and summary of the accomplishments derived from a working group "Models for Alternative Management Policies for Marine Ecosystems" which has been supported through NCEAS during 2001-2003. Second, I will prepare a monograph based on analyses of the bioenergetics models developed for a total of 47 fish species over the past several years. Third, I will develop a subset of those models and use them to provide guidance to management of predator-prey interactions in the Colorado River reaches of the Grand Canyon where fish populations are currently being manipulated as part of an active adaptive management program sponsored through the USGS's Grand Canyon Monitoring and Research Center.

Per Lundberg
Sabbatical Fellow
09/01/2002-06/30/03

Dynamics of large mammalian herbivores in changing environments: Alternative modeling approaches
The world's populations of large herbivores have shown dramatically different dynamics during the last two decades. The abundance and distribution of some ungulate species has declined abruptly, while other species have become excessively abundant, and still others have shown complex, oscillatory dynamics. These patterns seem to result from a composite of influences, including those operating at global and local scales. Conventional population models are rooted in assumptions about steady state and do not adequately incorporate environmental variability. We propose a working group that will exploit data sets and expertise from different regions to develop new models of ungulate population dynamics, capable of accommodating the complexity of environmental interactions at different spatial and temporal scales.

Gary Mittelbach
Sabbatical Fellow
11/01/2002-06/30/2003

Determinants of species diversity at varying spatial scales
Understanding the factors that determine species diversity at varying spatial scales is fundamental to the management and preservation of biodiversity. I would like to spend 9 months of my upcoming sabbatical (Sept. 2002-June 2003) at NCEAS working on three projects that examine the processes regulating species diversity at geographical
scales ranging from local communities to cross-continental patterns. The first of these projects examines one of the fundamental mechanisms thought to regulate species diversity within a local community - the extent of spatial heterogeneity in resource availability and the richness of the regional species pool. To examine these mechanisms, I will analyze three years of field data from an experimental manipulation of soil nutrient heterogeneity and regional species pools on the diversity of plant species in a prairie savanna community. Results from this study will be synthesized relative to other studies that have manipulated soil nutrients, plant productivities, and species pools. In the second project, I will be examining the importance of climate and available energy in determining patterns of species richness across very broad spatial scales (e.g., continents). This work will be conducted as part of an ongoing NCEAS working group in "Energy and geographic variation in species richness". The above projects focus on ecological mechanisms thought to regulate biodiversity at varying spatial scales. Differences in species richness between geographical regions or biomes (e.g., tropics versus temperate zone), however, are ultimately determined by differential rates of evolutionary diversification (speciation minus extinction). Therefore, the third project I want to undertake while on sabbatical is to examine how differences in species diversity between the tropics and temperate regions (i.e., the latitudinal gradient) may be generated by differential rates of evolutionary diversification. In addition to these three research projects, I plan to participate in the NCEAS-based Knowledge Network for Biocomplexity (KNB) graduate seminar series on scale-dependent patterns in biodiversity.

W. John O’Brien  Sabbatical Fellow
01/01/2004-07/31/2004

**Global change and eutrophication: Modeling of arctic lake ecosystems**

Two projects involving the examination of complex data sets and the development of integrative models of ecological processes are proposed. Both of the projects address ecological questions of general interest and importance. One has as its primary goal the integration of biological and hydrological information to examine change in Arctic lake chemistry and productivity as it relates to indicators of global climate change. The second project involves synthesizing data from studies worldwide, including those from the Arctic LTER, in which lake nutrients have been manipulated (either experimentally increased or municipally decreased) to examine the impact of nutrients on zooplankton density and production as phytoplankton densities are altered.

Julia Parrish  Sabbatical Fellow
01/01/2004-09/30/2004

**Marine Conservation**

Marine conservation is a fast emerging multi-discipline responding to the depletion of resources in the marine environment. However, unlike terrestrial conservation, or the more broadly-based conservation biology, marine conservation lacks the written material – especially single volumes which integrate across issues and approaches – to codify itself. This gap is also present in the academic realm, where the vast majority of courses on conservation lack a serious marine component. My proposed work at NCEAS is to write a textbook on marine conservation, incorporating ecology and
marine biology; oceanography and physical science; fisheries and natural resource management; and law, economics, and social science.

Will Wilson
Sabbatical Fellow
07/01/2002-06/30/2003

A broad look at organismal interactions: Linking intraspecific social interactions to an interspecific resource-consumer framework

Three areas of ecological research have traditionally been considered distinct: resource-consumer processes, behavioral ecology, and the study of social interactions that lead to animal grouping. Recent work has demonstrated that animal grouping can emerge within a spatial resource-consumer model. Such a connection between these two areas provides an ideal situation for linking social interactions between individuals to an individual's resource gathering. This connection enables the general study of the overall selection on an individual possessing both foraging and social behaviors. The sabbatical work proposed here will build upon these results and combine these three areas into one synthetic framework for theoretical analysis. The overall goal is to understand the evolutionary stability of social interactions, and discover under what situations different types of social interactions should be expected. The tangible results of this work will be a book summarizing the empirical and theoretical literature of these three areas, and synthesizing these areas into a single theoretical framework that may provide a roadmap for future research. Simulation code developed for this work will also be made freely available over the Web.

Postdoctoral Fellows

Elizabeth Borer
Postdoctoral Fellow
09/01/2003-08/31/2004

Synthesizing intraguild predation theory and data

Although intraguild predation (IGP), a form of omnivory, is widespread in natural communities and has received significant attention in the recent theoretical and empirical literature, a gulf exists between theoretical predictions about the role of IGP in food webs and our understanding of its role in real communities. With few exceptions, the IGP literature falls into two categories operating at different time-scales: (1) theory presenting long-term effects of IGP on species persistence and population densities, and (2) short-term studies demonstrating IGP and, from theory, extrapolating the outcome for populations and communities. In addition, IGP models have been formulated for predator-prey (e.g. Holt and Polis 1997), host-parasitoid (Briggs 1993), and host-parasite (or pathogen) (e.g. Hochberg and Holt 1990) systems. Although the broad predictions of all of these model formulations are the same, this commonality is not generally recognized. I propose to synthesize this diffuse body of theory, assess the information available from short-term empirical studies, and test theoretical IGP predictions with empirical data.

Peter Buston
Postdoctoral Fellow
10/01/2002-9/31/2004

The ecology of hermaphroditic breeding systems
There is an enormous diversity of hermaphroditic breeding systems distributed throughout the plant and animal kingdoms. To gain a greater understanding of this diversity, I propose to investigate the socio-ecological factors that underlie the evolution of these systems. First, I will develop new game-theoretic models, to generate explicit predictions about how ecological, social, and genetic factors combine to influence the distribution of reproduction within the breeding systems of both sequential and simultaneous hermaphrodites. Second, I will synthesize the extensive, but scattered, empirical literature on plant and animal (vertebrate and invertebrate) hermaphroditic breeding systems, gathering data on the socio-ecological factors that theoretical models indicate might give rise to these systems. Third, I will use this database, in conjunction with the comparative method, to test the alternative models, and determine which factors are indeed the key determinants of the different hermaphroditic breeding systems. The research will provide a comprehensive socio-ecological framework within which the breeding systems of all hermaphrodites can be understood. The work is important because understanding the breeding system of a species can be the key to effectively managing and conserving its populations.

David Chalcraft
Postdoctoral Fellow
06/10/2002-12/17/2003

A Knowledge Network for Biocomplexity: Building and evaluating a metadata-based framework for integrating heterogeneous scientific data
Complexity is an inherent property of living systems that arises from direct and indirect interactions among the earth's physical, chemical, and biological components. Biocomplexity includes the structural and functional attributes of dynamic systems that arise at all levels of biological organization, including individuals, populations, and communities. Importantly, ecological components of biocomplexity (e.g., biodiversity, ecosystem services) are in crisis, and are undergoing potentially irreversible changes in the face of rapid human population growth and economic development. Wise stewardship, based on all available scientific knowledge concerning these natural systems, is essential. Data Catalyzed by these societal concerns, and facilitated by technology advances, scientists focused on complex ecological systems have generated an explosion of ecological and environmental data. When integrated with data from other disciplines (e.g., meteorology), these data have the potential to greatly enhance understanding of biocomplexity. However, broad-scale and synthetic research is stymied because these data are largely inaccessible due to their spatial dispersion, extreme structural and semantic heterogeneity, and complexity.
This material is based upon work supported by the National Science Foundation under Grant No. DEB99-80154.

Karl Cottenie
Postdoctoral Fellow
02/01/2003-01/31/2005

Local versus regional processes: Integrating space and environment
Both local and regional processes can structure local communities, however, their relative roles are poorly understood. The classical methodology used to determine their relative importance is to examine the shape of the relationship between local and regional diversity. However, this approach has been criticized on several conceptual
and methodological grounds. This proposal aims to integrate local (biotic and abiotic) and regional (spatial) information, using three novel research methodologies. These will be applied on a range of data sets, starting with zooplankton, but expanding to other aquatic taxa and terrestrial systems. Moreover, I will extend the methodology to genetic data, in order to make a direct comparison between processes working at the interspecific and intraspecific levels. The results will elucidate the processes that generate structure in populations and communities.

Sergio Floeter  Postdoctoral Fellow
09/01/2003-08/31/2004

Diversity, biogeography and macroecological patterns of Atlantic reef fishes
This proposal aim to develop the great potential of reef-fishes as model taxa for biogeographical and macroecological analysis of reef areas in the Atlantic. Detailed large-scale studies of Atlantic reef fishes were always hampered by the lack of reliable geographical distribution of species. Now a multi-institutional international team of researchers is building the most accurate species distribution database possible for the entire tropical and subtropical Atlantic. This extensive new database covering 2404 species from 74 families will be used to 1) synthesize current knowledge of reef fish diversity and endemism in the Atlantic, 2) search for large-scale patterns and affinities among zoogeographical provinces, and 3) advance our understanding of biogeographical and macroecological marine patterns through the test of a series of hypothesis including the operation of biogeographical barriers, dispersal potential, biotic invasions, and the stepping stones concept.

Sarah Gergel  Postdoctoral Fellow
09/01/2000-05/31/2003

Protecting water by conserving land: The importance of spatial arrangement in influence ecosystem processes
Strategic placement of restored wetlands can reduce sediment and nutrient inputs to aquatic systems, attenuating the effects of agricultural conversion. While the role of riparian buffer strips for controlling sediments and nutrient runoff is established, the benefits of strategic placement of conserved land in the rest of a watershed is poorly understood. I will create watershed models of select ecoregions to determine the optimal spatial arrangement of land in an entire a watershed for minimizing sediment and/or nutrient runoff. This work will address a fundamental question of ecology, "When does the spatial arrangement of habitats matter for the functioning of ecosystem processes?" and will provide critical information for managers regarding strategic land acquisition.

Ben Halpern  Postdoctoral Fellow
09/01/2003-08/31/2004

Predicting community-level responses to disturbance: Implications for reserve design (Hosted by NCEAS)
Determining the causes of community stability and productivity remains an elusive goal for ecologists and conservationists alike. A major impediment to filling this gap in our understanding is the lack of ecological data at a scale large enough and over long
enough a timeframe to allow differentiation of ephemeral and local changes in biological communities from persistent and general patterns. Using data from the Channel Islands kelp forest monitoring program, which spans hundreds of kilometers and 22 years, I will apply a variety of time-series and multi-factor statistical models to test which factors affect community variables such as stability, trophic and community structure, and productivity (measured as biomass). Results from this work will provide ecologists, conservationists, and resource managers an essential tool for developing more appropriate expectations for long-term responses of biological communities to anthropogenic influences, both negative (e.g., species invasions, species loss, habitat alteration, effects of climate change) and positive (e.g., protection within parks and reserves).

Tiffany Knight  Postdoctoral Fellow  
01/05/2004-01/04/2005

Beyond hand-pollinations: Linking pollen limitation to plant population biology
Pollen sufficiency is an important determinant of plant reproductive success, and thus a major driver in plant ecology and evolution. Despite hundreds of empirical studies addressing the causes and consequences of pollen limitation, we lack a quantitative synthesis. Our working group will bring together evolutionary biologists, pollination ecologists, plant demographers, and theoreticians to produce new insight into the ecological and evolutionary significance of pollen limitation. We will 1) use contemporary theory as a framework for synthesis (via meta-analysis) of published and unpublished empirical data to determine the ecological attributes that are generally associated with pollen limitation, and 2) develop new theory that integrates pollen limitation with plant modularity, resource allocation and perenniality, as well as with plant demography, population growth rates and time to extinction.

Bill Langford  Postdoctoral Fellow  
02/01/2002-01/31/2005

Evaluation functions for ecological image segmentation
This project examines and enhances various forms of evaluation functions used in the comparison and optimization of image segmentation algorithms. It defines quantitative criteria for definition of the evaluation functions and uses them in the design and selection of these functions. It also investigates the relationship between errors in landscape pattern metrics and segmentation and classification algorithms. Finally, it coordinates the creation of a repository of correct segmentations of aerial and remotely sensed ecological imagery to improve algorithm development by making rigorous comparison of algorithms possible.

Kate Lyons  Postdoctoral Fellow  
08/01/2003-07/31/2004

Temporal and spatial dimensions of mammalian community structure: Pattern and process
Although progress has been forthcoming concerning macroecological patterns across large spatial scales, relatively little attention has been focused on their temporal dynamics. Moreover, understanding the responses of species to climate change is
becoming increasingly important because of the effect humans have on the environment. Predicting how macroecological patterns will change in response to patterns of global warming may allow us to better prepare for the consequences of our actions through informed conservation practices and land use strategies. Comprehensive and spatially explicit data on Pleistocene mammals provide a unique opportunity to perform such spatiotemporal analyses. Community structure was dynamic: many species with historically sympatric ranges are now allopatric. I propose to examine macroecological patterns across the fluid landscape of community structure during the last forty thousand years. As is true in so many instances, the key to predicting the future lies in understanding the past.

Christy McCain
Postdoctoral Fellow
01/13/2004-01/12/2005

Elevational trends in biodiversity: Examining theoretical predictions across taxa

Documenting patterns and understanding factors producing and maintaining global biodiversity have been fundamental goals of ecological research since the first expeditions of Darwin and Wallace. After a century and a half of research on biodiversity patterns and processes, Brown asserted that a general explanation for patterns of biodiversity would emerge in the next few years, particularly for elevational and latitudinal patterns. Elevational gradients hold enormous potential for understanding general properties of biodiversity since variable topography is global, and predictable climatic patterns with large concomitant changes in biodiversity occur over small spatial scales. Additionally, biodiversity studies along elevational gradients have been amassed for many taxa on mountain ranges across the globe. Lomolino outlined some testable diversity hypotheses in a research agenda, which would lead to a general explanation for elevational patterns, including climatic hypotheses, species-area effects, community overlap patterns, and historical factors. In the first quantitative synthesis, I tested some of the predictions for elevational diversity patterns of non-volant small mammals (n = 51) with intriguing results. Peak alpha diversity occurred at higher elevations on taller mountains, evidence supporting a combination of climatic factors influencing diversity patterns. In contrast, gamma diversity patterns supported the predictions of the mid-domain effect, displayed a positive, linear trend with latitude, and showed trends consistent with species-area effects. To further examine these preliminary trends, I propose addressing the following questions: (1) Is there a latitudinal trend in elevation of peaks in diversity on mountainsides? (2) Does the species-area relationship inherent to elevational gradients mask other mechanisms producing and maintaining biodiversity? (3) Is there general support for the community overlap hypothesis on elevational gradients? (4) Are there general mechanisms producing elevational diversity patterns across taxa?

Jannicke Moe
Postdoctoral Fellow
10/01/2003-04/01/2004

Stoichiometry and population dynamics of consumer-resource systems:
A combined experimental and modelling approach (Hosted by NCEAS)

A recent approach in ecology, ecological stoichiometry, recognises resource quality (nutrient ratios) as a limiting factor in addition to resource quantity. In the proposed
project, we will apply this approach to study classical population-ecological problems in a new perspective. Theoretical models of consumer-resource systems have predicted dramatic and counter-intuitive changes in population dynamics, when nutrient recycling and nutrient-limited growth are considered. However, most of these models are not yet evaluated experimentally. An important prediction is that increased phosphorous enrichment leads to more unstable population dynamics of the consumer, and eventually to extinction, although the resource persists. We will test this prediction by exposing laboratory systems of zooplankton (Daphnia) and algae to a range of phosphorous concentrations, and study the long-term dynamics of the system. Using non-parametric modelling, we aim at developing a new statistically-derived model for this system. Such models make few a priori assumptions about the form of the functions, and are therefore well-suited for exploring unknown relationships among variables. By combining such a flexible modelling approach with the stoichiometric perspective, we expect to provide new insight into general ecological problems.

Angela Moles Postdoctoral Fellow 08/25/2003-08/24/2004

**The radiation of seed mass strategies worldwide**
Recent accumulation of large, multi-species databases of plant traits, combined with major advances in our knowledge of phylogenetic relationships among the angiosperms mean that it is now possible to investigate the role of shifts in seed mass, growth form and dispersal syndrome in the radiation of the angiosperms out of the tropics. Approximately 6500 seed masses are now known for species from all around the world (database accumulated during my PhD). The aim of this proposal is to array these seed masses on to the phylogenetic tree of angiosperms to quantify where and when in the history of the angiosperms the major divergences in seed mass occurred. Then it will become possible to assess how closely divergences in seed mass have been associated with divergences in growth form, dispersal mode or latitude, and to investigate the sequence in which shifts in plant traits and distribution have occurred.

Helene Muller-Landau Postdoctoral Fellow 01/01/2002-12/31/2003

**Landscape-scale variation in forest communities and the distribution of tree life history strategies**
Tree species vary greatly in their life history strategies, exhibiting variation in their seed size, growth rate, life span, fecundity, and many other characters. The distribution of strategies within a forest affects community structure and dynamics, including successional patterns of species turnover and biomass accumulation, spatial patterns of species occupancy, and resilience to disturbance of various kinds. Landscape-scale variation in factors such as the length of the growing season, nutrient availability, and disturbance regime influences the distribution of tree life history strategies found within local communities. I propose to use new analytical techniques to estimate the distribution of life history strategies within communities from existing data on tree species composition and species characteristics for as many tropical and temperate forests as possible. Then, I will analyze differences in the distribution of life history strategies between communities, and their associations with climatic and other factors.
In parallel, I will continue theoretical work on the evolution of life history strategies within communities. The overall objective is to contribute to a better understanding of the distribution of tree life history strategies within and among communities, and of the implications for forest structure and dynamics.

Jill Murray (formerly Schmidt)  
Postdoctoral Fellow  
03/05/2001-12/31/2003

**Bridging microbial and theoretical ecology to investigate cooperative strategies in bacteria**

Microbiologists have recently become equipped to identify the taxonomy of bacteria in situ, understand phylogenetic relationships among groups, and assay gene expression in individuals, a development that parallels the explosion of natural-history studies by general ecologists a century ago. One of the most exciting recent discoveries is that bacteria engage in extensive chemical signaling and density-dependent behavior, some of which appears to involve cooperative adaptive strategies. Paralleling early ecologists who studied cooperation, microbiologists have not yet developed rigorous theory to test these ideas. Because theoretical and microbial ecology have developed with little interdisciplinary crossover, microbiologists have not capitalized on the existing framework that is now available to investigate cooperation in higher organisms. The gap between empirical microbiology and quantitative theoretical ecology is a common theme that must be addressed as microbial natural history unfolds. I aim to work at the interface of the two fields; my goal is to learn if and how cooperative strategies play a role in the spatial distributions of bacteria in nature. This work will involve predictive numerical and simulation modeling of microbial foraging strategies and their resulting spatial patterns, developed to enable discrimination amongst modes of selective pressure in future experimental tests. A mechanistic understanding of adaptive strategies in bacteria is essential to the understanding microbial food webs, bacterial infections, biogeochemical cycles, and the bioremediation of contaminated habitats. The scaling of ecological theory to microscopic proportions will also benefit general ecology, as long-standing questions can be tested in microbial systems that can be modeled almost perfectly and tested over relatively vast spatial and temporal scales given the sizes and generation times of bacteria.

Christopher Pyke  
Postdoctoral Fellow  
12/05/2000-12/31/2004

**Climate, ecosystems, and land-use: Understanding environmental variability in human-dominated landscapes (Hosted by NCEAS)**

Environmental variation creates both risk and opportunities for conservation. The implications of environmental variation in any particular situation vary depending on climatic processes, ecosystem responses, and land-use patterns. Consequently, it is necessary to understand potential interactions between these factors in order to design conservation strategies that use variation to reduce risk and take advantage of opportunities to increase species persistence. Informed action can offset the natural tendency for risk from environmental variation to increase as the total amount of habitat in a landscape decreases. The proposed research addresses this issue by: (1) simulating how climate, ecosystems, and land-use interact over time to change patterns of
environmental variation, and (2) applying this framework to evaluate risks faced by vernal pool ecosystems in the Central Valley of California. The results of this work will help conservationists develop better tools for reserve design, understand processes underlying patterns of environmental variability, and manage local vernal pool landscapes to reduce risks associated with landscape and climate change.

Eric Seabloom  
Postdoctoral Fellow  
06/01/1997-06/30/2004

**Effects of plant-community composition on animal movement**
The evolution of behavior and plant-community dynamics are two seemingly disparate elements in ecology. However, the movement of animals through a landscape can have strong impacts on the competitive coexistence of various plant life-history strategies, and the distribution of resources can alter animal-movement patterns. Accordingly, animal behavior and plant-community dynamics can be inextricably linked by the influence of animal movement on the composition of plant communities and, in the case of herbivores, the effects of plant-community composition on animal movement. For disturbance-generating herbivores, the link between the animal-movement patterns and plant-community composition is particularly strong, because the animal's foraging success is dependent on the composition of the plant community and the animal's movement generates disturbances that can profoundly alter the competitive balance among plant species.

Disturbance-generating herbivores are of additional interest because of their strong effects on the physical environment. For example, the tunneling behavior of pocket gophers can increase the heterogeneity of soil nitrogen, phosphorous, and carbon at the soil surface, but soil mixing will decrease vertical variability. In addition, the burrowing activity of gophers will lower soil bulk density and increase water infiltration, temperature, and litter decomposition rates. Pocket gopher activity is also a major force determining the rates of soil movement on hillslopes.

In my research, I am using a variety of modeling techniques to examine the interactions between the behavior of disturbance-generating animals, the structure of the associated plant community, and the ecosystem processes that result from this interaction. These models range from spatially-explicit movement models to analytical models of animal energetics and soil erosion.

This modeling work is closely coordinated with a series of field experiments designed to test the predictions in the California grassland system. This system is of particular interest, because of the high density of pocket gophers and their large apparent impacts on plant community composition and soil, nutrient, and water flux. In addition, the outcome of these studies is of profound conservation interest, because of widespread invasion of California native grasslands by exotic annual species.

Jonathan Shurin  
Postdoctoral Fellow  
09/01/2000-05/31/2003

**Detecting species interactions in survey data: New approaches and applications**
Geographic variation in community structure can be driven by the physical environment, biotic interactions, stochastic factors such as colonization and disturbance history, or by interactions among all three. The question of what factors are most
important in structuring communities remains highly contentious. This proposal
describes work aimed at integrating techniques for detecting interspecific associations
with ordination approaches for analyzing patterns of species distributions with respect
to the physical environment. My goal is to generate synthetic models of community
dynamics that include biotic and abiotic processes. I will apply the new method to the
analysis of a large data set of zooplankton species distributions and limnological
features among lakes, and to time series data of species abundances within lakes.

Melinda Smith Postdoctoral Fellow
06/17/2002-12/31/2003

A Knowledge Network for Biocomplexity: Building and evaluating a metadata-
based framework for integrating heterogeneous scientific data
Complexity is an inherent property of living systems that arises from direct and indirect
interactions among the earth's physical, chemical, and biological components.
Biocomplexity includes the structural and functional attributes of dynamic systems that
arise at all levels of biological organization, including individuals, populations, and
communities. Importantly, ecological components of biocomplexity (e.g., biodiversity,
ecosystem services) are in crisis, and are undergoing potentially irreversible changes in
the face of rapid human population growth and economic development. Wise
stewardship, based on all available scientific knowledge concerning these natural
systems, is essential. Data Catalyzed by these societal concerns, and facilitated by
technology advances, scientists focused on complex ecological systems have generated
an explosion of ecological and environmental data. When integrated with data from
other disciplines (e.g., meteorology), these data have the potential to greatly enhance
understanding of biocomplexity. However, broad-scale and synthetic research is
stymied because these data are largely inaccessible due to their spatial dispersion,
extreme structural and semantic heterogeneity, and complexity.

This material is based upon work supported by the National Science Foundation under
Grant No. DEB99-80154.

Richard Stevens Postdoctoral Fellow
12/15/2002-12/14/2004

Environmental determinants of biodiversity
Understanding the mechanistic bases of patterns in biodiversity has challenged
ecologists and evolutionary biologists alike for more than a quarter of a century
(Rosenzweig 1995). Although the ubiquity of gradients in species richness is well
documented at coarse scales of resolution, it is unclear to what extent patterns are
recapitulated at the level of local communities or for any other aspect of biodiversity
(Stevens and Willig 2001). Biodiversity represents the totality of variation in living
things (Tilman 2000). Thus, it is likely that no one measure such as species richness, or
any one perspective, such as that of taxonomic diversity, can provide a comprehensive
characterization. Investigations that simultaneously explore fundamental components
of biodiversity (i.e., taxonomic, functional, or phylogenetic diversity) will allow for
analyses that provide deeper, more comprehensive understanding regarding the
distribution of biota across space and time. Although secondary gradients (e.g.,
latitudinal diversity gradients) have been described ubiquitously, much less is known
about the primary environmental gradients or suite of gradients that cause such patterns. Numerous biotic and abiotic characteristics vary spatially in different but correlated ways. Distinguishing the relative contributions of a number of environmental characteristics to gradients in biodiversity will contribute substantially to our understanding of ecology, biogeography, and evolution. Moreover, resolution of the effects of primary gradients on the spatial distribution of biodiversity may also greatly enhance our understanding of the mechanistic basis of secondary gradients such as those described for latitude.

Mark Torchin  Postdoctoral Fellow
10/01/2003-09/30/2004

Using biological invasions to test predictions of population control by parasites

Introduced species are a major threat to global biodiversity, ranked second only to habitat loss (Vitousek 1990, Wilcove et al. 1998). The damage caused by exotic species results from the high population densities and large body sizes that they attain in their new location (Vitousek 1990, Wilcove et al. 1998, Ruiz et al. 1999, Torchin et al. 2001, 2002). Escape from the effects of natural enemies is a frequent explanation given for the success of introduced species (Keane and Crawley 2002, Shea and Chesson 2002). Recently, Torchin et al. (in press) demonstrated that introduced species are parasitized by half the number of parasite species compared to where they are native and that introduced populations are also less heavily parasitized (% infected) than native populations. However, while parasites are ubiquitous and pervasive, the extent to which parasites mediate invasions and result in increased ecological performance of introduced species has not been evaluated. Further, the extent to which introduced parasites and pathogens are responsible for damage to native species has not been quantified. Using existing data, I propose to extend a database which I developed for a NCEAS working group (Diseases and Conservation Biology) and employ a meta-analysis to test several hypotheses which explore the role of parasites in biological invasions. Further, by using biological invasions as “natural experiments”, I will design this project to investigate a more fundamental question in ecology: How do parasites affect the distribution and abundance of their hosts?

Diego Vázquez  Postdoctoral Fellow
10/01/2002-09/30/2004

Null models for specialization and asymmetry in plant-pollinator systems

Pollination biologists have recently suggested that pollination systems may have a greater degree of generalization in plant pollinator interactions than previously thought. However, there have been no attempts to provide null models against which to compare the observed patterns. I propose to conduct research to develop such models, and to use them to test patterns of specialization observed in available datasets of plant-pollinator interactions. My proposed research has the potential to provide important insights about how plants and pollinators interact, and to synthesize ideas on plant-pollinator interactions, species-abundance patterns, and abundance-range size relationships.
Jack Williams  
Postdoctoral Fellow  
06/17/2002-08/20/2003  

A Knowledge Network for Biocomplexity: Building and evaluating a metadata-based framework for integrating heterogeneous scientific data  
Complexity is an inherent property of living systems that arises from direct and indirect interactions among the earth's physical, chemical, and biological components. Biocomplexity includes the structural and functional attributes of dynamic systems that arise at all levels of biological organization, including individuals, populations, and communities. Importantly, ecological components of biocomplexity (e.g., biodiversity, ecosystem services) are in crisis, and are undergoing potentially irreversible changes in the face of rapid human population growth and economic development. Wise stewardship, based on all available scientific knowledge concerning these natural systems, is essential. Data Catalyzed by these societal concerns, and facilitated by technology advances, scientists focused on complex ecological systems have generated an explosion of ecological and environmental data. When integrated with data from other disciplines (e.g., meteorology), these data have the potential to greatly enhance understanding of biocomplexity. However, broad-scale and synthetic research is stymied because these data are largely inaccessible due to their spatial dispersion, extreme structural and semantic heterogeneity, and complexity.  
This material is based upon work supported by the National Science Foundation under Grant No. DEB99-80154.  

Working Groups  

Paleobiology Database (Hosted by NCEAS)  
John Alroy, Charles Marshall and Arnold Miller – leaders  

Aberhan, Martin  
Head, Jason  
Olszewski, Tom  
Alroy, John  
Holland, Steven  
Patzkowsky, Mark  
Bambach, Richard  
Huber, Brian  
Pfefferkorn, Hermann  
Behrensmeyer, Anna  
Hughes, Nigel  
Plotnick, Roy  
Bottjer, David J.  
Hunter, John  
Raymond, Anne  
Boyce, C. Kevin  
Ivany, Linda  
Rees, P.M. (Allister)  
Budd, Ann F.  
Jablonski, David  
Rogers, Raymond  
Carrano, Matthew  
Johnson, Kirk  
Sims, Hallie  
Clyde, William  
Kidwell, Susan  
Stein, William  
Doyle, James  
Kiessling, Wolfgang  
Tiffney, Bruce  
Eble, Gunther  
Korn, Dieter  
Uhen, Mark  
Erwin, Douglas  
Kosnik, Matthew  
Wagner, Peter  
Fara, Emmanuel  
Kowalewski, Michal  
Wang, Hongshan  
Foote, Michael  
Lidgard, Scott  
Wang, Xiaoming  
Fursich, Franz  
Looy, Cindy  
Wilf, Peter  
Gastaldo, Robert  
Lupia, Richard  
Wing, Scott  
Gensel, Patricia  
Marshall, Charles  
Harper, David  
Miller, Arnold  

Our picture of global diversification and extinction on long time scales is mostly based on generalized data for Phanerozoic marine macroinvertebrates. While every effort was
made to guarantee the comprehensiveness of this data set, the community has been aware that sampling artifacts may contribute to the observed trends. Until now, we have been unable to remove these effects. Several robust methods for doing this are now available, but these methods use locality-specific data that are not a part of the existing, more generalized compilations. In order to confirm the reality of the major observed patterns, a collaborative data compilation project needs to be initiated. We wish to form a working group to do this. As a first step, we propose a workshop this August involving workers who have specialized in analyzing paleontological diversity data. This workshop will determine the scope, goals, structure, and time table of a database project. Immediately after the workshop, a post-doc who will serve as project coordinator will begin a two-year residency at NCEAS. Over the following two years, experts specializing on particular parts of the fossil record will meet at NCEAS to guide the data collection process. A final meeting will focus on preparing collaborative publications showing how these data influence our picture of marine diversification and extinction.

### Understanding the role of infectious disease in mammalian mating and social systems (Extended)

Sonia Altizer and Charles Nunn – leaders

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<th>Altizer, Sonia</th>
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<tbody>
<tr>
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<td>Fulford, Jenny</td>
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<td>Gittleman, John</td>
<td>Poss, Mary</td>
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<td>Lindenfors, Patrik</td>
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<td>Ezenwa, Vanessa</td>
<td>Nunn, Charles</td>
<td>Vitone, Nick</td>
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This meeting will focus on (1) integrating the various datasets that are being compiled by individual members of the group, which is necessary for distributing these data over the WWW, (2) finalizing statistical results that are being conducted currently by individuals or subgroups of the working group, and (3) finishing manuscripts that are co-authored by three or more members of the working group. We have made great progress on compiling records of parasites and infectious diseases in over 100 species of wild primates, with the first round of results from our analyses nearly finalized. In addition to examining the effects of host social and mating behavior, two interesting patterns that have emerged in repeated comparative tests are the importance of host density and host diversification rates in explaining parasite community diversity within species. Members of our working group have begun compiling similar data on carnivores and ungulates, while others are building databases of parasite species traits (including host specificity and transmission mode). We have already produced four published (or in press) papers that acknowledge NCEAS support, initiated a second effort to collaborate with Conservation International in applying these data to conservation issues, and received NSF funds to support components of this project that lie outside the realm of NCEAS funding. At this stage, the bulk of our remaining research can be accomplished individually and within subgroups over email. However, a final meeting is necessary to integrate these currently independent datasets and spearhead our efforts to disseminate the data and results over the WWW and through journal publications. Merging multiple datasets on hosts and parasites requires the
expertise of both veterinary parasitologists and comparative biologists examining the
data simultaneously. At the meeting in June, 2003, we would also like to work with
Mark Schildhauer to develop a format for data presentation over the WWW. Moreover,
during the past two meetings theoreticians in our group have developed an innovative
individual-based model for varying social and mating systems to examine the
consequences for the spread and evolution of infectious disease. The conceptual
framework for this model required three full meetings to develop, and was surprisingly
advanced by input from nearly everyone in the working group. Because this model will
be coded and tested during the next 10 months, it will be essential to obtain feedback
and criticism from behavioral ecologists and parasite specialists following their initial
series of simulations.

**Beyond hand-pollinations: Linking pollen limitation to plant population biology**
Tia-Lyn Ashman, Tiffany Knight, Susan Mazer, and Martin Morgan – leaders

Amarasekare, Priyanga  Johnston, Mark  Parker, Ingrid
Ashman, Tia-Lynn  Knight, Tiffany  Steets, Janette
Burd, Martin  Mazer, Susan  Vamosi, Jana
Campbell, Diane  Mitchell, Randall  Wilson, Will
Dudash, Michele  Morgan, Martin

Pollen sufficiency is an important determinant of plant reproductive success, and thus a
major driver in plant ecology and evolution. Despite hundreds of empirical studies
addressing the causes and consequences of pollen limitation, we lack a quantitative
synthesis. Our working group will bring together evolutionary biologists, pollination
ecologists, plant demographers, and theoreticians to produce new insight into the
ecological and evolutionary significance of pollen limitation. We will 1) use
contemporary theory as a framework for synthesis (via meta-analysis) of published and
unpublished empirical data to determine the ecological attributes that are generally
associated with pollen limitation, and 2) develop new theory that integrates pollen
limitation with plant modularity, resource allocation and perenniality, as well as with
plant demography, population growth rates and time to extinction.

**Patterns in microbial biodiversity**
Brendan Bohannan, Peter Morin, Anna-Louise Reysenbach, and
Jennifer Hughes – leaders

Bohannan, Brendan  Jürgens, Klaus  Ovreas, Lise
Brown, James  Kane, Matthew  Petchey, Owen
Colwell, Robert  Kuske, Cheryl  Reysenbach, Anna-Louise
Fuhrman, Jed  Leibold, Mathew  Smith, Val
Green, Jessica  Morin, Peter  Staley, James
Horner-Devine, Claire  Murray, Jill  Tiedje, James
Hughes, Jennifer  Muyzer, Gerard  Ward, David
Huisman, Jef  Naeem, Shahid

Microorganisms represent the vast majority of Earth's biodiversity and they play a
crucial role in nearly every process of environmental importance. However we know
very little about how microbial diversity is generated and maintained. Our ignorance is
due in part to the isolation of microbial diversity studies from the general study of
biodiversity. The proposed working group will bring together microbial biologists who are gathering microbial diversity data and ecologists who study biodiversity, to share tools and approaches, to look for patterns in microbial diversity data, and to propose future directions for microbial biodiversity research.

**Facilitation and competition on alpine elevation gradients: A global experiment on the organization of plant communities**

Ragan Callaway, Richard Michalet, Robin Brooker, and Christopher Lortie – leaders

We propose to organize three meetings, each 7-10 days, in order to analyze data and develop conceptual, empirical, and mathematical models with a working group that has been loosely organized and conducting experiments on interactions in alpine plant communities around the world. Results from one of the nine sites for which data have been collected, the French Alps, and other preliminary analyses indicate that interactions shift from highly competitive in low elevation alpine meadows to highly facilitative in communities >1000m higher and near the physical limits of plant growth. These competitive and facilitative interactions also appear to be coupled with community properties such as biomass, diversity, evenness, and the relative abundance of target species. Furthermore, shifts in species interactions and the intensity of species interactions along elevation gradients appear to correlate with community characteristics and regional climate. We are requesting funds from NCEAS to solve the problems inherent to such a large group of investigators from different parts of the world with a large data set. Funding will allow us to work cohesively as a group on statistical analyses of experimental data, to integrate experimental results with community properties in innovative ways, and to develop empirical and conceptual models for the relationship between climate, biogeography, and plant interactions on gradients.

**Integrating the aquatic with the terrestrial component of the global carbon budget**

Jonathan Cole, Carlos Duarte and Yves Prairie – leaders

The traditional compartmentalized approaches to developing inventories of carbon pools and fluxes in the biosphere have generated gaps in the form of key components. Among these key components, freshwater and wetland ecosystems, have been largely ignored or assumed negligible. Recent literature suggests that freshwater ecosystems contribute significantly to some regional carbon balances. We hypothesize, based on a preliminary assessment of the easily available data, that these key components are critical for a reliable estimation of carbon movements at a global scale as well. While the oceans and
terrestrial forests are responsible for the net uptake of atmospheric CO2, freshwater ecosystems process a large amount of terrestrially-derived primary production and alter the balance between C sequestration and net CO2 release. This project aims at synthesizing existing information on the linkage between terrestrial and freshwater ecosystems to yield an improved representation of carbon cycling.

**Ecological processes and evolutionary rates**
Niles Eldredge and John Thompson – leaders

Brakefield, Paul
Jablonski, David
McPeek, Mark
Eldredge, Niles
Lenski, Richard
Miller, William
Gavrilets, Sergey
Lieberman, Bruce
Thompson, John

In recent years, the science of ecology has become increasingly directed toward questions at larger spatial and temporal scales. The same is true of evolutionary biology. Our working group will be a direct attempt to evaluate where and when evolutionary biology is important to our understanding of ecological analyses of large-scale spatial and temporal processes. This evolutionary/ecological link is at the heart of the major questions identified at the recent combined GSA/ESA symposium (Hunter 1998). This group will also build explicitly upon one of the research areas that has already become established at NCEAS through related working groups: the role of ongoing evolution in the organization of biodiversity.

**SpecNet**
John Gamon – leader

Cheng, Yufu
Held, A. Alexander
Oliphant, Andrew
Christensen, Torben
Houston, Stan
Qian, Yonghai
CORDOVA, Vicente
Huemmrich, Karl
Rahman, Faiz
Dungan, Jennifer
Huxman, Travis
Salinas-Zavala, Cesar
Fenstermaker, Lynn
Johansson, Torbjörn
Sims, Dan
Gamon, John
Katul, Gabriel
Steffey, Duane
Gutschick, Vincent
Luo, Hongyan
Tweedie, Craig
Hastings, Steven
Oechel, Walter
Vourlitis, George

SpecNet (Spectral Network) is a network of terrestrial flux tower sites where 'near surface' remote sensing is being conducted to improve our understanding of controls on the biosphere-atmosphere carbon exchange. SpecNet sampling closely matches the spatial and temporal scale of flux measurements, allowing a direct comparison of remotely sensed signals to factors affecting fluxes. We propose a SpecNet Working Group that will examine the optical, thermal, and flux data emerging from these sites. A primary goal will be to standardize the remote sensing instrument, algorithms, data processing protocols, and data products for comparative analyses. The next step will be to compare results across ecosystems to reveal contrasting controls on carbon flux. This effort will help link remote sensing to fluxes, assist in validating satellite products (e.g. NPP derived from the MODIS sensor), and will provide an improved scientific foundation for emerging carbon policy.

**Analysis of long-term litter decomposition experiments: Synthesis at the site, regional, and global levels**
Although numerous short-term experiments have been used to develop conceptual and simulation models of decomposition, very little is known about the later stages of this process. Exclusion of this later stage has led, at best, to incomplete understanding of ecosystem carbon and nitrogen dynamics. We propose a working group to examine the wealth of litter and decomposition data that has been produced by several recent long-term field experiments. Our analysis will initially be based on data from LIDET (Long-term Intersite Decomposition Experiment Team), a 27-site experiment conducted over a 10-year period. We will then incorporate results of other networks in Canada and Europe as well as other long-term results into this synthesis. Data will be used to reexamine fundamental paradigms that have guided ecosystem analysis for over a decade. We will also test the ability of simulation models developed from short-term experiments to predict long-term trends. Results from our working group will then be used to produce global maps of litter decomposition-related variables including litter production, substrate quality, carbon and nitrogen stores, and decomposition rates.

Spatial and temporal community dynamics: Sharing data to answer questions
Jeff Houlahan, C. Scott Findlay and David Currie – leaders
Brown, James Houlahan, Jeff Rojo, Carmen
Cuming, Graeme Legendre, Pierre Russell, Roly
Currie, David Magnuson, John Tilman, David
Ernest, Morgan Muldavin, Esteban Woiwod, Ian
Findlay, C. Scott Noble, David Wondzell, Steve
Fuhlendorf, Samuel Raimondi, Pete

General ecological principles can, by definition, only be derived from studies that span multiple taxa, geographic areas, and time periods. Such a broad research agenda implies data-sharing among many researchers from diverse geographic regions. Many of the technological barriers to data-sharing have been and are being addressed but there still exist many sociological obstacles to data-sharing because researchers are often, understandably, reluctant to share hard-won datasets. We propose to identify the key barriers to data-sharing and provide incentives to overcome these barriers. Once an effective data-sharing model is developed we will build a ‘pilot’ database using multi-species, site and time period datasets contributed by the working group participants. This database will be used to answer fundamental ecological questions such as; Are more diverse communities more stable? Is the diversity-stability relationship scale, taxon or habitat specific? Are natural communities regulated primarily by biotic or abiotic factors? Does the answer to that question depend on the scale, taxa and/or habitats being studies? Do spatial and temporal variability change in some predictable way with scale? This working group is intended to be a pilot project for a large-scale ‘consortium’ of ecologists sharing multi-species, site, and time period datasets to derive general ecological principles.

Science Environment for Ecological Knowledge (SEEK) (Hosted by NCEAS)
The goals of the Science Environment for Ecological Knowledge (SEEK) are to make fundamental improvements in how researchers can 1) gain global access to ecological data and information, 2) rapidly locate and utilize distributed computational services, and 3) exercise powerful new methods for capturing, reproducing, and extending the analysis process itself. The project involves a multidisciplinary team of computer scientists, ecologists and technologists from the Partnership for Biodiversity Informatics (PBI), a consortium comprising the National Center for Ecological Analysis and Synthesis (NCEAS); the San Diego Supercomputer Center (SDSC); the University of Kansas (KU); and the University of New Mexico (UNM) and partnering institutions (Arizona State University, University of North Carolina, University of Vermont, and Napier University in Scotland).

An ecological-economic analysis of pest-control services: The Brazilian Free-tailed Bat as a model
Thomas Kunz – leader
Betke, Margrit Gomez, Irma McCracken, Gary
Cleveland, Cutler Grant, William Medellin, Rodrigo
Correa Sandoval, Hallam, Thomas Moreno-Valdez,
Adriana Nelly Horn, Jason Arnulfo
Federico, Paula Kunz, Thomas Sansone, Chris
Frank, Jeff Lopez, Juan Stevens, Richard

Ecosystem services underpin human existence, yet we know little about the magnitude of these services in terms of what policy makers need to incorporate into decision-making frameworks. The objective of this project is to analyze existing databases for developing an ecological-economic model of pest-control services provided by an important insectivorous bat (Tadarida brasiliensis). Computer algorithms will be developed for estimating numbers of bats based on infrared thermal imaging, and population models of pest species will be developed based on available life-history data. Dynamic modeling and GIS will be used to integrate extant databases on bat foraging from Dopper radar (NEXRAD) data, crop and insect phenology, seasonal migration of bats and insects, and agricultural crop distribution, yield, and inputs. Ultimately, models will include sensitivity analysis to estimate the monetary value of the pest-control service, and thus
provide the first comprehensive analysis of a major vertebrate predator of importance to agroecosystem productivity in North America.

**Ecological metaphors: Their cultural resonance and what we can do about it**

Brendon Larson – leader

Baake, Ken       Grady, Joseph       Larson, Brendon
Bono, Jim        Haila, Yrjo         Mikkelson, Gregory
Callicott, J. Baird Hurlbert, Stuart Rohrer, Timothy
Cuddington, Kim  Lach, Denise        Schell, Charlotte
Fox Keller, Evelyn Lakoff, George    Slobodkin, Lawrence

Ecologists commonly use metaphors to develop their ideas and to communicate them to the public. Unfortunately, by their very nature metaphors may be interpreted in different ways by different constituencies, and this may lead to misunderstanding of ecological concepts. For example, a recent paper in Science (Chew and Laubichler 2003, Science 301: 52-53) reported on the prevalent use of the term “natural enemies” in recent scientific literature. “Natural enemies” and related terms such as exotic and invasive resonate with foreign policy, so it is perhaps unsurprising that some individuals claim that invasive species policy is xenophobic. As another example, consider the challenges that have arisen with the attempt to convince people that “disturbance” is an important and beneficial ecological process. Our NCEAS working group, consisting of ecologists, metaphor researchers, philosophers and science communication scholars, will assess whether there is anything we can do to ameliorate the misinterpretation and misapplication of ecological metaphors. Can we better control which metaphors are used? Is there any way to reduce misinterpretation of established metaphors? Practically, we will develop suggestions for wise metaphor use among ecologists.

**The Meta-Community Concept: A framework for large scale community ecology?**

Mathew Leibold – leader

Amarasekare,      Holt, Robert       Loreau, Michel
Priyanga          Holyoak, Marcel     Mouquet, Nicolas
Chase, Jonathan   Hoopes, Martha     Shurin, Jonathan
Cottenie, Karl    Law, Richard        Tilman, David
Gonzalez, Andy    Leibold, Mathew

The concept of meta-communities was developed in an effort to link community ecology theory at the local level with regional and global models at larger spatial scales. Currently there are two contrasting views of meta-communities. The "patch-dynamics" perspective is based on the idea that similar local habitat patches are colonized by species that interact to produce communities consisting of different species depending on their dispersal abilities. In contrast, the "species-sorting" view assumes that sites differ in their abiotic environment, causing interacting species to sort themselves differently along gradients depending on their competitive abilities at different sites. The first view ignores local population dynamics and therefore allows for nonequilibrium abundances but it ignores intrinsic heterogeneity among local sites. The second view is generally modeled using equilibrium models of local population dynamics but accounts for heterogeneity among sites. Empirical evidence suggests that both of these approaches are useful for understanding patterns in real communities.
Thus there is a need for a more synthetic approach. We propose to form a collaborative group to work on such a synthesis. Our goal is to explore what happens when both sets of metacommunity processes occur. We hope to use this synthetic approach to explore their roles in regulating phenomena such as the trophic structure, patterns of diversity and composition along environmental gradients and the role of regional processes such as dispersal in ecosystem processes.

**PrecipNet: Analysis and synthesis of precipitation and ecosystem change**

Michael Loik – leader

Barker, David  
Cable, Jessie  
Grizzle, Heath  
Huxman, Travis

Lambrecht, Susan  
Loik, Michael  
Nagel, Jennifer  
Patrick, Lisa

Smith, Stanley  
Tissue, David  
Zak, John

The goal of the NCEAS PrecipNet Synthesis Group is to analyze and synthesize results of the effects of climate change on ecosystems. In particular, we will analyze data from studies on the effects of altered timing and magnitude of rain and snowfall across different ecosystems and geographic regions. Another important goal is to promote interdisciplinary research between natural and social scientists regarding the impacts of precipitation and ecosystem change and the interrelationships with human systems and institutions. Our meeting will result in: a review article on the current state of knowledge about precipitation change effects on ecosystems; development of databases on the world wide web and on CD-ROM that would be available for all global change studies; and maps predicting how ecosystem responses to precipitation change will affect ecological communities across regional scales. The PrecipNet Synthesis Group includes James Ehleringer (Univ. Utah), Brent Haddad (UC Santa Cruz), John Harte (UC Berkeley), Rod Heitschmidt (Ft. Keogh Range Exp. Sta.), Alan Knapp (Kansas State Univ.), Guanghui Lin (Biosphere II, Columbia Univ.), Michael Loik (UC Santa Cruz), William Pockman (Univ. New Mexico), Rebecca Shaw (Carnegie Inst. For Plant Biology), Eric Small (New Mexico Tech), Stan Smith (Univ. Nevada, Las Vegas), David Tissue (Texas Tech Univ.), Jake Weltzin (Univ. Tennessee), David Williams (Univ. Arizona), and John Zak (Texas Tech Univ.).

**Life-history variation and community structure in neotropical rainforest communities: Ecological and phylogenetic influences**

Susan Mazer, David Ackerly, Miguel Martinez-Ramos and Horacio Paz – leaders

Ackerly, David  
Condit, Richard  
Harms, Kyle  
Ibarra-Manriquez,  
Guillermo  
Martinez-Ramos,  
Miguel

Mazer, Susan  
Moles, Angela  
Muller-Landau, Helene  
Paz, Horacio  
Pitman, Nigel  
Poorter, Lourens  
Silman, Miles

Terborgh, John  
Vriesendorp, Corine  
Webb, Campbell  
Wright, Ian  
Wright, Joseph

Several key questions in evolution and ecology may be answered by the analysis of comparative data sets in which information on the demography, life history, and relative abundance of large numbers of species is jointly analyzed. For example, the detection of strong associations between habitat, soil quality, seed mass, life form, dispersal mode,
and other life history traits has shed light on the selective forces (e.g., light availability and disturbance) that influence the evolution of these attributes within and among taxa.

Virtually all investigators of plant communities have used this approach on single community-level data sets compiled by their own research group (Jackson, 1981, Garwood, 1983, Foster and Janson, 1985, Mazer, 1987, Ibarra-Manríquez & Oyama, 1993, Grubb & Metcalfe, 1996 [flora of Queensland, various sites, analyzing pooled data], Rees 1997 [British flora pooled]), Harms and Dalling, 1997, Clark et al., 1998, Hodkinson, et al., 1998 [British flora, pooled]. Relatively few researchers have evaluated data sets including information from more than one community (Hammond & Brown, 1995 (three Neotropical communities), Lord, Westoby & Leishman, 1995 (five temperate floras), Lord et al., 1997 [tropical vs. temperate floras]). In the proposed NCEAS working group, we will bring together a group of community ecologists and evolutionary biologists to use community-level data to address two sets of questions that depend on the joint analysis of multiple data sets. Because these questions (see below) require the analysis of both pooled and separate community-level data, we have selected participants who have independently collected similar data in ecologically similar plant communities.

The roles of natural enemies and mutualists in plant invasions
Charles Mitchell and Alison Power – leaders
Agrawal, Anurag   Klironomos, John   Power, Alison
Bever, James      Maron, John       Seabloom, Eric
Callaway, Ragan   Mitchell, Charles Torchin, Mark
Gilbert, Gregory  Morris, William
Kareiva, Peter    Parker, Ingrid

Invasive plant species both threaten native biodiversity and are economically costly (OTA 1993, Williamson 1996, Wilcove et al. 1998, Mack et al. 2000, Pimentel 2002). Recent results (Mitchell and Power 2003) suggest that invasive plants become widespread problems, in part, because they are released from attack by pathogens relative to their native range. However, the roles of herbivores and mutualists in plant invasions remain controversial (Maron and Vila 2001, Keane and Crawley 2002, Agrawal and Kotanen 2003), and the potential for interactive effects of natural enemies and mutualists has been little considered. This working group will examine the joint roles of herbivores, pollinators, mycorrhizal fungi, and pathogens in plant invasions. The first goal of this working group will be to more fully quantify the effects of plant introductions on their associations with these enemies and mutualists. We will achieve this by synthesizing existing data on the geographic occurrence and impact of insect herbivores, mycorrhizal fungi, pollinators, and pathogens. We will then examine to what degree changes in naturalized plants' associations with these other organisms can explain major patterns in biological invasions, particularly variation among naturalized species in their ecological impacts.

An information infrastructure for vegetation science
Robert Peet, Dennis Grossman, Michael Jennings and Marilyn Walker – leaders
Anderson, Mark
Faber-Langendoen, Don
Gramling, Joel
Vegetation classification is of central importance to biological conservation for planning and inventory, to resource management for monitoring and planning, and to basic scientific research as a tool for organizing and interpreting ecological information. All of these activities require that ecological units be defined and that their distribution on the landscape be known and understood. Vegetation classification contributes significantly to analysis of ecological problems that vary in scale from persistence of tiny populations of endangered species to global projections of the impact of climate change. Technological advances have made practical large-scale analyses that cross agency jurisdictions or geographic regions and address applied ecological issues as diverse as global change, ecosystem management, and conservation planning. However, all such efforts depend on having available a common set of well defined and broadly accepted classification units.

Seasonality and the population dynamics of infectious diseases
Mercedes Pascual and Andrew Dobson – leaders
Alonso, David Dobson, Andrew Koelle, Katia
Altizer, Sonia Grenfell, Bryan Lele, Subhash
Bjornstad, Ottar Hosseini, Parviez Pascual, Mercedes
Cattadori, Isabella Hudson, Peter Rodo, Xavier
Codeco, Claudia Kendall, Bruce Rohani, Pej
De Leo, Giulio King, Aaron Satake, Akiko
Seasonal variation takes many forms in the natural world. All of us notice the annual cycles in temperature, day length, and rainfall, and these have profound effects on rates of resource production and availability that plants and animals respond to in order to modify their reproduction and maintenance schedules. These regular cycles impose constraints and create opportunities for transmission of infectious diseases. Humans also superimpose seasonal processes onto their lives in a way that creates opportunities for infectious diseases; for example school semesters and annual vacations. This working group will examine the different ways in which seasonal variation in population size, contact rates and the survival of free-living infectious stages modifies the population dynamics of infectious diseases. The working group will bring together biologists, epidemiologists and mathematicians all of who have worked on different aspects of these problems. The workshop is particularly relevant to our understanding of the potential disease problems associated with climate change.

Exotic species: A source of insight into ecology, evolution, and biogeography
Dov Sax, Steven Gaines and Jay Stachowicz – leaders
Blackburn, Tim D'Antonio, Carla Grosberg, Richard
Brown, James Davis, Mark Hastings, Alan
Bruno, John Gaines, Steven Holt, Robert
Exotic species pose a serious threat to the structure and function of native ecosystems and cause significant economic damage. In spite of these costs, exotic species present unique opportunities to advance our conceptual understanding of ecological patterns and processes. By using exotic species as a vast array of natural experiments we can address questions at scales that would otherwise be non-experimental, and we can observe processes that have occurred repeatedly in the past, but that have previously gone unrecorded. Indeed exotic species may present one of the best inroads available to understanding ecology, evolution and biogeography. The goals of this working group are three-fold. First, to explore the insights that exotic species provide to fundamental conceptual issues in ecology, evolution and biogeography. Second, to provide a model for the budding field of invasion biology, which currently is focused strongly on applied issues, but which could be redirected to simultaneously study both applied and conceptual issues. Third, to use the insights we gain to ecology, evolution and biogeography to in turn improve our ability to manage and mitigate the damage caused by exotic species. To accomplish these goals, we propose a novel model that includes the delegation of work prior to the first meeting of the working group; we have identified a motivated body of scientists who are ready to initiate this work. This approach should allow us to produce a great number of conceptual insights, as well as a great number of important publications, that will advance the study of ecological systems and our ability to effectively manage them.

Can we now determine if, when, and how microbial community composition impacts ecosystem processes? Will that understanding yield critical new information about ecosystem function and response to change?

Josh Schimel – leader
Allen, Michael  Neff, Jason  Treseder, Kathleen
Bohannan, Brendan  Schimel, Josh
Firestone, Mary  Sinsabaugh, Robert

Linking populations and process dynamics has been a major thrust in ecology for the last decade or more. This issue has been a concern in microbial ecology, but linking microbial community dynamics with ecosystem scale processes has been a major challenge. There remains debate as to whether any such linkages really exist, though there are theories about which processes should be sensitive to community composition and there have been a number of individual studies that support these theories. There has not, however, been any broad and effective synthesis to test theories or critically assess how best to establish microbe-ecosystem linkages. We propose a working group that will identify the most successful current approaches for establishing linkages, work with available data sets and existing ecosystem models to determine how to best incorporate appropriate microbial community dynamics into larger-scale models, and work with the models to evaluate the effects of incorporating microbial dynamics into them.
Macro-Ecology and biogeography: Hierarchical (Bayesian) model development using data from South Africa

John Silander – leader
Barber, Jarrett  Holsinger, Kent  Reeves, Gail
Cowling, Richard  Latimer, Andrew  Silander, John
Gelfand, Alan  Laurie, Henri  Tadross, Mark
Hegerl, Gabriele  Lewis, Paul  Wu, Shanshan
Hewitson, Bruce  Midgley, Guy
Holder, Mark  Rebelo, Anthony

We propose a Working Group that will focus on developing hierarchical (Bayesian) statistical models to explain joint spatial patterns in plant species distributions (and thus diversity), using unique datasets from South Africa.

The statistical models will: be individual species-based, be spatially explicit, utilize individual species attributes (including phylogenetic information), and include various explicit sources of environmental heterogeneity. The models will be hierarchical in attempting to explain joint patterns of species distributions, thus getting at diversity directly from a mechanistic perspective. We know of no other studies which have taken this approach. In building, validating and comparing the models, we have access to unique data sets from South Africa: 1) the Protea Atlas species inventory; 2) A set of explanatory GIS data layers for the Cape Floristic Region (CFR); 3) cladistic/phylogenetic data on taxa in the Proteaceae; 4) a database of up to 4000 releves from the CFR; and 5) potentially, access to a database of the distribution (at ¼ degree grid cells) of all 23,000 flowering plant species in Southern Africa. The CFR is one of the world's hottest hotspots of plant diversity, and the Protea Atlas dataset may be the most complete presence-absence data set for any taxonomic group across any region.

Global change and infectious disease

Mark L. Wilson and Leslie A. Real – leaders
Ahumada, Jorge  Hawley, William  Singer, Burton
Bouma, Menno  Hay, Simon  Smith, David
Dobson, Andrew  McKenzie, Ellis  Smith, Katherine
Glass, Gregory  Pascual, Mercedes  Wilson, Mark
Gupta, Sunetra  Real, Leslie
Halloran, M. Elizabeth  Sachs, Jeffrey

A major element underlying many emerging and reemerging infectious diseases is environmental change. This may be manifested through direct and intentional landscape changes (e.g. hydroelectric dams, agricultural development projects, irrigation, urban expansion, mining, deforestation), indirect habitat changes that favor transmission (e.g. increased vector breeding sites, evolution of virulence, or enhanced contact with infectious agents), and the possibility that other indirect abiotic effects including climate change might alter the intensity or distribution of various diseases. A better understanding of these processes is needed for risk is to be understood and reduced, and for outbreak forecasts are to be made accurate and credible. The goal of this sub-group is to explore various associations between environmental change and specific infectious
diseases that have strong environmental links by analyzing data sets with extensive and well-documented temporal and/or spatial variation.

Specifically, we propose to begin by analyzing two categories of infectious disease. The first is vectorborne disease. Within this category we focus on a mosquito-borne anthroponosis, human malaria, which will be analyzed using data from various sites and sources throughout the world. Time-series analysis and study of spatial patterns among cases and environmental variables will be undertaken using standard time-series and GIS-based statistical models. An attempt will be made to test hypotheses that are based in the biology of vectors, human ecological relations with the environment and each other, and climatic factors that influence transmission.

Diarrheal diseases comprise the second category. Evolutionary theory and empirical studies indicate that diarrheal diseases evolve increased or decreased virulence in response to environmental changes. Specifically, this work suggests that when waterborne routes of transmission are available natural selection will favor highly exploitative pathogen variants because in such environments the costs of exploitation are low. Even ill, immobilized hosts can act as sources of infection because fecal material is removed and washed in water that can contaminate supplies of drinking water. Conversely, if safe water supplies are provisioned, we predict pathogens to evolve toward benignity. There exists a great amount of data in the literature and in unpublished records (e.g., located in ministry of health archives) that we propose to analyze to test this prediction. Our focus in this second category will be on the bacterial agents of dysentery, because the inherent virulence of these agents varies at the species level, and the frequencies of these species in human populations spans the length of time over which water supplies have been improved (i.e., over the past century).

Working Groups With Near Term Relevance for Resource Managers and Policy Makers

A Knowledge Network for Biocomplexity: Building and evaluating a metadata-based framework for integrating heterogeneous scientific data
Jim Reichman, James Brunt, John Helly, Matthew Jones and Michael Willig – leaders
Andelman, Sandy J.        Fegraus, Eric         McPherson, Guy
Biggs, Harry               Garrett, Karen        Peel, Mike
Bowles, Christy            Gotelli, Nicholas J.  Smith, Melinda
Branan, Bill               Gramling, Joel        Stromberg, Mark
Carney, Karen              Gross, Katherine L.  Swemmer, Tony
Chalcraft, David R.        Horner-Devine, Claire Trollope, Winston
Cleland, Elsa              Jennings, Michael D.  Vandermast, David
Collins, Scott L.          Keddy, Paul          Waide, Robert B.
Cox, Stephen B.            Knapp, Alan K.       Williams, Jack
Devine, Claire             Kruger, Judith       Willig, Michael R.
Drake, John                Loreau, Michel       Welsey, Brian J.
Dukes, Jeff                Mau-Crimmins,        Wojdak, Jeremy
Emery, Sarah               Theresa              Zambatis, Nick

Complexity is an inherent property of living systems that arises from direct and indirect interactions among the earth's physical, chemical, and biological components.
Biocomplexity includes the structural and functional attributes of dynamic systems that arise at all levels of biological organization, including individuals, populations, and communities. Importantly, ecological components of biocomplexity (e.g., biodiversity, ecosystem services) are in crisis, and are undergoing potentially irreversible changes in the face of rapid human population growth and economic development. Wise stewardship, based on all available scientific knowledge concerning these natural systems, is essential. Data catalyzed by these societal concerns, and facilitated by technology advances, scientists focused on complex ecological systems have generated an explosion of ecological and environmental data. When integrated with data from other disciplines (e.g., meteorology), these data have the potential to greatly enhance understanding of biocomplexity. However, broad-scale and synthetic research is stymied because these data are largely inaccessible due to their spatial dispersion, extreme structural and semantic heterogeneity, and complexity.

Setting priorities and making decisions for conservation risk management
Mark Burgman – leader
Andelman, Sandy Franklin, Janet Regan, Helen
Ben-Haim, Yakov Hayes, Keith Ruckelshaus, Mary
Burgman, Mark Keith, David Runge, Michael
Carmel, Yohay Langford, Bill Spanos, Aris
Costello, Christopher Mace, Georgina Stirling, Andy
Cumming, Geoff Manly, Brian Thompson, Colin
Elith, Jane Mayo, Deborah Tyre, Andrew
Fegraus, Eric McCarthy, Mick Wilcox, Chris
Ferson, Scott Meiring, Wendy Wintle, Brendan
Fidler, Fiona Moilanen, Atte
Fox, David Possingham, Hugh

Risk-based decisions are made routinely in medicine, toxicology, engineering, psychology, insurance and finance. The development of methods in these fields has been rapid but the paths followed and the tools developed have been different. To some extent the differences reflect the kinds of data and the range of problems people need to solve. In part, the differences are because methods have grown in relative isolation. A common problem facing practitioners in conservation biology is to identify priorities that discriminate among a suite of alternative actions. Biologists make decisions on a routine basis, but with little understanding of the techniques for decisions involving risk. The kinds of questions conservation biologists are obliged to answer will benefit substantially from advances in decision analysis and risk assessment made in other disciplines. This project will develop and expand the toolkit for problem solving available to conservation biologists by reviewing risk-based, priority setting methods in different fields, and bringing together people from different disciplines to examine the problems confronting conservation biologists, resulting in new approaches to finding solutions to priority setting and decision making problems.

Global change impacts on landscape fires
Michael Flannigan and Sandra Lavorel – leaders
Cary, Geoff Flannigan, Michael Fotheringham, C.
A major problem in projecting ecological change and understanding its mechanisms is the lack of non-equilibrium dynamics in ecological models. The inclusion of disturbance, especially fire, is essential for dynamic vegetation models to simulate transient changes in vegetation composition and structure. Understanding landscape dynamics in relation to fire, and how these dynamics may be altered by climate and land use changes is a priority. The development of fire-vegetation models at landscape scales is a crucial gap in land management. Additionally, understanding human impacts on the fire regime is critical for projecting vegetation change in human-modified landscapes, which now occupy large proportions of the globe. The objective of this working group is to use the current well-developed understanding of fire behavior/fire ecology and fire-weather to develop a set of dynamic fire-climate-vegetation models that simulate fire effects at temporal and spatial scales relevant to vegetation change. We will use a common modeling environment, LAMOS, to conduct this research. LAMOS (a Landscape Modeling Shell) is an interactive and flexible landscape modeling platform designed to include alternative methods for simulating vegetation response to landscape change. This proposal specifically addresses three questions: 1) How well do different landscape fire models reproduce fire statistics under current climate, both with respect to each other and with respect to fire history records at selected sites, 2) At what spatial and temporal scales does landscape pattern influence the fire regime, and 3) Under which weather conditions are fire patterns sensitive to fuel landscape pattern, and how often under present / future climate is the threshold of sensitivity crossed.

**Models of alternative management policies for marine ecosystems**

Robert Francis and James Kitchell – leaders

Aydin, Kerim   Gaichas, Sarah   Olson, Robert
Crowder, Larry Hinke, Jefferson Orbach, Michael
Dalton, Michael Kaplan, Isaac Polovina, Jeffrey
Field, John Kitchell, James Pooley, Samuel
Fluharty, Dave Martell, Steve Walters, Carl
Francis, Robert Nelson, Russell Watters, George

We are employing comparative approaches based on a common modeling framework developed for each of five large marine ecosystems in the North Pacific Ocean. Each of these ecosystems has served as the focus of controversy over the ecological consequences of fishery management practices, protection for threatened or endangered species, and the relative importance of large-scale environmental variability. Each of these ecosystems has been the focus of model development effort using the common framework of an Ecopath/Ecosim approach. We are using these five models as the basis for evaluating policy effects on ecosystem structure, clarifying the tradeoffs in fishery and conservation goals, and designing robust management strategies. We have also created novel ways of visualizing complex ecosystem models, as a way to make them more accessible to policy makers. Our efforts are supported by the National Center for Ecological Analysis and Synthesis.
Development of tools for the practical design of marine reserves
Alan Hastings and Louis Botsford – leaders
Baskett, Marissa Gaylord, Brian Micheli, Fiorenza
Botsford, Louis Halpern, Ben Rosenberg, Andy
Brumbaugh, Dan Hastings, Alan Wahle, Charles
Carr, Mark Kinlan, Brian Warner, Robert
Fluharty, Dave Largier, John Yoklavich, Mary
Gaines, Steven Leff, Jamie

We propose a working group to examine the general question of moving from theory to policy, specifically looking at the design of marine reserves, building on the quantitative results obtained under a previous NCEAS working group, "A Theory of Marine Reserves", by J. Lubchenco, S. Gaines and S. Palumbi. Whereas the modeling in that working group was a development of a general theory of marine reserves, the focus of the working group proposed here will be an application of that theory to specific problems. Rather than consider ideal optimal reserve configurations, we will study implementing actual marine reserves, given a specific situation and constraints (i.e., current fishing rate, current state of the ecosystem, limited area under consideration, uncertainty in larval dispersal, fisher behavior). The goal will be to develop scientifically sound design tools that can be used in ongoing and future implementation efforts for reserve systems, considering reserves designed both to improve fisheries and to conserve natural marine ecosystems. This effort can be viewed as a paradigm for the problem of translating ecological theory into practical policy applications.

The ecology of marine diseases (Extended)
Drew Harvell – leader
Dobson, Andrew Jani, Andrea McCallum, Hamish
Ellner, Stephen Kim, Kiho Pascual, Mercedes
Gerber, Leah Kuris, Armand Porter, James
Harvell, Drew Lafferty, Kevin Ward, Jessica

I am requesting funding for one more meeting of the Marine Disease Working Group. The three main objectives of our working group are: (1) detect evidence of increasing impacts of disease in the ocean, (2) assess application of terrestrial pathogen models to marine outbreaks (and in the process, compare what’s known of characteristics of terrestrial and marine disease), (3) develop statistical and modeling approaches for marine diseases.

A dynamic integrated model of land use, carbon flows and carbon sequestration supply in Costa Rica
Suzi Kerr and Alexander Pfaff – leaders
Cifuentes-Jara, Miguel Kauffman, J. Pfaff, Alexander
Hughes, Flint Kerr, Suzi Tosi, Joseph
Jobse, Judith Liu, Shuguang Watson, Vicente

With the rise in importance of global climate change, society is actively exploring the possibility of using forest ecosystems as a carbon sink. Tropical forests may offer over two-thirds of such opportunities. The protection of tropical forests could offset global
fossil fuel C emissions and reduce the cost of emissions limitations set in Kyoto. Certified emissions credits (CERs) under the Clean Development Mechanism (CDM) established in Kyoto will likely incorporate tropical forest sinks within efforts to meet emissions targets. While this could in principle result in significant economic and sequestration benefits, actual evidence on tropical C sinks is sparse. However, society must soon make key decisions concerning tropical forest sinks in the CDM.

The first major goal of our project is to estimate how much C sequestration will be generated in Costa Rica in response to any given monetary reward for C sequestration. Our advances in the ecological and economic components will be coupled to produce our first integrated output, an estimated supply or, equivalently, cost function for C sequestration (i.e., a relationship between the C reward and the C sequestration supplied by land users).

Our advances in the economic component start with excellent existing GIS databases on land use and land cover, and on the factors expected to affect land use choices. We will extend both of these types of data sets, in particular extending land-cover information back in time, and adding improved data on land returns. Next, we will both apply and extend the frontier of economic, observationally-based modeling of land use to provide a map from key factors to land choices.

On the ecological side, our advances start with systematic and comprehensive measurement of aboveground and soil C present within the range of forest ecosystems of Costa Rica, as well as the C dynamics within land-use gradients of each of those systems (e.g., pastures, croplands, and secondary forests of varying ages). With this and existing data, we will calibrate and verify both process-based and empirically-based ecological models that generate C predictions of varying complexity. This provides a map to C stocks from land use choices within different ecosystems. Our second goal is to contribute to the effective design of the rules that allow C sequestration in tropical locations to replace emissions reductions in developed countries. Our analyses will provide the necessary information for the baselines that permit CERs to be defined, and a C market to function. We will also perform integrated sensitivity analyses to determine whether simplified versions of our disciplinary and integrated models maintain sufficient accuracy. Sufficient accuracy will ensure the sequestration outcomes envisioned, while greater simplicity, which translates to lower costs of participation in trading, will stimulate further participation, lowering costs and raising efficiency of implementation of the Kyoto emissions limitations.

In order to achieve these goals we need to closely integrate the economic and ecology work creating dynamic feedbacks between physical and ecological characteristics of land and human land use choices. We also need to integrate the process-based and empirical ecological models to maximize the complementarities between them.

**Stochastic demography for an increasingly variable world**
William Morris, Catherine Pfister and Shripad Tuljapurkar – leaders

| Agrawal, Anurag | Klironomos, John | Power, Alison |
| Bever, James | Maron, John | Seabloom, Eric |
| Callaway, Ragan | Mitchell, Charles | Torchin, Mark |
| Gilbert, Gregory | Morris, William | |
| Kareiva, Peter | Parker, Ingrid | |
Both the means and the variances of such important environmental variables as growing-season temperature and rainfall are projected to increase in many regions over the 21st century. While effects on organisms of changes in mean conditions have often been anticipated, the potential effects of increasing variability have been relatively neglected. We propose a Stochastic Demography Working Group to assess how increasing environmental variability is likely to impact populations of plants and animals. Using unpublished demographic data for a diverse set of taxa and new theoretical tools developed by group members, we will compare the effects of changes in the means vs. the variances of environmental variables, as well as the pattern of sensitivity to environmental variability across species, life histories, and habitats. In addition, we will ask whether the demographic processes that most influence population growth are the least sensitive to environmental variation, a pattern that has been observed in the relatively small number of species previously tested and that would serve to buffer populations against increasing environmental variability. Our ultimate goal is to improve the ability of ecologists to forecast the consequences for the long-term viability of populations of not only overall trends in environmental conditions but also expected changes in year-to-year variability.

Serengeti: The origins and future of a complex ecosystem (Extended)
Craig Packer and Stephen Polasky – leaders
Abrams, Peter  Hilborn, Ray  Packer, Craig
Costello, Christopher  Holt, Robert  Polasky, Stephen
Coughenour, Michael  Hopcraft, Grant  Ritchie, Mark
Dobson, Andrew  McNaughton, Samuel  Sinclair, Anthony
Fryxell, John  Mlingwa, Charles
Galvin, Kathy  Olff, Han

The Serengeti ecosystem exemplifies a number of general features of terrestrial food web dynamics and can therefore be viewed as a model system for studying a complex interplay of basic ecological principles. These include: (1) the diverse roles of generalist top predators in governing coexistence in prey communities, (2) the importance of omnivory and intraguild predation in modulating the magnitude of 'top-down' impacts of predators, (3) trophic cascades; (4) the implications of movement, landscape pattern, and spatial heterogeneity for food web dynamics, and, (5) the impact of temporal variation on stability and species composition of local communities. The Serengeti, like many ecosystems, is subject to increasing human use. Understanding human behavior and the links between humans and the ecosystem provides a necessary foundation for conservation.

A synthetic analysis of the scientific basis of ecological restoration of stream ecosystems
Margaret Palmer and J. David Allan – leaders
Alexander, Gretchen  Carr, Jamie  Galat, David
Allan, J. David  Clayton, Steve  Gloss, Steven
Bernhardt, Emily  Dahm, Cliff  Goodwin, Peter
Bowman, Margaret  Follstad-Shah, Hassett, Brooke
Brooks, Shane  Jennifer  Jenkinson, Robin
We will assess the quality of the science underlying ecological restoration activities using stream ecosystems as model restoration systems. We will assemble a unique data set that spans multiple ecoregions and many different types of restoration activities performed by diverse groups with various stakeholder interests. Specifically, our data set will address: what kinds of restoration activities, at what scale, and by what means, are taking place; how goals were set and success measured in these restoration efforts; the extent to which scientific criteria were used; the extent to which adaptive management was an explicit component of the restoration activity; and the extent to which scientists are forming partnerships with restorationists in order to use restoration projects as opportunities for scientific experimentation. Our synthesis will facilitate the linkage between the practice of ecological restoration and the science of restoration ecology and will attempt to establish standards for data gathering to scientifically assess restoration methods and success.

Conservation planning tools
Robert Pressey – leader
Andelman, Sandy Groves, Craig Rodrigues, Ana
Bakarr, Mohamed Machado, Ricardo Sarkar, Sahotra
Cowling, Richard Polasky, Stephen Stoms, David
Crist, Patrick Possingham, Hugh Williams, Paul
Davis, Frank Pressey, Robert Wilson, Kerrie
Faith, Dan Revelle, Chuck

For the purposes of this working group, planning tools are software packages, including simple algorithms as well as decision-support systems, that are used to guide decisions about conservation action. These tools use data on the distribution of biodiversity within planning regions but might also use other data such as geographic adjacency or proximity, past land use, threats, and expected costs of conservation. The main goals of the working group are to: (1) produce a review of conservation planning tools and techniques to inform present and potential users about their applications, advantages, limitations and appropriateness for particular planning problems and circumstances; (2) review current and potential approaches to combining expert judgments and data analysis in the application of planning tools; and (3) make planners and managers aware of the potential and limitations of planning tools for dealing with the problems they encounter.

Dynamics of large mammalian herbivores in changing environments:
Alternative modeling approaches
Norman Owen-Smith, N. Thompson Hobbs, Andrew Illius, Per Lundberg – leaders
Boone, Randall
Cope, David
Coulson, Tim
Festa-Bianchet, Marco
Fryxell, John
Gaillard, Jean-Michel
Gordon, Iain
Gross, John
Hilborn, Ray
Hobbs, N.
Illius, Andrew
Kendall, Bruce
Lundberg, Per
Moehlman, Patricia
Ogutu, Joseph
Owen-Smith, Norman
Stenseth, Nils
Vucetich, John
Wang, Guiming

The world's populations of large herbivores have shown dramatically different
dynamics during the last two decades. The abundance and distribution of some ungulate
species has declined abruptly, while other species have become excessively abundant,
and still others have shown complex, oscillatory dynamics. These patterns seem to
result from a composite of influences, including those operating at global and local
scales. Conventional population models are rooted in assumptions about steady state
and do not adequately incorporate environmental variability. We propose a working
group that will exploit data sets and expertise from different regions to develop new
models of ungulate population dynamics, capable of accommodating the complexity of
environmental interactions at different spatial and temporal scales.

**Linking marine biodiversity to ecosystem functions and services**
Boris Worm and Enric Sala – leaders
Baron, Nancy
Beaumont, Nicola
Duffy, Emmett
Folke, Carl
Jackson, Jeremy
Lotze, Heike
Micheli, Fiorenza
Muthiga, Nyawira
Palumbi, Stephen
Sala, Enric
Stachowicz, Jay
Worm, Boris
Biodiversity, or biological diversity, is the variation of life at all levels of organization, from the level of genetic variation within and among species to the level of variation within and among communities, ecosystems and biomes. It is well-documented how human impacts are changing biodiversity in terrestrial (Wilson 1999) and marine ecosystems (NRC 1995). Historical studies in marine systems have further shown that long-term impacts often lead to the simplification of food webs, as species and species groups are driven to such low abundances that they become functionally extinct (Jackson et al. 2001, Lotze and Milewski 2002). The general consequences of these trends and changes for ecosystem functions, such as primary and secondary productivity, carbon and nutrient cycling, food and habitat provision are little understood in marine systems. The recent research focus on biodiversity, however, has generated a significant, albeit diffuse body of theory and empirical studies. Without synthesis, it is difficult to communicate to the public and to environmental managers why marine biodiversity matters, what the ecological and economic consequences of species loss and changes in biodiversity are, and how dramatic consequences can be prevented. The proposed working group aims to fill this gap. In addition to quantifying the link between marine biodiversity and ecosystem functioning, we will analyze the potential for the disruption of marine ecosystem services, which are those functions that are vital to our food supply, economies, and human health (see Fig. 1). Finally, we will use the results from our analyses to evaluate the costs and benefits of maintaining the status quo versus implementing significant global conservation measures. In three consecutive workshops we will (1) collate experimental and observational evidence on how marine biodiversity and ecosystem functions are linked in a web-accessible database, (2) conduct and publish a series of meta-analyses to derive generalizations about the effects of species loss, ecological simplification and changes in marine biodiversity on ecosystem functions and services, (3) write a policy paper that translates our results into management strategies.

**Meetings Hosted by NCEAS**

<table>
<thead>
<tr>
<th>Leader</th>
<th>Project Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Margaret Cavanaugh</td>
<td>National Science Foundation Advisory Committee for Environmental Research and Education</td>
</tr>
<tr>
<td>Chuck Cook</td>
<td>Conservancy Marine Workshop of California Nature Conservancy</td>
</tr>
<tr>
<td>Frank Davis</td>
<td>Coastal Reserves</td>
</tr>
<tr>
<td>Katherine L. Gross</td>
<td>National Parks Fellowships</td>
</tr>
<tr>
<td>Kathy Hibbard</td>
<td>Ecosystem model-data intercomparison working group IV</td>
</tr>
<tr>
<td>Rick Hooper</td>
<td>Scoping A Synthesis Facility for the Hydrologic Sciences</td>
</tr>
</tbody>
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**Scientific Visitors**
Name

Jordi Bascompte  CSIC-Consejo Superior de Investigaciones Científicas
Michael Bonsall  Imperial College, London
Sarah Gaichas  University of Washington
Steve Jackson  University of Wyoming
Andrew Liebold  USDA Forest Service
Patricia Moehlman  The Wildlife Trust
Christina Tague  San Diego State University
John Vucetich  Michigan Technological University

Research Training Activities

Seven graduate student interns and seven undergraduate interns were involved with research activities at NCEAS during the reporting period. They are listed below, along with the titles of the projects they worked on.

Graduate Student Interns

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<tr>
<th>Intern</th>
<th>Sponsor and Project Title</th>
</tr>
</thead>
</table>
| Sarah Abramson       | Jim Reichman  
Kids Do Ecology                                                                 |
| Britta Bierwagen     | Jim Reichman  
Kids Do Ecology                                                                 |
| Andrea Chadden       | Jim Reichman  
Mellon Informatics (Hosted by NCEAS)                                                     |
| Erin Leckey          | John Alroy  
Paleobiology Database                                                                   |
| Julie Love           | Jim Reichman  
Integrating Marine Ecology Data for Scientific Analysis and Resource Management: A Community Database Prototype |
| Jill Wertheim        | John Alroy  
Paleobiology Database                                                                   |
Undergraduate Student Interns

<table>
<thead>
<tr>
<th>Intern</th>
<th>Sponsor and Project Title</th>
</tr>
</thead>
</table>
| Valerie Bullard | Jim Reichman  
Kids Do Ecology                                                                   |
| Helen Claudio   | John Gamon  
SpecNet                                                                              |
| Jeremy Goldberg | Diego Vázquez  
Null Models for Specialization and Asymmetry in Plant-Pollinator Systems            |
| Rupech Naik     | Diego Vázquez  
Null Models for Specialization and Asymmetry in Plant-Pollinator Systems            |
| Ben Turner      | Chris Pyke  
Climate, ecosystems, and land-use: Understanding environmental variability in human-dominated landscapes |

Education and Outreach Activities

NCEAS’ Kids Do Ecology (KDE) program continues as our primary means of outreach to the K-12 Santa Barbara schools. Sarah Abramson, a graduate student intern, coordinates KDE activities. Visits by NCEAS and UCSB-associated scientists to 5th-grade classrooms remain the core of our local outreach activities. During these visits, scientists help students formulate and execute an ecological experiment, including data analysis and presentation.

Ten Santa Barbara classes and ten scientists participated in the “Scientist in the Classroom” program during the past year. A total of 205 students participated, including 135 minority students (65.7%). Examples of this year’s projects include: Why do some flowers get visited by pollinators more than others; Spider contests over a web: are winners larger; How does pollution affect fairy shrimp; Moldy Bread: looking at mold growth on bread that has been handled by dirty and clean hands; How degrading: How fast do different types of trash biodegrade; Mussel predation by sea stars: does size
matter; The role of dispersal in determining species assemblages on islands; Can We Test Water Quality By Observing Macroinvertebrate Community Composition; Examining seed germination and plant growth along a water gradient. The students will present their projects at a poster session at NCEAS 24 May, 2004, to share what they learned with each other and NCEAS residents.

In response to the 2002 site review we have updated the Kids Do Ecology web site. The new version of the site contains a simpler front page where students can select the topics of interest. The topics for kids are: Learn about Ecology, World Biomes, Marine Mammals, Kids Do Ecology in Santa Barbara, EcoLinks, and Conservation Projects. Learn about Ecology contains information describing what ecology is, what ecologists do, as well as information about how to become an ecologist and what type of preparation is required. This part of the site also explains the general purpose of Kids Do Ecology and where to find more information, organized for different grade levels. World Biomes contains information about different biomes geared towards a 5th grade level. This section also contains information about research that NCEAS residents do in different biomes. Marine Mammals pages describe the marine mammal species found in the Santa Barbara Channel and archives the data collected by students in the Los Marineros program. These pages also contain learning activities pertaining to data collection and graphing results. KDE in Santa Barbara is devoted to the projects that the local 5th grade classes do each year as well as pictures and descriptions from the poster session. EcoLinks provides students with further links to learn about Ecology on other web sites. Conservation Projects is devoted to the Common Ground in Conservation program and showcases the species that students learn about, as well as the projects that they have exchanged each year.

There are separate links to find out about NCEAS and the entire Kids Do Ecology project, teachers, and contact information. The section for teachers contains information about Kids Do Ecology projects, how to get involved, and links to other sites (e.g. ESA’s educators web site) where they can find curriculum information. The Kids Do Ecology web site (before its update) is featured in the 2003 Educators Road Map to the Web released by T.H.E. Journal.

We plan to implement a Spanish language version of the Kids do Ecology web site in the coming year.

**Publications**

Below we list publications for the reporting period 1 May, 2003 – 31 April, 2004. Note that this list includes publications that have been reported to us by participants in NCEAS activities during this period, and actual publication dates may precede this period. *Previously reported as in press.*

Press.


Lafferty, K.D. In press. Fishing for lobsters indirectly increases epidemics in sea urchins. Ecological Applications.


