NCEAS

National Center for Ecological Analysis and Synthesis

1995-2001
Report to the National Science Foundation

Final Report for Period: 05/1995 - 04/2001
Submitted on: 08/13/2001
Principal Investigator: Reichman, Omer J.
Award ID: 9421535
Organization: U of Cal Santa Barbara
Title:
CEAS: Center for Ecological Analysis and Synthesis

Project Participants

Senior Personnel

Name: Reichman, Omer
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Murdoch, William
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Goodchild, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Davis, Frank
Worked for more than 160 Hours: Yes
Contribution to Project:
Deputy Director, half-time, until 12-31-98

Name: Andelman, Sandy
Worked for more than 160 Hours: Yes
Contribution to Project:
Deputy Director, full-time, beginning 01/01/99

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Worked for more than 160 Hours: Yes
Contribution to Project:
Director of Computing

Post-doc

Graduate Student

Undergraduate Student

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

NCEAS has received an award from the Andrew W. Mellon Foundation to support two postdoctoral fellows.

Activities and Findings

Research and Education Activities:

NCEAS research activities include working groups, workshops, sabbatical fellows, postdoctoral fellows and graduate student interns. We continue to focus the majority of our support on longer term working group activities and on resident sabbatical and postdoctoral fellowships, rather than on stand-alone workshops.

During the period 2/1/99-1/31/00 NCEAS hosted 12 workshops (for 10 unique projects) and 68 working group meetings (for 46 unique projects). In addition, the Center hosted 6 sabbatical fellows and visiting scholars, and 16 postdoctoral fellows.

Requests for Proposals:

NCEAS has now issued ten Requests for Proposals with target dates of 8/1/95, 12/31/95, 9/1/96, 1/20/97, 8/15/97, 1/20/98, 8/11/98 and 1/20/99, 8/11/99 and 1/10/00. As of 1/31/00 we have received a total of 343 proposals, of which 168 were selected for funding.

Workshops:

In the past year NCEAS sponsored or co-sponsored five workshops that involved an average of 14 participants and lasted an average of three days. Workshop descriptions and lists of participants can be found at the NCEAS web site under research activities. Several of these activities involved synthesis and analysis of existing data sets and served to initiate longer-term collaborative research. The workshops have also led to a number of papers that are published or under review in peer-reviewed journals.

In September, 1999, NCEAS Science Advisory Board recommended that NCEAS should focus efforts on working groups and other activities that require NCEAS computing and other facilities, rather than on workshops that involve presentations rather than synthesis and analysis of data. As a result, NCEAS is now supporting workshops only under exceptional circumstances.

NCEAS Workshops since 2/1/99:

LTER Network Data Managers Meeting. 2-20-99 to 2-23-99.

Steve Rothstein. Workshop on Cowbird Management.   7-13-99

Jaap Kaandorp. Modelling Growth and Form of Sessile Marine Organisms. 8-23-99 to 8-27-99.

Michael Goodchild. Digital Library Workshop. 9-20-99 to 9-21-99

Steve Rothstein. Workshop on Willow Flycatcher Recovery Team. 10-29-99

Working Groups:

Since May 1995, NCEAS has sponsored 65 Working Groups. Forty-two groups have completed their work, and the remainder are in progress. Details about these groups and their activities are available on the NCEAS web site (www.nceas.ucsb.edu). Groups that were initiated during the past year are listed below, along with project abstracts for these groups, where available.

NCEAS working groups:

Developing the Theory of Marine Reserves
Jane Lubchenco
We are requesting funds to support an NCEAS working group that will focus on the development of a theoretical basis for the design and establishment of marine reserves. Although there has been an increase in the number of marine reserves designated to manage marine resources, there has not been a concomitant increase in our understanding of marine reserve theory. As a result, reserve designs have often relied heavily on theory formulated for terrestrial ecosystems or on no theory at all. Recent research on open ecosystems suggests that marine reserves designed using these principles are likely to be ineffective at protecting marine communities over the long term. This fact, along with constantly increasing human pressure on marine ecosystems, indicates that a theory of reserve design specific to marine ecosystems is urgently needed. A multidisciplinary working group organized through NCEAS has the potential to make a significant contribution to our current understanding of marine reserves. Summaries of progress to date are available on the NCEAS web site.

Ecological Monitoring of Multi-Species Habitat Conservation Plans
Frank Davis
Adaptive management of conservation lands depends on reliable and timely information concerning the effects of management actions on targeted species and ecosystem processes. Design and implementation of a monitoring system for regional, multi-species habitat conservation plans such as the Natural Community Conservation Plan (NCCP, see
http://ceres.ca.gov/CRA/NCCP/intro.htm) in southern California pose significant scientific, technical, and institutional challenges. The objective of this 1-year Working Group is to develop monitoring principles and guidelines for the NCCP reserve system that are scientifically defensible, respond to institutional and economic constraints, and can be integrated into an adaptive management framework.

Body Size in Ecology and Paleoecology - Linking Pattern and Process Across Spatial, Temporal and Taxonomic Scales
Felisa Smith
Body size has long been a central area of research in both ecology and paleoecology. With few exceptions however, ecologists have focused on spatial relationships and/or short time spans, and paleoecologists on long time scales. Little cross-linkage has existed between the two disciplines. Additionally, most studies of ecogeographic or evolutionary phenomena are restricted to single taxa. We propose to form a working group consisting of paleoecologists and ecologists, studying organisms as diverse as marine invertebrates, terrestrial
woody plants and mammals. Our aim is to synthesize the patterns of body size distribution across local to broad geographic space and from contemporary to ôdeepö time, and then to examine the processes that lead to the observed patterns.

Invasion Biology: Toward a Theory of Impacts
Ingrid Parker
The past decade produced an impressive collection of books and edited volumes on 'invasion biology' (Groves and Burdon 1986, Mooney and Drake 1986, Joenje et al. 1987, Drake et al. 1989, Hengeveld 1989). These volumes brought together case histories of a large number of invasive exotic organisms from all taxonomic groups, and invaded
communities from all corners of the globe. In addition to compiling case histories, this explosion of volumes produced a forum for the development of general observations and mostly verbal theory about the patterns and dynamics of invasions. Commonly noted was the lack of rigorous, mechanistic, experimental examples or tests of theory.

In the years since the symposia that spawned these initial volumes, researchers have gone beyond natural history and have begun investigating particular invasions in great biological detail and with more rigorous methods. In addition, in part as a response to the general recognition of exotic species invasions as one of our most pressing environmental problems (Hedgpeth 1993, Office of Technology Assessment 1993, Ruesink et al. 1995, both researchers and agencies have begun compiling databases of introduced species.

It is now time to regroup and figure out what we've learned. Because of the recent surge of empirical work, we are in a much better position now than we were a decade and a half ago to move beyond arm-waving, and the time is right for a new synthesis. A summary of project results is provided on the NCEAS web page.

Understanding the Role of Individual-Scale Processes in Community-Level Dynamics; What are the Dynamically Relevant Organizational Scales for Predicting Community Dynamics
Oswald Schmitz
Community ecologists continually strive to build models that realistically describe the dynamics of the systems they study. An important challenge is discovering which biological details are needed for accurate predictions. There is increasing evidence that processes operating at the level of individuals in communities can have an important bearing on the overall dynamics of the community as a whole. A Working Group will be convened to synthesize existing empirical information on the role of individual behavior and life-histories in shaping community dynamics, identify limitations of existing theory in dealing with issues of scaling from individuals to communities and begin developing new mathematical tools that explicitly deal with scaling from individual-level processes to community dynamics.

The Evidence Project-Supporting Scientific Claims
Mark Taper
Scientists strive to understand the operation of natural processes. To this end, they collect data both experimental and observational. The objective and quantitative interpretation of data as evidence for one hypothesis over another hypothesis is an integral part of the scientific process. None of the existing schools of statistical inference fully addresses the needs of working scientists. Scientists are forced to twist their thinking to pigeon hole their analyses into existing paradigms. We believe that a revision of statistical theory is in order, reflecting the needs of practicing ecologists. Through a dialog amongst working scientists, statisticians and philosophers this working group will seek to construct a new statistical approach focused on the quantification of evidence, which will supplement traditional paradigms. We will hone and demonstrate our approach through applications to difficult problems of ecological data analysis.

Decision Theory in Conservation Biology - Are There Rules of Thumb?
Hugh Possingham
Ecological theory and complex, often spatially explicit, computer simulations are two ways in which ecologists have attempted to help managers solve conservation problems. Both methods have provided little guidance. Ecological theory is simple enough to be general, but lacks the constraints and trade-offs to be usefully applied in the real world. Complex computer simulations target specific ecosystems ad problems (are not general), require many parameters that may be hard to estimate, and the robustness of the ensuing decisions may take years of simulating to evaluate. The primary purpose of this sabbatical will be to use existing work on the application of formal optimism tools, like stochastic dynamic programming, to develop
simple and robust 'rules of thumb' for two major conservation problems, disturbance management and metapopulation management. In its grandest sense, I wish to outline a theory of applied conservation
biology - something which I believe does not exist.

This research proposal arises from an NCEAS working group on population management held in August 1997 (Shea, Mangel and Possingham). Some ancillary projects initiated in the workshop need to be completed., In the July 1998 NCEAS proposal round I will apply for funds to reconvene parts of the population management workshop. My research will be split between the problem described above and
tidying up ancillary projects from the working group.

A Sampling-Standardized Analysis of Phanerozoic Marine Diversification and Extinction
John Alroy
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 postdoc, who will serve aqs 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.

An Information Infrastructure for Vegetation Science
Robert Peet
Vegetation classification is of central importance to biological conservation for plannning 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 persisitence 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.

Through the combined efforts of The Nature Conservancy (TNC), the Ecological Society of America Vegetation Panel (ESA-VP), and the Federal Geographic Data Committee (FGDC), the United States is on the verge of having its first fully fu

Nitrogen Transport and Transformations; A Regional and Global Analysis
Robert Howarth
On behalf of the Scientific Committee on Problems in the Environment (SCOPE), we request funds to partially support the final synthesis activities of the SCOPE International Nitrogen Project. This project was established in 1993 to improve our understanding of the global nitrogen cycle via a focus upon changes at the scale of large regions; since that time four regional workshops have been held in the U.S., Chile, Taiwan, and Japan, with a fifth planned for China this October. Here, we describe a two year plan aimed at synthesizing and completing the Nitrogen Project. We have secured funds from the Mellon Foundation for a final symposium and for a book to be published in the SCOPE series. Our request to NCEAS is for support for 3 major activities that will lead up to and/or expand the final symposium and book. These include: 1) a number of small working groups that will focus on specific uncertainties in the global N cycle and will meet at the Center 2-3 times over an 18 month period; 2) a sabbatical as an NCEAS fellow for the co-chair of the SCOPE Nitrogen Project, Bob Howarth; and 3) the creation of a web site at the Center devoted to providing data and information on regional to global scale N cycling.

Analysis and Synthesis of Trace Gas Fluxes
Dennis Ojima

Current estimates of atmospheric growth of key trace gas species are based on scanty measurements of the sources and sinks of these compounds. The terrestrial processes controlling the fluxes of these trace gas have been studied over the past decades, but a coordinated effort to synthesize these studies and to analyze the environmental controlling factors has not been conducted. A critical synthesis of information on the biotic and abiotic controls of trace gas fluxes is needed in order to advance our ability to determine regional estimates of various trace gas compounds. The U.S. TRAce Gas NETwork (TRAGNET) is developing an accessible data base of multi-year trace gas flux data (and ancillary data).

Sampling Curves in Ecology; Theory and Application
Gareth Russell, Michael McKinney
The working group is founded on the proposition that various empirical 'sampling curves' such as species-area, species-time, can be derived from a simple sampling curve by incorporating the patchy nature of communities in space and time. Its participants have made recent advances in theory which link together two or more types of sampling
curve. The group has four phases. In the first and second phases, we will put the 'state of the art' into the context of a framework that identifies two types of distortion of a basic sampling curve: the island model and the landscape model. In the third phase we will use this framework to combine the approaches of the island and landscape models into unified theory. In the fourth phase we will explore the practical implications of a unified theory for conservation. The end result will be an edited volume, Sampling Curves in Ecology: Theory and Application.

Habitat and Climate Inference from the Structure of Mammal Communities
John Damuth
Paleomammalogists have explored in recent years a variety of techniques for inferring past climate and vegetation from structural characteristics of fossil mammal communities and faunas. These techniques hold enormous promise for expanding temporal and geographic ranges over which we can make accurate, objective reconstructions of terrestrial habitat characteristics (chiefly, vegetation) and local or regional climate. However, we badly need a comparison, evaluation, and synthesis of the various methods. This working group developed a global dataset of mammal faunas, by
pooling and standardizing the data participants contributed, as well as by compiling additional information at the workshop. This dataset will allow us to evaluate different variables and methods by checking them against the same global dataset, in order to generate the most effective means of using mammalian community data to infer climate and habitat. In future work we will apply the techniques to Quaternary and Tertiary data, both to test out the techniques in practice and to shed light on selected paleoecological questions.

A Supply Function for Carbon Sequestration - Multi-Disciplinary Estimation and Integrated Sensitivity Analysis
Alexander Pfaff

Analyzing the Demographic Structure of Geographic Ranges-Investigating Techniques to Predict Geographic Range Size
Brian Maurer
We propose to develop a technique to study geographic variation in the demography of species of birds in North America adequately sampled by
the Breeding Bird Survey. We will examine a general model of population dynamics that includes geographic variation in density dependent and independent population processes. The procedure we use will estimate parameters of this model using estimating equations

Interdisciplinary Synthesis of Recent Natural and Managed Floods
William Michener
Science, policy, and resource management knowledge gaps as they relate to flooding will be addressed by three NCEAS working groups. Specific objectives are to:
 synthesize existing knowledge, incorporating inter-site comparative analyses where appropriate;
 relate results from studies of natural flood disturbances to those of managed floods to devise scientifically sound management prescriptions;
 examine how floods have served as the impetus for policy change and evaluate the effectiveness of those policies; and
 identify needs and design research approaches that can take advantage of new ôwindows of opportunityö.

Ecology of Infectious Disease; Roles of Biodiversity, Biotic Interactions, and Global Change
Richard Ostfeld

Emerging infectious diseases plague humans thoughout the world, but the ability of scientists to anticipate and prevent epidemics is severely limited. Forecasting disease outbreaks will require a better understanding of the ecological interactions among pathogens, vectors, hosts, reservoirs, humans, and their environments. The goals of this Working Group are to describe the general patterns and principles that characterize the roles of biodiversity, biotic interactions, and global change in the dynamics of disease; and to organize and synthesize ecological information such that biomedical researchers can apply it to disease abatement.

Predicting Population Level Effects of Toxicants
Roger Nisbet
Exposure to sub-lethal concentrations of many toxic compounds in the environment affects the rates of assimilation and utilization of food by individual organisms. These effects may lead to large changes in the dynamics of a population, and to the structure of communities. Dynamic energy budget (DEB) models have had considerable success in describing the effects of toxicants on individual performance, notably in describing changes in rates of growth and reproduction. This proposal has two components:

Synthesis of DEB theory for effects of contaminants on individual organisms.
Development of DEB-based theory for population dynamics, including synthesis of three different modeling approaches currently applied to practical problems in conservation ecology, environmental impact assessment, and water quality management.

The first will be the responsibility of R.M. Nisbet during a one-year sabbatical at NCEAS. The second will involve a working group of theorists and experimentalists. Methodology will be evaluated through modeling marine microcosms, before widening the group's activity to natural and managed populations.

Extending, Synthesizing, and Applying Recent Advances in Competition Theory
Peter Abrams

Optimal Management of Ecosystem Services
Joan Roughgarden

Prospectus For An Analysis of Recovery Plans and Delisting
Dee Boersma

Theoretical and Empirical Approaches to the Study of Gene Flow in Fragmented and Managed Populations
Victoria Sork

Developing and Testing Methods for Estimating Species Extinction Risk
Mark Burgman

The Ecological Consequences of Altered Hydrological Regimes
Robert Naiman

Evaluation of the Nursery Role of Wetlands and Seagrasses for Better Conservation and Management
Michael Beck

3.4. Sabbatical Fellows and Visiting Scholars

During the reporting period the Center sponsored sixteen sabbatical fellows.

Names with * are continuations of sabbaticals initiated during Year 4.

Gay Bradshaw Sabbatical Fellow
05-01-99 - 10-31-00
Restoring the Landscape-An Analysis of Native American Approaches to Ecological Restoration

James Brown Sabbatical Fellow
09-01-99 - 01-15-00
Sabbatical Proposal to Spend Fall Semester 1999 at NCEAS

Andrew Liebhold Sabbatical Fellow

06-29-99 - 08-27-99
Application of Geostatistics in Ecology

Bruce Milne Sabbatical Fellow
01-01-00 - 06-30-00
Center Fellow Proposal - Theoretical Landscape Ecology

Cynthia Moss Sabbatical Fellow
10-15-99 - 11-30-99
Analysis and Synthesis of Results of Studies Carried Out Over Three Decades by the Amboseli Elephant Research Project in Kenya

William Reiners Sabbatical Fellow
01-01-00 - 12-31-00
Modeling Ecological Influences Across Landscape Space - A Sabbatical Proposal

Robert Warner Sabbatical Fellow
09-01-99 - 08-31-00
Open vs. Closed Marine Populations - Synthesis and Analysis of the Evidence

*Frederic Wagner Sabbatical Fellow 01/01/98 - 03/31/99
Synthesis of elk influences on the northern yellowstone ecosystem and role of research in national park policy setting

*Roger Nisbet Sabbatical Fellow 07/01/98 to 06/30/99
Predicting Population Level Effects of Toxicants. Sabbatical Fellow

*Ted Case Sabbatical Fellow 08/10/98 to 06/15/99
The Biogeography of Endemism, Age, and Area.

*Warren Porter Sabbatical Fellow 09/01/98 to 08/31/99
Climate-Ecological Interactions; Individual, Population and Community Connections

*Joan Roughgarden Sabbatical Fellow 09/01/98 to 08/31/99
Optimal Management of Ecosystem Services

*Mike Willig Sabbatical Fellow 09/01/98 to 08/31/99
Latitudinal Gradients of Diversity-A Taxonomically & Geographically Comparative Perspective

*Hugh Possingham Sabbatical Fellow
12/01/98 to 04/30/99
Decision Theory in Conservation Biology - Are There Rules of Thumb?

*Rudolf de Groot Visiting Scientist
12/27/98 to 03/27/99

*Robert Howarth Sabbatical Fellow
01/01/99 to 06/30/99
Nitrogen Transport and Transformations; A Regional and Global Analysis

3.5. Postdoctoral Fellows

Eighteen postdoctoral fellows were in residence at NCEAS for all or part of the past year. Nine fellows were engaged as members of Working Groups while others were funded for independent research. Several NCEAS postdoctoral fellows completed their stays at NCEAS during 1999, or will complete them in early 2000. Priyanga Amaresekare accepted a position at University of Chicago, Jordi Bascompte accepted a position at the Spanish Academy of Sciences, Ottar Bjornstad accepted a position at Pennsylvania State University, Kathy Cottingham has accepted a faculty position at Dartmouth College, Tim Keitt accepted a position at the State University of New York, Stony Brook, Bruce Kendall accepted a faculty position at UC Santa Barbara, Camille Parmesan has been offered a faculty position at the University of Texas, Fiorenza

Micheli has accepted a faculty position at Stanford University. Several other fellows will be interviewing for faculty positions over the next several months. Names with * are continuations of postdoctoral fellowships initiated during Years 1-4.

NCEAS Postdoctoral Fellows, 2/1/99 -1/31/00

Cheryl Schultz
03-01-99 - 02-28-01
Managing Natural Areas; How Do We Select Among Land Management Options?

Garry Peterson
05-06-99 - 06-30-00
Theories for Sustainable Futures; Understanding and Managing for Resilience in Human-Ecological Systems

Barney Luttbeg
07-01-99 - 06-30-01
The Evidence Project

Mary Towner
07-01-99 - 06-30-01
The Evidence Project

Lisa Thompson
07-01-99 - 06-30-01
The Ecological Consequences of Altered Hydrological Regimes

Brian Enquist
07-01-99 - 12-31-00
Allometry

Jack Williams
09-20-99 - 09-19-01
Integrating Satellite and Pollen Data With Biogeochemical Modelling to Reconstruct Long-Term Trends in the Productivity and Carbon Sequestration of Terrestrial Ecosystems

Michael McCarthy
09-29-00 - 06-30-00
Developing and Testing Methods for Evaluating Species Extinction Risk

Camille Parmesan*
06/01/96 - 03/31/99
Assessing Effects of Globa l Change by Geographica Analysis of Population-Level Persistence Data

Eric Seabloom*
06/01/97 - 05/31/99
Plant-Animal Interactions in the Landscape

Jordi Bascompte*
01/16/98 - 1/15/00
Habitat Fragmentation; From Spatially Explicit Models to the Analysis of Patterns in Real Ecosystems

Tim Keitt*
01/15/98 - 08/31/00
The Ecological and Evolutionary Dynamics of Species' Borders

Jochen Schenk*
05/01/98 - 04/30/99

Towards an Explicit Representation of Root Distributions in Global Models

John Alroy*
09/01/98 to 08/31/00
Paleoecology of North American mammals; large-scale patterns and processes

Ottar Bjornstad*
09/15/98 - 12/31/00
Recruitment Variability and Population Dynamics

Priyanga Amarasekare*
09/15/98 - 09/14/00
Spatial Processes and Multi-Species Interactions; Insights for Biodiversity Management

Leah Gerber*
01/15/99 - 01/14/00
The Influence of Body Size on Effects of Disease in Populations

Dawn Kaufman*
12/15/98 - 12/14/00
The Latitudinal Gradient of Diversity - Synthesis of Pattern and Process

Researchers at NCEAS must integrate an array of arbitrarily structured and poorly documented data sets. It is critically important that NCEAS investigators, in collaboration with the Center's technical staff, prepare and organize information about these data to facilitate appropriate use and dissemination of the synthesized databases. While some work has been completed towards the development of standards for ecological metadata, relatively little has been done on issues surrounding the technological implementation of a system that could make use of those content standards. Along these lines, we received one-year supplemental NSF funding to hire a software and database developer (Rudolf Nottrott) for the project 'Automation of Ecological Data Management Using Structured Metadata.' This effort is using Standardized General Markup Language (SGML) to formalize a content standard for ecological metadata, and is building a suite of automated data management tools written in Java that use this formalized standard.

Findings:

Findings from NCEAS projects have been reported in over 220 peer-reviewed publications in more than 67 journals. These are listed under the section on products and publications.

Training and Development:

Graduate Student Training

In collaboration with the Society for Conservation Biology, NCEAS initiated another multi-campus graduate seminar, involving 19 universities, 23 faculty and over 200 graduate students, to evaluate the effectiveness of recovery plans for endangered species. This effort is modeled after the successful NCEAS/AIBS multi-campus graduate seminar and working group last year, which analyzed the role of science in Habitat Conservation Plans prepared under the Endangered Species Act. This activity provides graduate students with direct experience in the application of ecological science to important policy issues. Students gather data and develop a large database of information about a representative sample of recovery plans. At a workshop at NCEAS students participate in the analysis of the database and in developing scientific publications and policy recommendations to the U.S. Fish and Wildlife Service, based on this analysis.

In addition, the Center supports two different types of graduate interns: working group research assistants and programmatic research interns. The former are requested by working groups as part of their request for funds, whereas the latter are appointed by the Director in order to help meet ongoing Center-based activities related to outreach, data management, and long term research initiatives. Both groups are hired by competitive searches that are announced to relevant campus departments via the Internet. Students are selected based on their academic record, training, and research interests. The Center makes special efforts to recruit individuals from underrepresented minorities. Table 8 lists the eleven interns that were employed at the Center last year and their associated projects.

Table 8. NCEAS Graduate Interns, 2/1/99 - 1/31/00
(Faculty supervisors are indicated in parentheses)

Intern   Project Title

Scott Bell Kids Do Ecology (Jim Reichman)

Cory Craig Developing and Testing Methods for Classifying Species Extinction Risk (Sandy Andelman)

Ayoola Folarin Ecological Stoichiometry of Plant-Herbivore Interactions (James Elser)

Kaho Hoshino The Nursery Role of Near Shore Sea Grass Beds (Michael Beck)

Andrea Huberty Ecological Stoichiometry of Plant-Herbivore Interactions (James Elser)

Michael Jennings Ecology of Steppe and Grassland Vegetation of the Columbia Plateau (Frank Davis)

Keri Johnson Ecosystem Model-Data Intercomparison Working Group on Data - Synthesis, Formats, and Establishment of an EMDI Server Facility (Richard Olson)

Lisa Kramer Ecology Transformed (Edward Hackett)

Dale Lockwood Developing the Theory of Marine Reserves (Jane Lubchenco)

Brendan Lucey Spatial Ecology of Infectious Disease (Leslie Real)

Kirsten Parris Analysis and Synthesis of Results of Studies Carried Out Over Three Decades by the Amboseli Elephant Research Project in Kenya

Heather Rosenburg Data Management for the Ecological Sciences (Matt Jones)

Michael Sommers A Sampling-Standardized Analysis of Phanerozoic Marine Diversification and Extinction (John Alroy)

Matt Wilson Value of the World's Ecosystem Services and Natural Capital;Toward a Dynamic, Integrated Approach (Robert Costanza)

Outreach Activities:

The Center is expanding outreach efforts to improve Internet access to ecological data and information. In keeping with this approach, we rely almost exclusively on the Internet and the World Wide Web to disseminate Center-related information and summaries of findings.

In collaboration with the University of California's Centers for Water and Wildlands Resources, we continue to maintain a Web-based, interactive version of their Directory of Environmental Expertise in the University of California and California State University Systems.

A comprehensive report on the analysis of the role of science in Habitat Conservation Plans under the Endangered Species Act, a project sponsored jointly by NCEAS and AIBS is available on the Center's web site, and has been accessed from over 1000 different computers. In addition, the comprehensive database developed as part of this project is also available on the NCEAS web site.

In the K-12 area, we are continuing our partnership with the Los Marineros program, which serves as the core science curriculum for the 5th grade classes of the Santa Barbara School District. NCEAS maintains the 'Kids do Ecology' program. 'Kids do Ecology' focuses on improving science education and increasing awareness of ecology in the local community. The program is a partnership with a locally developed science curriculum called Los Marineros which is the basis of the natural and physical sciences curriculum for all 5th grade students in Santa Barbara. Los Marineros was developed jointly by the Channel Islands Marine Sanctuary and the Santa Barbara Museum of Natural History and is currently coordinated by the museum.

The partnership has several distinctive features. Rather than initiate a new program with the local schools, the Center tapped into an existing, highly acclaimed program and fulfilled a need they identified. The Center has employed two graduate interns (successively) to coordinate the program. These students were very interested in science education and both had some experience before joining. The Center paid salaries equivalent to Graduate Assistantships at UC-Santa Barbara, and used matching support from the Graduate Division to defray some of the out-of-state tuition expenses.

The total cost to NCEAS has been approximately $39,000 over 25 months.
The goal of the Kids Do Ecology program is to enhance student appreciation of science by exposing them to a complete empirical experiment related to some aspect of ecology. Scientist volunteers from NCEAS (sabbatical visitors, post-docs, staff scientists and graduate interns) adopt a 5th grade class and develop an ecology experiment that the class conducts during the school year. The program has been carried out for 2 years and NCEAS scientist participation has increased each year. In 1997/98, the first year that scientists visited local classrooms, eleven scientists worked with ten classes, in the current year (1998/99) twenty scientists are working with fifteen classes.

The twenty-five 5th grade classes that have been involved in the past two years represent almost 800 local students (71% of whom represent minority populations). Every class participating produces a final experiment report that is published on the Kids do Ecology website (http://www.nceas.ucsb.edu/nceas-web/kids/). The website also houses general science and ecology information which children around the world can use. At the end of the 1998-1998 school year the students will hold a poster session much like those at scientific meetings to present their results.
NCEAS also serves as the database manager for the Los Marineros program -- data collected during fieldtrips as part of the Los Marineros curriculum are integrated into lessons on the website relating to data, graphing and the scientific method. By integrating numerous class data sets in a common database NCEAS has created a warehouse for local school-based data. The program has been evaluated by scientists, teachers and students using a survey with both structured and open items. Results of these surveys have helped NCEAS refine and enhance the program. The response by those participating has indicated that the program has been a success.

Journal Publications

Abrams, P.A., "The adaptive dynamics of consumer choice.", American Naturalist., p. , vol. , (1999). Accepted

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Web/Internet Site

URL(s):

www.nceas.ucsb.edu

Description:

The Center"s web site provides detailed information on the mission and all research, training and outreach activities conducted at NCEAS. In addition, comprehensive databases compiled as the result of NCEAS working groups, lists of publications resulting from NCEAS projects, as well as a wealth of other information, is available on the web site.

Other Specific Products

Product Type: Data or databases

Product Description:

The following databases have been developed as a result of NCEAS working groups:

Summary of average global value of annual ecosystem services
Summary of maximum global values of ecosystem services
Summary of minimum global values of ecosystem services
International values of ecological and economic resources and processes
U.S. ecosystem service values by habitat type
Intrinsic and Extrinsic Variability in Community Dynamics (for Little Rock Lake, Cascade and LTER sites)
Intrinsic and Extrinsic Variability in Community Dynamics
(for Dorset, Ela and Mono Lake sites)
Decline in Carbon Assimilation of Forests: Australia (BFG)
Decline in Carbon Assimilation of Forests: Colorado (FEF)
Decline in Carbon Assimilation of Forests: Florida (Gainesville)
Decline in Carbon Assimilation of Forests: Hawaii
Decline in Carbon Assimilation of Forests: N. Carolina (SETRES)
Decline in Carbon Assimilation of Forests: N. Sweden (Flakaledin)
Decline in Carbon Assimilation of Forests: N. Wisconsin

Sharing Information:

These databases are accessible through the NCEAS web site. In some cases data sets have been designated as 'restricted distribution' status. This indicates that permission must be obtained from the project leader before data sets can be distributed. In a few cases, data are proprietary and cannot be distributed without permission from the relevant organization or agency.

Product Type: Software (or netware)

Product Description:

'Sites,' decision support software for nature reserve network design was developed by the NCEAS Biological Diversity working group led by Sandy Andelman. This software uses simulated annealing and a boundary length modifier to facilitate spatially explicit reserve system design, for complex conservation goals. The software is now being used by The Nature Conservancy, the world's largest conservation organization, as well as by several state and federal agencies to facilitate conservation planning and resource management.

Sharing Information:

The software is available on CD-Rom, by request from NCEAS.

Contributions

Contributions within Discipline:

The idea for an ecological synthesis center is based on the premise that there is a significant amount of knowledge about the ecological world, but that it is scattered in disparate places and formats, making true synthesis difficult.

The Center facilitates analysis and synthesis activities by providing
facilities and logistical support. A number of visitors have mentioned this as an important service that allows them to conduct a working group while they are busy with many other responsibilities. In the final analysis, the most important element of NCEAS is the opportunity to interact in distinctive ways. We work with
NCEAS visitors to customize their approach to the issue at hand, guiding them towards novel approaches. We suggest that they seek collaborations with colleagues that might not come intuitively to mind. Furthermore, once groups arrive they interact with each other and with other visitors in ways that could not have been imagined in the initial phases of their proposed work. As important as the direct results from any particular activity at NCEAS are, we are convinced that it is the unanticipated interactions fostered by the Center atmosphere that will eventually be the most important legacy of NCEAS.

There is growing evidence that NCEAS is creating a 'culture of synthesis' within ecology and related disciplines. Thus collaborations fostered at NCEAS are beginning to permeate through the discipline. Since May 1995, NCEAS has hosted over 1285 different visitors from 51 states (including Puerto Rico) and 36 foreign countries. This represents a 60% increase in the total number of participants in NCEAS activities during the past year. During the period 2/1/99-1/31/00, NCEAS hosted 7 workshops and 37 working groups in a total of 162 meetings. In addition, the Center hosted 15 sabbatical fellows and visiting scholars, and 18 postdoctoral fellows.

NCEAS research findings are being disseminated widely in journals. In total, 220 papers have been published in 567 journals, including Science, Nature, Trends in Ecology and Evolution, Ecology, and American Naturalist. In addition 4 books and 65 book chapters have been produced from NCEAS activities.

We expect that one of the major impacts NCEAS will have on changing the culture of the ecological community is through its effort in ecological informatics. Most NCEAS projects bring together pre-existing data, so it is in the best interest of the Center to promote activities which make data sharing and access more
effective. Therefore, the Center has hosted several working groups and committees whose responsibilities include informatics. For example, ESA's Committee on Data Archiving and Storage met twice at NCEAS, and NCEAS has hosted its own Informatics Working Group. In addition, we help many of the groups that come to the Center get their data in formats that promote sharing and analysis, which imbues the group members with a sense of what can be done with regard to
informatics. For example, for those groups that are interested, we establish a private user area on our web site through which the members can exchange information, data, manuscripts, and figures when they are away from the Center.

Contributions to Other Disciplines:

Contributions to Human Resource Development:

NCEAS continues to emphasize training and outreach activities, especially in the areas of Graduate Student Training, Informatics, and K-12 science education. One product from one of the Center's activities in 1998, the analysis of the role of science in habitat conservation plans, has emerged as a novel approach to providing new type of teaching opportunities and new venues for integrating education in ecology with increasing the role of science in policy and resource management. This model, a web-coordinated, multi-campus graduate seminar, is already being used for additional projects on other topics.

Kid do Ecology (KDE), NCEAS' continuing partnership with the Los Marineros program, which serves as the core science curriculum for the 5th grade classes of the Santa Barbara School District, provides an opportunity for both fifth grade students and their teachers to interact with senior Center scientists, postdocs and graduate students. In the past two years almost 800 students, 71% of whom represent minority populations, and 25 5th grade teachers, have participated in this program. Every class participating produces a final experiment report that is published on the Kids do Ecology website (http://www.nceas.ucsb.edu/nceas-web/kids/), which provides access to information about the project for educators around the world.

NCEAS is already having an impact on the ecological community, both through its efforts in ecological informatics, and by catalyzing a culture of collaboration and synthesis among ecologists who participate in Center activities.

Contributions to Resources for Research and Education:

Many of NCEAS' contributions have been described elsewhere in this report.

Contributions Beyond Science and Engineering:

NCEAS' project on evaluating the role of science in habitat conservation plans (HCPs) under the Endangered Species Act has influenced the way the U.S. Fish & Wildlife Service and National Marine Fisheries Service administer the HCP process. Specifically, several of the recommendations produced in the NCEAS/AIBS report (available on the Center's web page) have already been incorporated into revisions of the HCP handbook, a guide for federal employees who administer and provide permits for these plans. In addition, the HCP report itself has been accessed by more than 1000 unique computers (presumably representing approximately the same number of different individuals). A follow-up activity at the Center will bring together land-owners, upper-level federal and state agency managers, and scientists to develop specific suggestions for how to improve ecological monitoring, incorporate uncertainty, and expand the role of independent peer review in the HCP process.

A second NCEAS project on models for reserve network design has developed a number of practical software modeling tools that are being tested by scientists and planners in The Nature Conservancy (the world's largest conservation organization) and several state agencies. In addition to providing exposure to practical tools that will facilitate more systematic and science-based planning, several members of the working group have conducted training workshops for ngo and agency staff in applying ecological and conservation biology principles to conservation planning and management on the ground.

Categories for which nothing is reported:

Organizational Partners

Contributions: To Any Other Disciplines

Introduction

Ecologists seek to understand complex, dynamic biotic and abiotic interactions across many scales. Such understanding is fundamental to our ability to sustain, manage and restore healthy, functioning ecological systems in the face of unprecedented human modifications and environmental change (NSB 1999). Although considerable progress has been made in advancing ecological knowledge, vast amounts of relevant information about ecological patterns and processes remain largely inaccessible because they exist in widely disparate locations and formats and the culture of synthesis is not widespread (Pickett 1999).

Recognizing the potential value of existing complex data sets and the need for new approaches to assembling, accessing and synthesizing this information, the ecological community rallied around the notion of creating a synthesis center - a unique facility to promote access to ecological information, analytical tools, and collaborations among ecological scientists. In 1994, NSF initiated a special competition for a center for ecological analysis and synthesis. After extensive review, the award was made to the University of California, Santa Barbara. The National Center for Ecological Analysis and Synthesis (NCEAS) began operation May 1, 1995, under the guidance of the original PIs William Murdoch (who served as interim Director for the first year) and Michael Goodchild.

NCEAS began with a specific mission and set of goals articulated by the ecological community through a series of national workshops. In only 4.5 years, through support of innovative research (Tables 1-2), NCEAS has already exceeded many of these goals with regard to the nature and scope of what was initially imagined. In this very short time, relative to the history of the discipline, NCEAS has enabled ecologists to overcome many intellectual and technical barriers to synthesis and has dramatically altered the culture of ecological research.

The vision for NCEAS has been to catalyze a new culture of synthesis. The NCEAS research model mixes junior and senior ecologists with scientists from other disciplines and resource managers in small, interactive groups. This model for collaboration has been particularly successful with 1) interdisciplinary syntheses that bring together people who have not collaborated before to focus on novel questions and approaches and 2) intensive, sustained investigations to make progress in core areas of ecology. Over the next six years we plan to continue to serve the ecological community by cultivating a new generation of ecologists who merge interdisciplinary interactions, intensive analysis or modeling, and the technology and culture of information management with their inherent intellectual curiosity and commitment to yield important, scholarly research.

Below, we provide information about the array of activities at the Center. We concentrate on the major features of the Center's research activities. A comprehensive list of NCEAS projects (Appendix 1), and other documentation and ancillary information are available in appendices and on the web (www.nceas.ucsb.edu/renewal). All figures and tables cited in the text are provided in Appendix 2. Additional information was presented during the site visit in 2000.

<u>The Center's Mission</u>

The Mission for the Center is quite broad and, as the name implies, its primary objectives are analysis and synthesis. Analysis includes the examination of large data sets, analytical work on ecological patterns and processes, computer models and simulations, and the development of theory. Synthesis includes the amalgamation of data and the integration of ideas. The nature of the Center's activities, which promote planned and serendipitous interactions, significantly increases the opportunities for novel solutions to important questions.

The Mission of NCEAS is to:

Advance the state of ecological knowledge through the search for general patterns and principles, and

Organize and synthesize ecological information in a manner useful to researchers, resource managers, and policy makers addressing important environmental issues

Given the influence of NCEAS activities on the process of conducting ecological research, it is reasonable to add a third element to the Center's Mission Statement:

Influence the way ecological research is conducted and promote a culture of synthesis and collaboration.

It may have been presumptuous to propose this when NCEAS began, but it now appears that NCEAS is having such an influence. Graduate students, interns, and Postdoctoral Associates are learning the skills of true synthesis and senior scientists are adopting readily the NCEAS model of collaboration. It is virtually impossible to convey in writing what may be the essence of NCEAS – that intense spark of insight and scholarship that can emerge when individuals from disparate disciplines focus on a question (Pickett 1999; Pickett et. al. 1999).

NCEAS operates under five goals established early in the Center's development:

1. *Develop opportunities that accelerate and initiate paradigms* – it is difficult to identify *a priori* those areas or topics that will yield the next important advance in a discipline or ensure that advances will actually be made. However, an effective approach is to employ an operational model, establish an intellectual atmosphere and provide a physical setting that maximize the possibility that important research will be conducted. A review conducted by the Center's Science Advisory Board (SAB; Appendix 3) found that research at NCEAS often catalyzes or accelerates advances in the field. The caliber of research conducted by visitors to the Center, as revealed by publications and other products, provides evidence of the value of these unique opportunities.

2. *Make NCEAS the facility where scientists look to support analysis and synthesis of existing ecological information using creative approaches* – 1706 scientists from 49 states and 39 countries have participated in NCEAS research activities. The

Center receives 40 - 80 proposals annually (representing approximately 260-520 individuals), 35% of which are supported (Figure 1). While it is difficult to assess who actually knows about NCEAS and who contemplates research at the Center, the number of unique visitors, the breadth of the disciplines they represent, and the range in academic rank and scope of their home institutions (Figures 2-4 and Table 3) suggest that the Center is broadly known and utilized.

3. *Maintain a Center with a national character and broad interests* – In addition to the breadth of participation, research at the Center spans all of ecology and many adjacent disciplines, from genetics to evolutionary ecology and ecological economics. NCEAS participants belong to more than 240 scientific societies (www.nceas.ucsb.edu/renewal/societies) and 21% of the visitors are international. Every effort has been made to keep NCEAS from succumbing to one approach, sub-discipline, or view of ecology, and the Center has broad geographic, institutional, and intellectual representation.

4. *Provide information to scientists, managers, and policy makers* – By its very nature, NCEAS research depends on large amounts of data. Because ecological data are inherently complex and heterogeneous the Center has developed skills and tools to address many components of information management. Initially, this was done project-by-project and we expect this customized support to continue. Beginning this year, we have expanded our efforts to facilitate data synthesis. Along with several collaborating institutions, we are developing generic solutions to managing complex ecological information. The goal is to make all aspects of the data stream as coherent and convenient as possible by technologically and culturally promoting data access. In addition, the Center has supported several efforts to facilitate access to that information by managers and policy makers.

5. *Maintain a Center that provides flexible, convenient support for visiting scientists* – The Center is flexible both operationally (scheduling and supporting meetings and resident scientists and providing customized computing support) and scientifically (allowing projects to evolve toward newly discovered questions and approaches). This flexibility promotes an interest and willingness to take on a major research effort, and leads to effective collaboration. As one visitor noted, NCEAS substantially lowers the activation energy required to initiate a project.

Evidence of Progress

NCEAS should be judged by the scope and significance of the research it supports, and by the degree to which these activities influence the way we conduct our science. These are very difficult to assess. The Center is still quite new, and is just reaching full stride, so traditional metrics such as citation indices may not be the most effective evaluation criteria. In an effort to evaluate the significance of the research conducted at NCEAS, and the effectiveness of the NCEAS model in promoting synthesis, we conducted two studies. In the first the SAB divided into 4 groups. Each group selected and reviewed 4-8 papers, with several criteria in mind. Elements of their comments are included below, and the numerical responses to the evaluation criteria are in Appendix 3. The second review, by Dr. Ed Hackett, a social scientist whose specialty is the nature of collaborations, involved analyses of how NCEAS scientists interact and how participants' own research approaches changed after visiting the Center (Appendix 4). In addition, the present and past Postdoctoral Associates at NCEAS developed a short report on the benefits and limitations of postdoctoral research at the Center (Appendix 5).

Before presentation of the results of these evaluations, a few highlights:

- The 1706 scientists participating in NCEAS research activities during the first five years of the Center's operation have produced more than 220 peer-reviewed papers in 67 journals, including many leading publications (Figure 5 and www.nceas.ucsb.edu/renewal/pubs);
- NCEAS participants belong to more than 240 different scientific societies (www.nceas.ucsb.edu/renewal/societies);
- In addition to results from specific projects, numerous anticipated but unpredictable interactions have taken place between and among resident and visiting scientists, resulting in significant new research collaborations;
- A number of projects have developed major synthetic data sets that will have significance to the broader ecological community (Appendix 6);
- In the last 18 months NCEAS Postdoctoral Associates have accepted faculty positions at Dartmouth College, University of Texas, University of California, University of Chicago, the National Science Council of Spain, and Stanford University;
- 411 graduate and undergraduate students have been involved in NCEAS research activities, at the Center, as well as through web-based collaborative seminars;
- NCEAS has become a major participant in emerging informatics research efforts (including recent awards totaling $3.9M);
- NCEAS' resident scientists are involved in the science curriculum of the Santa Barbara School District and the Center serves as the "database manager" for the 5^{th} grade science classes;
- The results of Center research have received recognition in local, regional, and national press including SCIENCE, NATURE, the NY Times, LA Times, National Public Radio, Public Television, and other national television programs;
- NCEAS projects have influenced public policy and resource management in many ways, from testimony before Congress to the development of analytical tools.

Overview and Evaluation of Science Activities

Research Projects - NCEAS supports several types of research activities. The most distinctive are Working Groups – small groups that meet for several days to weeks multiple times a year. Unlike workshops, Working Groups actually conduct research at the Center. NCEAS also supports 4-6 Center Fellows (sabbatical visitors), 10-15 Postdoctoral Associates, and several graduate interns each year. A list of working groups, sabbatical, and postdoctoral research projects is provided in Appendix 1 (also at www.nceas.ucsb.edu/renewal/projects). Approximately 40% of the proposals received are requested by the NCEAS staff or SAB. The remainder come in on their own. The proposals are reviewed by the SAB and recommendations are made to the Director and Deputy Director.

Research at NCEAS stretches from genes to the biosphere and includes all levels of organization in between. The sense of the SAB from their review of papers is that it is too early to claim breakthroughs, but rather, many of the papers they read made major advances in the field. They also noted that research at NCEAS often accelerated advances already taking place. Of 24 papers read, more than 70% were viewed as high caliber, 50% were indicative of the novel NCEAS approach, and 36% were viewed as major advances (Appendix 3). While we have nothing to compare directly to these numbers, most members of the SAB thought these ratings far exceeded manuscripts they receive for review or characteristic papers published in mainline journals.

A number of research themes has emerged naturally from both proposals submitted and from proactive efforts by the Center. It is impossible to capture the breadth and depth of research done in all areas, but below we provide several examples of research themes, with some commentary from the review of papers conducted by the SAB.

Population Dynamics – An important series of research projects has made contributions to understanding complex population dynamics. These projects tend to be deeply analytical, and rely on the Center's computing capabilities. In one of the most significant projects at NCEAS,
the Complex Population Dynamics Working Group, a collaboration between statisticians and theoretical ecologists, combined the most advanced techniques of each discipline to address the question of what governs population cycles (Kendall et. al. 1999). The group quantified
interactions and forces proposed in various hypotheses as drivers for cycles, and modeled the results. Employing various statistical techniques ("probes"), the group compared empirical evidence from long-term time series and experiments to outcomes from the models. Focusing on one particularly comprehensive dataset for which the causes of cycles were known (Nicholson's blowfly data) the authors identified which of their models most closely approximated the actual population dynamics. In this test case, the best-fit model was the one that was known to be operating in the experimental population. The techniques are being applied with good success to a forest insect population and to spatially distributed experimental mite predator-prey systems.

Recognizing that population management is the core issue in three unnecessarily distinct ecological realms -- conservation, resources harvesting, and pest control -- Shea and her Working Group (Shea et. al. 1998) analyzed the opportunities for synthetic approaches that would benefit all three. Their analysis suggests that using decision theory as a tool and combining time-series data with process-based models would yield robust results for these areas of population management. Scores of additional papers have involved the analysis of population dynamics. In addition, the CPB/NCEAS global population database (http://cpbnts1.bio.ic.ac.uk/gpdd), the largest collection of animal and plant population data in the world, provides a valuable community resource for understanding the behavior of natural and managed populations and how communities are assembled.

Community Properties – Several projects at NCEAS have combined data synthesis and specific analyses to characterize important community patterns in a new manner. Micheli, et al. (1999) considered the dual nature of community variability – compositional (e.g., relative abundance of species) and aggregate variability (total abundance, biomass, etc.). Their results reveal that these two types of variability combine in four ways – stasis (low in both compositional and aggregate variability), synchrony (low compositional, high aggregate), asynchrony (high compositional, high aggregate) and compensation (high compositional, low aggregate). They then present examples and link them to a suite of biotic and abiotic features.

In another study, Dr. Camille Parmesan analyzed the latitudinal and altitudinal shifts in butterfly populations in response to global warming (Parmesan, 1997; Parmesan et al, 1999). Dr. Parmesan first documented the movements in multiple populations in North America. She followed this work by looking a similar data for European butterfly populations with similar results, yielding one of the few replicated tests of the biotic effects of warming. It is pertinent to note that both the Micheli and Parmesan studies came from Postdoctoral Associates synthesizing large amounts of empirical information and analyzing the resulting patterns.

Numerous other studies of community properties have included dynamics at species borders (Holt 1997), invasion of alien species (Parker 1998) and the relationship between top-down and bottom up influences (Cottingham & Carpenter 1998). One large project, consisting of three interrelated Working Groups, is just beginning an analysis of the ecology of infectious diseases (Dobson 1999; Real & Dobson 2000; Wilson & Ewald 2000)

Synthesis and Evaluation of Global Datasets – One strength of the NCEAS model is the opportunity to support the analysis of large datasets that deal with particular ecological processes over large areas. For example, Jackson et al. (1999) developed a global-scale estimate of root biomass. This alone was a significant result, but the most important aspect of the research is that one community (terrestrial ecologists) provided extremely important information to another community (global carbon analysts and modelers). In a series of Working Groups, Howarth (1998) and colleagues (co-sponsored by SCOPE) determined how human activity has altered the nitrogen cycle globally. They discovered that terrestrial deposition of anthropogenically derived nitrogen has doubled recently and this, in turn, may have altered nitrogen fixation in the oceans (in some locations by as much as 15-fold). These striking results were presented as a plenary symposium at the 1999 Ecological Society of America meetings.

Related to the Howarth results is a paper by Downing, et. al. (1999). This study used meta-analysis (from the results of a Working Group on this statistical approach; Osenberg, et al, 1999) to combine the results of many individual experiments involving nutrient bioassays. The paper identifies which types of experiments (by temporal and spatial scale, etc.) were most useful, and how patterns of response to nutrient addition varied by location. The SAB group that reviewed this paper considered this a classic study of how to effectively employ meta-analysis.

Many other projects at NCEAS involve global patterns, including studies concerning trace gases (Ojima & Mosier 1997), global primary production (Prince 1997; Gower & McMurtrie 1997), global change (Steffen 1996), soil warming (Rustad & Marion 1999) and an analysis of altered hydrologic regimes (Naiman 1999)

Spatial Dimensions of Ecology – One of the richest areas of analysis at NCEAS involves ecological processes in a spatial context. An emphasis on this topic was building before NCEAS began, but research at the Center has contributed significantly to recent advances. The “Spatial Ecology” workshop in NCEAS’ first year produced an influential book (Tilman and Kareiva 1997) that highlights recent progress and future prospects. Several projects have focused on the dynamics of geographic ranges (Holt 1997; Fagen, et al, 1999) and a number of paleo-ecology projects (Alroy 1998; Alroy and Marshall 1998; Gittleman 1999 & McKinney 1999; Damuth 1998), provide an understanding of how ecological, evolutionary, and earth history phenomena interact to influence distribution, abundance, and diversity of species. In an interesting application of the dynamics of distribution ranges, Clark, et al (1998) synthesized the work of paleo-ecologists and theoreticians to solve Reid's Paradox on the rapid spread of oaks in northern Britain.

Other research in spatial ecology includes in-depth analytical, theoretical, and modeling contributions. In a particularly influential paper, Hanski and Gyllenberg (1997) developed a model that predicted two important patterns of the distribution of species – the species-area relationship and the positive relationship between species range and local abundance. To do so, the authors' model combines the mechanisms behind these two patterns -- divergence of species along a generalist/specialist gradient and colonization/extinction dynamics, respectively -- to integrate these two formerly disconnected spatial patterns.

Importantly, new knowledge about spatial ecology has been used in conservation and management contexts, such as the projects by Gilpin and Stine (1996) who used GIS-based optimization models for land use planning, and Ingrid Parker (1999), whose Working Group considered aspects of invasive species.

Ecological Economics – This is an example of NCEAS-supported research that is highly interdisciplinary. The earliest project in this area at NCEAS was an attempt to determine the economic value of the world's ecosystem services (Costanza, et al., 1997). The authors, who included ecologists and economists, calculated the value to be $ 33 trillion/year, twice the GDP of all of the countries in the world. Traditional economists view the authors' approach to valuation as highly controversial, but this project continues at NCEAS with an attempt to consider alternatives to standard means of determining valuation. Other projects include the folding of ecological variation into economic analyses (Roughgarden 1999), and an analysis of the feasibility of using carbon sequestration credits in Costa Rica (Pfaff 1998).

Conservation and Resource Management - Another major focus for NCEAS activities is the application of ecological knowledge to the solution of significant environmental problems. Such efforts are among the most challenging NCEAS endeavors. In addition to being scientifically complex (theoretically and empirically), there are significant cultural barriers between the academic and policy/resource management communities that inhibit meaningful progress. Nevertheless, there are indications that NCEAS is on the leading edge in the applied ecology arena, particularly in the areas of conservation planning and population management. A number of publications from these efforts have been influential (e.g., Dale et. al. 1998; Shea et. al.1998; Hastings and Botsford 1999); here we highlight some of the more nontraditional contributions of NCEAS activities that are changing not only our ecological understanding, but the way that practitioners utilize that understanding.

The software tools for conservation decision support produced by the working group on terrestrial reserve siting (Andelman 1998) integrate new developments in spatial modeling with a practical framework for conservation planning. These tools are already being used internationally by The Nature Conservancy, other NGOs and several state agencies (e.g., Oregon, Idaho, Texas, and Massachusetts) and are fundamentally changing the way these organizations do conservation planning. In addition, the database and report produced by the working group on habitat conservation plans (Kareiva 1997) and follow-up workshop (Courtney & Brosnan 1999) catalyzed the U.S. Fish and Wildlife Service to make substantive changes to their staff training process, including formal revision of their training manual to incorporate new insights from the working group.

The Society for Conservation Biology is holding an international workshop to identify strategic research priorities in conservation biology for the next decade. The product of the workshop will be a book to be published by Island Press, targeted at both public and private funding organizations internationally, the academic community, NGOs, and agencies. Approximately half of the ten new research focus areas identified for the workshop evolved directly out of NCEAS activities.

Evaluation of Working Groups – Dr. Edward Hackett of Arizona State University is conducting a study of NCEAS research approaches. He began with a survey of Working Groups to characterize their activities and determine how participants' experience at NCEAS affected their own research. The survey was distributed to 133 Working Group participants, 69% of whom responded (68 men, 19 women, 4 unknown). A brief summary of his report (Appendix 4) is presented here.

1. Orientation toward integrative work – Participants overwhelmingly support synthesis and integration in ecology. Respondents differed sharply over whether ecology is more specialized now than in the past. The most striking aspect of this element of the survey is the strong rejection of the notion that sharing ideas is risky and that specialization is advisable.

2. Working Group Processes – Working Groups work well, and teamwork is high. Ideas are expressed, shared, and considered by the groups. Group members generally believed that a few people made exceptional contributions to the group, and accordingly, 41% thought a few members dominated the discussions. Competition, however, was not viewed as a problem. There was general agreement on the standards and methods to be employed by the group and on what constitutes a scientific achievement, although agreement was not universal. Working Groups were generally viewed as successful and as having made significant contributions; 80% believed the groups accomplished what they set out to do.

3. Satisfaction with the NCEAS activity – 98% were satisfied with the overall group experience; some concern was expressed with authorship and pre-meeting arrangements.

4. Influence on researcher behavior – This is a complicated issue, but virtually all visitors would urge others to participate in Working Groups and the great majority (88%) plan to collaborate with group members again. Approximately half would be more likely to share data in the future while a quarter would not and the remaining quarter are reluctant to do so.

5. Influences of NCEAS on research behavior – More than 70% of the respondents agreed their work probably would become more collaborative and they would be more inclined to use literature from other disciplines. More than half thought they would use more comprehensive data and theory, but 20% thought they were not

more likely to do so. These items are at the core of the NCEAS model, and the survey provides evidence of the efficacy of the NCEAS approach. Moving to the next level, 40% reported that they would increase the diversity of species, geographic range, or temporal scale of their research.

6. Further influences on research behavior – About a quarter of respondents will use more primary data (other than their own) in their research, and 45% will use more secondary information, than they did prior to working at NCEAS.

The responses to the 14 questions in items 5 and 6 were in four categories – Not Likely (1), Somewhat Likely (2), Probable (3), and Highly Likely (4). About a third of all respondents averaged less than 2.0 across all 14 questions, while 29% averaged more than 3.0. Strikingly, 71% responded that change in at least one dimension was probable and another 20% answered highly likely, suggesting that the NCEAS experience is having an affect on some aspects of synthesis for virtually all participants. Aggregate scores were unrelated to age, sex, or tenure status. Dr. Hackett's research will expand, and assessment of whether NCEAS is achieving its goals with regard to researcher behavior will continue if the Center is refunded.

<u>Research by Postdoctoral Associates</u> – the Associates have been responsible for or involved with many of the important projects at the Center. As part of the review of NCEAS activities for this proposal the Associates were asked to evaluate the advantages and limitations of conducting research at NCEAS (Appendix 5). The key points of their assessment are:

Benefits – unique opportunity to meet and work with top scientists, strong interactive postdoctoral research community, independence and scholarly freedom, opportunity for a diverse research experience, and being at NCEAS is an important advantage in the job market.

Limitations – no formal mentors, fieldwork is not supported, and multi-authored papers may lead to awkward situations. In general, these were viewed as concerns only for certain types of postdoctoral applicants.

<u>**Overview of NCEAS Strengths**</u>

<u>Center Model</u> - The NCEAS model provides three distinctive benefits:

1. *Time* – Productive scientists are extremely busy, and there is the sense that considerable time is being spent on unproductive activities at their home institutions. It is very difficult to find time to concentrate on intensive research for even a few hours without interruptions and various obligations. Visits to the Center isolate scientists from these responsibilities, allowing them to focus on research in creative, productive bursts of intellectual activity. Even the location of the Center allows scientists to optimize their time by moving between lodging, restaurants, and the meeting rooms on their own schedules, which often includes evenings and weekends.

2. *Interactions* – two types of interactions occur at NCEAS: organized and unanticipated interactions. While organized interactions through Working Groups represent the formal purpose of a NCEAS visit, the meetings are often loosely structured and most evolve rapidly toward productive aspects of the research question.

Perhaps even more important than organized interactions are the anticipated but unpredictable interactions that occur simply because people with overlapping interests are in the same place at the same time. This intellectual by-catch results when individuals have coffee or lunch together and discover they have a shared interest in a topic that may not be associated with the purpose for which either came to NCEAS. These chance meetings can spin off into distinct projects and lasting collaborations, generating complex phylogenies of ideas and results.

3. *Flexibility* – an important characteristic of NCEAS research projects is that they rarely end up as proposed. The projects often move laterally as the investigators pursue the most pertinent and productive elements of their research questions. In the intellectually open atmosphere engendered at NCEAS, scientists naturally move toward the most interesting areas of inquiry. In addition, the Center often supports changes in the direction of a group by funding an additional participant(s) when the group discovers that one area of expertise is missing or supporting additional meetings. Some have wondered whether supporting risky or innovative projects would lead to high "failure" rates – projects that attempt truly new approaches should be more prone to failure than redundant research. The flexibility provided to NCEAS projects reduces the chance of true failures and actually fosters innovation and creativity.

Other Important Features of NCEAS

Research Scope - Research results represent the most important aspect of NCEAS' activities. The evaluation of research presented above indicates that the Center's scientists have made major intellectual contributions that are broadly representative in terms of topic, geography, gender, academic rank (or its equivalent in agencies), and university size and scope(Figures 3 – 5).

Postdoctoral Research - One measure of the effectiveness of NCEAS is reflected by the Postdoctoral Associates. Their extraordinary success (in terms of publications and positions accepted) no doubt is due both to the quality of postdoctoral applicants and their scholarship once they arrive at NCEAS. When the first cohort of Associates began interviewing for positions they met with some skepticism or ambivalence about their activities at NCEAS. The most recent group to obtain positions indicates their time at NCEAS now is viewed as an important component of their research experience. Initially there was some concern that the NCEAS postdoctoral associates were "mentorless". Accordingly, we provide funds to allow them to visit a mentoring scientist or bring them to the Center for short visits. However, this has not been a problem and the Associates essentially have access to dozens of possible mentors from among the hundreds of visitors to NCEAS.

Graduate Interns have been much more important to the Center than was originally imagined. Interns often develop and maintain data sets for Working Groups, and participate in their intellectual activity. Interns have come from a variety of Departments on the UCSB campus. In addition, we have recently begun supporting Interns at the home institutions of the Group Leaders. This is advantageous because it uses less space at NCEAS and provides effective local supervision. It should be noted that many other graduate students (108) from around the world have participated in research activities at the Center.

Outreach – The major outreach activity at NCEAS involves scientific publications and presentations at scientific meetings. The Center is almost entirely web-based, and we receive contacts from numerous domains through the web. In addition, the Center is involved in a myriad of outreach activities to other audiences. Perhaps the most intriguing involves the Los Marineros program, which serves as the basis of the physical and natural science curriculum for the 5th grade in the local school district. The Center's scientists work with classes to develop experiments and observations focused on the ocean. Data gathered in the projects, as well as standard, annual projects (e.g., classifying and quantifying trash on beaches) are hosted on our web site under Kids Do Ecology. The program has been highlighted at the ESA meetings and will be featured at an upcoming Society for Conservation Biology meeting.

Relationship with Campus - NCEAS has broad support from scientists and the administration on the UCSB campus. Regular contact is maintained with campus scientists, 85 of which have participated in NCEAS research activities. In addition, NCEAS scientists provide a substantial portion of the seminar speakers for the Ecology, Evolution, and Marine Biology Department. The university's administration has assisted the Center in many ways and frequently acknowledges the Center's contributions to campus and the University of California.

The Science Advisory Board, whose 19 members are drawn from appropriate disciplines and organizations, plays a major role in the success of the Center (Appendix 3). The SAB provides advice on specific proposals and research activities, and on more strategic matters. The SAB is independent from the Director, and nominates and elects its own members. Recently, the SAB has moved toward including non-ecologists (e.g., economists) and agency scientists.

Education of senior scientists – a number of senior scientists has said how much they learned by participating in NCEAS research activities. Specifically, they note that while short term visits with scientists and listening to seminars are beneficial, participation in a working group or spending a sabbatical visit at the Center provides a much deeper learning experience. Thus, unlike workshops that rely on combined wisdom and expert opinion, the activities at NCEAS seem to promote true learning and new understanding, even among the experts.

Management and conservation oriented research activities – More than 40% of the projects at NCEAS have direct or indirect application to environmental policy and management issues (Appendix 1). The traditional model of information transfer involves scientists handing off the results of a study to resource managers for application. Many attempts have been made by agencies and institutions to promote this type of transfer, but logistic and cultural characteristics of the entities and individuals involved make it difficult.

Rather than employing the typical information transfer format, Center research results and recommendations have been passed on through less traditional routes, often with scientists getting directly involved. Perhaps the best example is the review of Habitat Conservation Plans under the Endangered Species Act (Kareiva et. al. 1999). This project examined the role of science in developing HCPs and if the information was being used properly. To conduct the analysis, the Group Leader, Dr. Peter Kareiva, organized graduate seminars at 8 universities. All seminars analyzed the same two HCPs and each analyzed an additional 2-5 plans for a total of 43. More than 100 graduate students were involved in the analysis, 35 of whom came to NCEAS with their faculty instructors, to conduct a grand synthesis of the data (which included results from a 965 item questionnaire). Smaller groups returned to complete the analysis and prepare publications (the data for the project are available on the NCEAS website). The results indicated that the HCP process could be effective, but that there are significant areas where its scientific underpinning could be improved. The results reverberated through the Department of Interior, causing a re-evaluation of the entire process, as well as catalyzing another NCEAS/USFWS project to evaluate the role of science in endangered species recovery plans (Boersma & Kareiva 1999. Just as importantly, the students involved received hands-on training in the complex world of resource management and policy. The approach developed for this activity was both an excellent research project and pedagogical exercise, so much so that the report is being used as a case study at the John F. Kennedy School of Government.

Other examples of non-traditional information transfer include projects that have affected reserve design, both terrestrial and marine (Andelman 1998; Lubchenco, Palumbi & Gaines 1998), management of marine fisheries (through both simulation modeling and information for establishing research priorities) (e.g., Hilborn 1997), conservation of an endangered parrot species in Tasmania and Australia, development of a population viability analysis handbook for The Nature Conservancy, and assistance for the Allegheny Power Company in their attempt to put a comprehensive economic value on their natural resources (in conjunction with the Electric Power Research Institute).

Training – Although the original NCEAS proposal contained training workshops, a majority of the training efforts have been less traditional (e.g., the HCP project mentioned above). Graduate interns are full collaborators in Working Groups, gaining insights into research and its culture that cannot be obtained in a traditional setting. Postdoctoral Associates also develop collaborative skills, and the recognition that synthesis is a valid form of research. Finally, as noted, senior scientists often gain new insights and skills at NCEAS rather than simply learning new facts.

Location – NCEAS was initially located off campus in downtown Santa Barbara because space was not available on campus, and there was interest in developing it as a national rather than university-specific center. Many imagined that NCEAS would move to campus as soon as space was available. In the mean time however, the downtown location has become an important part of the NCEAS model. At one level, the convenience and ambiance of the location promotes a productive atmosphere. Visitors can walk from their hotels to the Center, and meals are available at all hours, unlike locations near campus. More importantly, visitors often state that by being off campus the Center has a different "feel" – that coming to this location promotes the sense that something distinctive is happening. Even scientists on campus now seem to appreciate the opportunity to come to the center and get away from their daily responsibilities.

The most common concern expressed about the Center being off-campus is library access. However, this has not been a major problem. Visiting scientists do not use library material as much as they imagined, since they often deal with data rather than publications. We also provide a courier service that will obtain articles as needed and resident scientists are given full library privileges. Finally, the new California Digital Library has access to hundreds of journals on line and anyone using a NCEAS computer has access to the CDL.

Improvements, New Approaches

Several aspects of NCEAS' activities need improvement. In some cases this is the result of attempting to employ fairly standard approaches that have not proven effective in the NCEAS model (e.g., "workshops"). In a few cases, chronic situations have been difficult to resolve (e.g., involving minorities in NCEAS activities). Below we discuss improvements that we anticipate will resolve some of these issues and we propose several new approaches.

Proposed Improvements

Group size and length of stay - It is clear from both casual observation and analysis that the most effective groups are intermediate in size (8-12 individuals) and are composed of people who know each other in twos and threes. This provides new perspectives, while avoiding working with completely unknown individuals who might not contribute to the proceedings. During the first 4 years of operation, working group size averaged 13 individuals, who stayed an average of 6 days (Figure 5). The tendency is for larger groups and shorter stays, a natural temptation as group leaders want to be inclusive, and shorter stays appear more attractive to busy people. However, emphasizing the optimum configuration of size and length of stay requires the leader to choose those who are most likely to contribute. Thus, while allowing for flexibility, we plan to strongly encourage working groups to maintain effective group sizes and lengths of stay and require proposals outside this range to be strongly justified.

Center Fellows – We continue to receive relatively few applications for sabbatical visits, and many of those are for half year or one semester stays (even though we provide up to half salary and a housing allowance). This is surprising and it is not clear what can be done about it. Certainly enough scientists know about NCEAS to provide a pool of possible sabbatical visitors. Many ecologists may view a sabbatical as an opportunity to concentrate on fieldwork. One situation working against sabbaticals is that many scientists have working spouses who may not be able to leave their job. We believe the most effective approach is to expand our proactive efforts to seek applicants.

Postdoctoral Associates – Recognizing that postdoctoral positions at NCEAS are distinctive and may require some start-up time, we offer to Postdoctoral Associates an opportunity to be evaluated for a third year of support. We will formally involve the SAB in this review by having the Associate prepare a packet of information presenting their research and c.v., and a research talk during the SAB meeting preceding the end of their second year. The Associates' progress will be discussed, and decisions will be made concerning continued support. We will also more actively promote the opportunity for Associates to visit or bring in mentors to help them with specific interests.

Project Scope – The projects at NCEAS tend to be manuscript-sized. That is, the scope of the questions, the way in which the answers are presented, or the short stays of some groups tend to yield manuscript-sized results. This may be a product of our publishing and reward system, but we hope to encourage projects that address very important issues and perhaps yield a single key paper for that topic. We plan to promote this approach more actively, and highlight the opportunity for several scientists to collaborate for months to a year on a single issue (see below). In addition, we will use the

SAB to identify "groups of groups" – projects that can be spawned from previous activities by combining the ideas and participants in new ways.

Promote Synthesis Activities and Publications – More than 220 research papers have been produced from NCEAS projects. We will work with NCEAS' scientists to encourage one or more truly synthetic papers from their work. We have been approached by a number of publishers about establishing a publication series associated with NCEAS. So far we have declined, recognizing that authors have had no trouble publishing their products. Among the 200 + publications are 2 books, 12 edited volumes and 46 book chapters (Figure 6). However, we might consider co-sponsoring a publication series devoted to synthesis with a reputable publisher which could accept true synthesis papers from NCEAS projects, and provide an outlet for other types of synthesis not conducted at the Center.

Subdiscipline Representation – Most of the subcategories (by level of organization, taxon, geography, etc.) of ecology have been represented at NCEAS. While it is preferable to make sure many scientists know about NCEAS and let the applications arrive from all areas, we may need to consider targeting a few areas to promote greater representation. To do so, we will involve the SAB in identifying gaps and then specific individuals or ideas to pursue.

Application of NCEAS Project Results – 40% of the projects at NCEAS have an applied aspect and 19% of NCEAS' participants are from agencies or NGOs. Furthermore, many novel and important contributions have been made to resource management and conservation (see above). However, we have had limited success in attracting resource managers or policy makers to spend time at NCEAS. We have had more success recently in attracting agency representatives (and have one U.S. Forest Service scientist on sabbatical at NCEAS), and we will continue to encourage their participation, as well as initiate other venues for interaction and collaboration.

NCEAS involvement with management-oriented projects was one area a mid-term site review identified as needing attention. We have come to realize that we cannot expect to change the cultural characteristics of academic or agency science in the short term. Rather, we have focused on novel ways of assisting with management approaches to conservation issues and transferring pertinent information to resource managers (see pages 7 & 10) that we believe will eventually catalyze these cultural changes.

Participation by Underrepresented Populations – The mid-term review also suggested that NCEAS increase its effort to involve under-represented populations. It appears that women are fairly well represented in NCEAS activities (28% of participants, 24% of Group Leaders) compared to other organizations (Figure 7). Although we do not track participation by ethnic minorities, it is clear that relatively few are involved at NCEAS. As part of a national problem, the pool of eligible minorities (especially at the postdoctoral and faculty level) available for NCEAS activities is quite low. The Center does participate in a Kids Do Ecology program with 5th graders in the Santa Barbara School District, >70% of whom are ethnic minorities.

To more directly address this issue, we are developing a working collaboration with Dr. Carlos Robles to bring minority graduate students to NCEAS to participate in research activities. Specifically, we have received supplemental funds to invite students and an appropriate faculty mentor from California State University – Los Angeles, a minority-serving institution, to projects targeted to their interests.

Strategic Planning

Initial activities at NCEAS were directed toward securing the involvement and support of the ecological community and its allied disciplines. By the end of the fourth year of operation, it was evident this was occurring and so, as planned, more attention is now given to the future of NCEAS. Several elements of the future of NCEAS must be considered.

Research - The Center is maintaining an appropriate research portfolio involving core ecological topics and projects connected to a number of allied fields. We will continue to support a mix of projects proposed to NCEAS and solicited by Center scientists, SAB members, and past visitors. We will institute several new approaches (small, long-term groups - perhaps only two scientists at a time), and use the expertise of the SAB to identify areas that might need special attention. At one level, we do not want to "plan" for the research that is done here, but continue to promote processes that identify and encourage productive research topics.

Informatics – We have all experienced the information revolution but research at NCEAS has come to rely on it. We foresee this effort expanding and funding for informatics research could surpass core support for analysis and synthesis. To avoid becoming an informatics center that does a little synthesis on the side, we propose to separate this activity to some extent from our core responsibility. Thus, we plan eventually to move the informatics research efforts to campus, while maintaining the in-house networking and analytical capabilities at the Center.

The Marine Science Institute, our parent unit on campus, is building a new building. One floor will be dedicated to informatics. Moving NCEAS informatics research to campus will yield several benefits: freeing up space, establishing an NCEAS enclave on campus, and embedding the informatics researchers in the rich, robust computing environment on campus (which has a strong environmental sciences flavor).

Consortia – The Center has unique strengths in its own right, but we also are interested in forming strategic consortia with other entities. Such collaborations would bring the combined strengths of the participants to bear on important scientific questions, and allow NCEAS to seek support from sources it could not approach on its own. The most advanced arrangement is an informatics consortium we have formed with the University of Kansas Museum of Natural History, LTER Network Office, and San Diego Supercomputing Center. We will pool intellectual and technological resources to address the general informatics needs of the systematics and ecology communities. We also have an arrangement with the University of California Natural Reserve System to host their information manager at the Center. These coordinated alliances will engender a level of integration that would not otherwise occur and our strategy is to seek specific alliances related to the NCEAS mission.

Intellectual Center(s) – NCEAS' success has spawned interest in other communities for similar opportunities. In some cases, these are in subdisciplines of ecology, which would tend to fracture NCEAS' breadth and balkanize the field, rather than maintaining the core idea of a center to synthesize information and ideas. At some point disciplines are distinct enough to warrant separate center emphases (e.g., NCAR, Institute for Theoretical Physics). There are fields, such as systematics and paleontology that overlap with ecology in important areas – e.g., the spatial and temporal patterns and processes of biodiversity – but have their own discipline-specific interests as well. As impetus for new Centers develops, NCEAS will seek to establish strategic alliances with those when such collaborations would benefit both fields.

Significance of NCEAS

Evidence suggests that the National Center for Ecological Analysis and Synthesis is meeting its mission and has exceeded the goals imagined for such a Center. Numerous scientific contributions have been published in major journals, almost two thousand scientists have visited NCEAS, the Postdoctoral Associates are having remarkable success securing good academic positions, and non-traditional approaches are being employed for research, education, and outreach. Visitors appreciate the opportunities provided by the NCEAS model, and testimonials abound as to the effectiveness of this approach.

While these proximal indicators are positive, in the final analysis the Center should be judged on two criteria – whether appropriate quantities of important ecological research are being generated, and whether the Center is affecting the way ecological research is conducted. Internal reviews of the nature and scope of research coming from NCEAS and an analysis of the effectiveness of the Center's model of collaboration conclude both are taking place. Scientists from NCEAS have produced several major papers and, while it normally takes several decades to recognize major breakthroughs, the SAB identified several papers that made major advances in the field. The preliminary results of Dr. Hackett's research suggest that scientists at NCEAS take advantage of opportunities at the Center, and the experience alters the manner in which they subsequently conduct research.

It is reasonable to ask whether the results of NCEAS projects could have happened in the absence of the Center. In some cases, the answer clearly is no. In other cases, where projects could have happened under other circumstances, the real question is, would they have? At the very least, it appears that synthetic efforts occur sooner and more efficiently with the opportunities at NCEAS and that the Center promotes a new way of conducting scientific research in our discipline and of generating distinctive, significant results.

As important as the research conducted at Center is, a longer lasting legacy may come from the nature of the research process at NCEAS. The essence of this approach is to bring together individuals who have much to learn from each other and facilitate their opportunities to interact intellectually. This is actually a very simple model that provides time, flexibility and opportunities for interactions. While most scientists probably imagined these would be aspects of the intellectual life they were joining, these elements are difficult to secure in circumstances filled with many ancillary obligations that impinge on scholarship. Thus, perhaps as never before, scientists need a place like NCEAS that is dedicated to these intellectual ideals.

Appendix 1. NCEAS Projects, 1995 – 1999.

Leaders	NCEAS Projects
Abrams, Peter Wilson, Will	Working Group; Extending, Synthesizing, and Applying Recent Advances in Competition Theory
Allen, Edith Covington, W. Falk, Donald	Developing the Conceptual Basis for Restoration Biology
Alroy, John	Paleoecology of North American mammals; large-scale patterns and processes
Alroy, John Marshall, Charles	A Sampling-Standardized Analysis of Phanerozoic Marine Diversification and Extinction
Amarasekare, Priyanga	Spatial Processes and Multi-Species Interactions; Insights for Biodiversity Management
Andelman, Sandy	Designing and Assessing the Viability of Nature Reserve Systems at Regional Scales. Integration of Optimization, Heuristic and Dynamic Models
Arneberg, Per	Comparative Studies of Abundance and Species Richness Patterns among Mammalian Nematodes
Bascompte, Jordi	Habitat Fragmentation; From Spatially Explicit Models to the Analysis of Patterns in Real Ecosystems
Beach, James Krishtalka, Leonard	Informatics Needs for the Systematics Community
Beck, Michael Heck, Kenneth	Evaluation of the Nursery Role of Wetlands and Seagrasses for Better Conservation and Management
Bjornstad, Ottar	Center Associate
Bjornstad, Ottar	Recruitment Variability and Population Dynamics
Boersma, Dee Kareiva, Peter	Prospectus For An Analysis of Recovery Plans and Delisting
Boring, Lindsay	New Directions and Applications for Ecosystem Science in the Private Sector
Bradshaw, Gay	Restorying the Landscape-An Analysis of Native American Approaches to Ecological Restoration

Brown, James Tilman, David Holling, C. Levin, Simon	Universal Phenomena in Ecology?
Brown, James	Sabbatical Proposal to Spend Fall Semester 1999 at NCEAS
Burgman, Mark Andelman, Sandy	Developing and testing methods for classifying species conservation status and estimating risk
Burton, Rebecca	Post-Doctoral Fellow
Cane, James	NSF Pollinator Decline Workshop
Carpenter, Stephen	Synthesis in Ecology-Applications, Opportunities, and Challenges
Carpenter, Stephen	Visiting Scientist
Case, Ted	The Biogeography of Endemism, Age, and Area
Chapin, F.	Arctic Boreal Processes that Feed Back to Climate; Extrapolation and Synthesis
Chapin, F. Sala, Osvaldo	Scenarios of Future Biodiversity; Causes, Patterns, and Consequences
Clark, James	The Role of Dispersal in the Holocene Expansion of Trees
Cornell, Howard Hawkins, Bradford	Predators, Pathogens, and Parasitoids as Mortality Agents in Phytophagous Insect Populations
Costanza, Robert Farber, Stephen	Working Group on the Value of the World's Ecosystem Services and Natural Capital; Toward a Dynamic, Integrated Approach
Costanza, Robert	Total Value of the World's Ecosystem Services and Natural Capital
Cottingham, Kathryn	Early Warning of Discontinuous Changes In Ecosystem State; Myth, Reality, or Somewhere In Between?
Courtney, Steven Brosnan, Deborah	HCP Report: The Way Forward
Crowley, Philip	Visiting Scientist
Dadd, Michael	Meeting of the Species 2000 Project
Damuth, John	Climatic and Habitat Inference from Features of Mammalian Paleocommunities
Davis, Frank Barrows, Cam	Ecological Monitoring of Multi-Species Habitat Conservation Plans

de Roos, Andre	Visiting Scientist
Debenham, Patty	Center Associate
Dobson, Andrew Holt, Robert	Infectious Diseases and Conservation Biology
Eldredge, Niles Thompson, John	Ecological Processes and Evolutionary Rates: A Proposal for a Working Group at NCEAS
Ellison, Aaron	ESA Committee on Data Archiving and Sharing
Ellner, Stephen	Visiting Scientist
Elser, James Fagan, William	Ecological Stoichiometry of Plant-Herbivore Interactions
Fagan, William	Post-Doctoral Fellow
Field, Christopher Harmon, Mark Holland, Elisabeth Kohlmaier, Gundolf	The Carbon Balance of Eurasia and North America
Gerrard, Ross	Postdoctoral Fellow
Gilpin, Michael Stine, Peter Church, Richard Gerrard, Ross	Investigating Alternative LandUse/Habitat Conservation Strategies Using GIS and Optimization Modeling Part II
Gittleman, John McKinney, Michael	Phylogeny and Conservation - Problems in the Quantification of Biodiversity
Gower, Stith McMurtrie, Ross	An Analysis of the Age-Related Decline in Aboveground Net Primary Production; Potential Causes and Stand-to Global Scale Implications
Grimm, Nancy	Aquatic-terrestrial Biogeochemistry (ATBGC)
Groves, Craig	The Nature Conservancy
Gunderson, Lance Holling, C. Peterson, Garry	Theories for Sustainable Futures; Understanding and Managing for Resilience in Human-Ecological Systems
Gyllenberg, Mats	Visiting Scientist
Hackett, Edward	Ecology Transformed? A Proposed Working Group to Study New Forms of Scientific Collaboration
Hanski, Ilkka	Sabbatical Fellow
Hart, Stephen	Analysis and Synthesis of the Historical Range of Variability in Ecosystem Structure and Function of Inland West Forests - Implications for Ecological Restoration. Sabbatical Fellow

Helly, John	Computational Ecology
Hibbard, Kathy	Ecosystem Model-Data Inter-comparison Working Group on Data - Synthesis, Formats, and Establishment of an EMDI Server Facility
Hilborn, Ray	Predicting Extinction: The Dynamics of Populations at Low Densities
Holt, Robert	The Ecological and Evolutionary Dynamics of Species' Borders
Holyoak, Marcel	Visiting Scientist
Hosseini, Parviez	Graduate Intern for Complex Population Dynamics
Howarth, Robert	Nitrogen Transport and Transformations; A Regional and Global Analysis
Hunsaker, Carolyn	Quantification of Uncertainty in Spatial Data for Ecological Applications
Ives, Anthony Frost, Thomas	Intrinsic and Extrinsic Variability in Community Dynamics
Jackson, Jeremy	Long-Term Ecological Records of Marine Environments, Populations and Communities
Jackson, Robert	Towards an Explicit Representation of Root Distributions in Global Models
Johnson, Edward Miyanishi, Kiyoko	Forest Fires: Behavior and Ecological Effects
Jones, Matthew Schildhauer, Mark Davis, Frank Reichman, O.	Automation of Ecological Data Management Using Structured Metadata
Kaandorp, Jaap Kubler, Janet	Modelling Growth and Form of Sessile Marine Organisms
Kareiva, Peter	Habitat Conservation Planning for Endangered Species
Kareiva, Peter	Developing a Modeling Paradigm for Spatially Explicit Urban Ecology Models
Kareiva, Peter	Infusing Ecological Theory Into The Design of Environmental Monitoring. Sabbatical Fellow
Kaufman, Dawn	The Latitudinal Gradient of Diversity - Synthesis of Pattern and Process
Kinzig, Ann Pacala, Stephen	Proposal for Workshop and Web-Based Working Group on The Theoretical Foundations of Biodiversity/Ecosystem Function Relationships

Kitchell, James	Apex Predators
Klaas, Ben	Graduate Intern
Lewinsohn, Thomas	Community Structure and Interaction Diversity in Insect-Plant Assemblages
Liebhold, Andrew Gurevitch, Jessica	Integrating the Statistical Modeling of Spatial Data in Ecology
Liebhold, Andrew	Application of Geostatistics in Ecology. Sabbatical Fellow
Lubchenco, Jane Palumbi, Stephen Gaines, Steven	Developing the Theory of Marine Reserves
Maurer, Brian Taper, Mark Lele, Subhash Dennis, Brian	Analyzing the Demographic Structure of Geographic Ranges-Investigating Techniques to Predict Geographic Range Size
Merrick, Jennifer	National Center for Environmental Decision-Making Research. Graduate Student Intern
Micheli, Fiorenza	Joint Effects of Top-Down and Bottom-Up Forces on the Structure and Dynamics of Estuarine and Coastal Marine Communities; Interactions Between Nutrient Inputs and Fisheries Exploitation
Michener, William Haeuber, Richard	Interdisciplinary Synthesis of Recent Natural and Managed Floods
Milne, Bruce	Center Fellow Proposal - Theoretical Landscape Ecology
Mooney, Harold	Ecological Monitoring
Moss, Cynthia Croze, Harvey	Analysis and Synthesis of Results of Studies Carried Out Over Three Decades by the Amboseli Elephant Research Project in Kenya
Murdoch, William	Integrative Research in Population Dynamics. Sabbatical Fellow
Murdoch, William Turchin, Peter	Complex Population Dynamics
Murdoch, William	Spatio-Temporal Conference
Naiman, Robert	Fresh Water and Environmental Change - The Ecological Consequences of Altered Hydrological Regimes
Nisbet, Roger	Predicting Population Level Effects of Toxicants
Ojima, Dennis	Analysis and Synthesis of Trace Gas Fluxes

Mosier, Arvin	
Olson, Robert Kitchell, James	Ecological Implications of Alternative Fishing Strategies for Apex Predators
Osenberg, Craig	Meta-Analysis, Interaction Strength and Effect Size; Application of Biological Models to the Synthesis of Experimental Data
Ostfeld, Richard	Ecology of Infectious Disease; Roles of Biodiversity, Biotic Interactions, and Global Change
Pace, Michael	Establishing Structure for the Synthesis and Integration of Progress in Ecosystem Science
Parker, Ingrid	Invasion Biology: Toward a Theory of Impacts
Parmenter, Robert	NSF Biodiversity Observatory Network Workshop
Parmesan, Camille	Assessing Effects of Global Change by Geographical Analysis of Population-Level Persistence Data
Parton, William Cougenhour, Michael Archer, Steven Hall, David	Interactions in Mixed Tree-Grass Systems
Peet, Robert Grossman, Dennis Jennings, Michael Walker, Marilyn	An Information Infrastructure for Vegetation Science

Pfaff, Alexander	A Supply Function for Carbon Sequestration - Multi-Disciplinary Estimation and Integrated Sensitivity Analysis
Porter, Warren	Climate-ecological interactions: individual, population and community connections
Possingham, Hugh	Decision Theory in Conservation Biology - Are There Rules of Thumb?
Pressey, Robert	Effectiveness of current Approaches to Identifying Priority Conservation Areas
Prince, Stephen	Global Primary Production Data Initiative Proposal to the National Center for Ecological Analysis and Synthesis
Quinn, James	U.S. Biological Resources Division IABIN Workshop
Ralls, Katherine Amrhein, Christopher Davis, Frank Howarth, Richard	A Multidisciplinary Analysis of Alternative Farmland-Retirement Strategies for Restoring San Joaquin Valley Ecosystems
Real, Leslie Dobson, Andrew	Spatial Ecology of Infectious Disease
Reichman, O. Brunt, James Helly, John Jones, Matthew Willig, Michael	A Knowledge Network for Biocomplexity: Building and Evaluating a Metadata-based Framework for Integrating Heterogeneous Scientific Data
Reichman, O.	Workshop on Data Management for the Ecological Sciences
Reichman, O. Schildhauer, Mark Jones, Matthew	Integrating Marine Ecology Data for Scientific Analysis and Resource Management: A Community Database Prototype
Reichman, O.	Los Marineros: A Channel Islands National Marine Sanctuary Program in Partnership with the Santa Barbara Museum of Natural History
Reichman, O. Krishtalka, Leonard	NSF Biodiversity Observatory Network Workshop
Reiners, William	Propagation of Ecological Influences Across Landscape Space

Reiners, William	Modeling Ecological Influences Across Landscape Space - A Sabbatical Proposal
Rex, Michael Strong, Donald	Deep Sea Biodiversity - Pattern and Scale
Rothstein, Stephen	Cowbird Management Workshop
Roughgarden, Joan	Proposal for Sabbatical Year at NCEAS
Roughgarden, Joan	Ecology and Economics
Russell, Gareth	New Tools for the Analysis of Population and Community Dynamics
Russell, Gareth McKinney, Michael	Sampling Curves in Ecology: Theory and Application
Rustad, Lindsey Marion, Giles	Proposed Workshop on Analysis, Synthesis, and Integration of Temperature Manipulation Research
Schmitz, Oswald	Understanding the Role of Individual-Scale Processes in Community-Level Dynamics; What are the Dynamically Relevant Organizational Scales for Predicting Community Dynamics?
Schultz, Cheryl	Managing Natural Areas; How Do We Select Among Land Management Options?
Seabloom, Eric	Post-Doctoral Fellow
Seastedt, Tim	Association of Ecosystem Research Centers Annual Meeting
Semmens, Brice	Los Marineros. A Channel Islands National Marine Sanctuary Program in Partnership with the Santa Barbara Museum of Natural History
Semmens, Brice	California Marine Managed Areas Survey
Shea, Katriona Mangel, Marc Possingham, Hugh	Working Group on Population Management
Shimada, Masakazu	Visiting Scientist
Sih, Andrew	Identifying and Characterizing Case Studies of the Successful Use of Basic Ecological Concepts to Solve Applied Problems
Smith, Felisa	Body Size in Ecology and Paleoecology - Linking Pattern and Process Across Spatial, Temporal and Taxonomic Scales
Smith, Robert	Analysis of Non-Linear Dynamics in Ecological Time Series;

	Use of Long-Term Data Sets to Evaluate the Role of Replication in Time and Space
Sork, Victoria	Theoretical and Empirical Approaches to the Study of Gene Flow in Fragmented and Managed Populations
Sork, Victoria	Synthesis of Geographical, Spatial-Temporal, and Metapopulation Models into the Analysis of Landscape-Level Genetic Data of Woody Plants. Sabbatical Fellow
Stanford, Jack	Organization of Biological Field Stations (OBFS) Meeting
Steffen, Will	Global Change and Terrestrial Ecosystems: A Synthesis
Strong, Donald Rex, Michael	Deep-Sea Biodiversity: Spatiotemporal Dynamics and Conservation Strategies
Taper, Mark Lele, Subhash Lewin-Koh, Nicholas	The Evidence Project - Supporting Scientific Claims
Thompson, John	Coevolution and the Organization of Biodiversity. Sabbatical Fellow
Tilman, David	Visiting Scientist
Tilman, David Kareiva, Peter	Spatial Ecology: The Role of Space in Population Dynamics and Interspecific Interactions
Tilman, David	Ecological Forecasting
Turner, Monica Dale, Virginia	Comparing Large, Infrequent Disturbances; What Have We Learned?
Wagner, Frederic	Synthesis of Elk Influences on the Northern Yellowstone Ecosystem and Role of Research in National Park Policy Setting. Sabbatical Fellow
Waide, Robert Willig, Michael	An Analysis of the Relationship between Productivity and Diversity using Experimental Results from the Long-Term Ecological Research Network
Walker, Marilyn Jones, Michael	A Circumpolar Comparison of Tundra Response to Temperature Manipulation: A Synthesis of International Tundra Experiment Data
Warner, Robert	Open vs. Closed Marine Populations - Synthesis and Analysis of the Evidence
Wilkinson, Robert	California Regional Climate Change

Williams, Jack	Integrating Satellite and Pollen Data With Biogeochemical Modelling to Reconstruct Long-Term Trends in the Productivity and Carbon Sequestration of Terrestrial Ecosystems
Willig, Michael	Latitudinal Gradients of Diversity-A Taxonomically & Geographically Comparative Perspective
Wilson, Mark Ewald, Paul	Environmental Change and Infectious Disease - Malaria and Shigella as Models
Wilson, Will	Visiting Scientist

Appendix 2. Tables and Figures.

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Table 1. Number of U.S. Participants at NCEAS by State, 1995 – 1999.

State	*# participants*
AK	11
AL	6
AR	2
AZ	61
CA	698
CO	133
CT	26
DC	39
DE	5
FL	44
GA	29
HI	11
IA	9
ID	12
IL	39
IN	5
IO	4
KS	21
KY	8
LA	10
MA	112
MD	45
ME	35
MI	30
MN	29
MO	11
MS	4
MT	15
State	# participants
NC	57
NE	4
NH	33
NJ	33
NM	31
NV	13
NY	89
OH	12
OK	6
OR	60
PA	21
PR	5
RI	5
SC	1
SD	2
TN	46
TX	22
UT	35
VA	55
VT	4
WA	129
WI	62
WV	1
WY	9
total	**2189**

Country	*# participants* = 597
ARGENTINA	7
AUSTRALIA	66
AUSTRIA	1
BELGIUM	1
BERMUDA	1
BRAZIL	5
BRITISH VIRGIN ISLANDS	1
CANADA	98
CHILE	6
CHINA	6
COLUMBIA	1
COSTA RICA	6
CZECH REPUBLIC	2
DENMARK	5
ECUADOR	4
FINLAND	9
FRANCE	21
GERMANY	27
INDIA	1
ISRAEL	3
ITALY	2
JAPAN	9
KENYA	1
MEXICO	2
NETHERLANDS	27
NETHERLANDS ANTILLES	1
NEW ZEALAND	10
NORWAY	2
PHILIPPINES	1
RUSSIA	2
SCOTLAND	8
SOUTH AFRICA	7
SOUTH KOREA	2
SWEDEN	26
SWITZERLAND	4
THAILAND	1
UNITED KINGDOM	52
VENEZUELA	3
ZIMBABWE	1
unknown	165

Appendix 3. Review of NCEAS Research Papers by Science Advisory Board

Table A3-1. NCEAS Science Advisory Board, 1999

Chair: Nancy Grimm, Department of Biology, Arizona State University

Members:

James Brown, Department of Biology, University of New Mexico
James Estes, Biological Resources Division, U.S. Geological Survey
Christopher Field, Carnegie Institution of Washington
Deborah Goldberg, Department of Biology, University of Michigan
Ilkka Hanski, Department of Ecology and Systematics, University of Helsinki
Robert Holt, Natural History Museum, University of Kansas
Jeremy Jackson, Scripps Institute of Oceanography, University of California, San Diego
Mathew Leibold, Ecology and Evolutionary Biology, University of Chicago
Jonathan Losos, Department of Biology, Washington University
Marc Mangel, Department of Environmental Studies, University of California, Santa Cruz
Peter J. Morin, Department of Ecology, Evolution, & Natural Resources, Rutgers University
William Murdoch, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara
Roz Naylor, Institute for International Studies, Stanford University
Michael Pace, Institute of Ecosystem Studies
Alison Power, Department of Ecology and Systematics, Cornell University
Ronald Pulliam, Institute of Ecology, University of Georgia
Daniel Simberloff, Department of Ecology and Evolutionary Biology, University of Tennessee
Alan Townsend, Institute for Arctic and Alpine Research, University of Colorado
Joseph Travis, Department of Biological Science, Florida State University

Table A3-2. Papers Included in Science Advisory Board Review.

Antonovics, J., P. Thrall and A.M. Jarosz. 1997. Genetics and the spatial ecology of species interactions. In D. Tilman and P. Kareiva, editors. Spatial Ecology - The Role of Space in Population Dynamics and Interspecific Interactions. Princeton University Press, Princeton, USA.

Chapin, F.S., B. Walker, R. Hobbs, D. Hooper, J.H. Lawton, O. E. Sala and D. Tilman. 1997. Biotic controls over the functioning of ecosystems. Science 277:500-504.

Clark, J.S., C. Fastie, G. Hurtt, S. Jackson, C. Johnson, G. King, M.A. Lewis, J. Lynch, S. Pacala, P.I. Prentice, E. Schupp, T. Webb and P. Wyckoff. 1998. Dispersal theory and Reid's Paradox of rapid plant migration. BioScience 48:13-24.

Costanza, R., R.C. d'Arge, R. de Groot, S. Farber, M. Grasso, Monica ; B. Hannon, K. Limburg, R.V. O'Neill, J. Paruelo, R.G. Raskin, S. Naeem, P. Sutton and M. Van Den Belt, Marjan. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-261.

Cottingham, K.L. and S.R. Carpenter. 1998. Population, community and ecosystem variates as ecological indicators: phytoplankton response to whole-lake enrichment. Ecological Applications 8(2):508-530.

Downing, J.A., C.W. Osenberg, and O. Sarnelle. Meta-analysis of marine nutrient-enrichment experiments: variation in the magnitude of nutrient limitation. Ecology 80: 1157-1167.

Ellner, S.P., B.E. Kendall, S. Wood, E. McCauley and C. Briggs. 1997. Inferring mechanism from time-series data: delay differential equations.. Physica D 110:182-194.

Fagan, W.F., R. Cantrell and C. Cosner. 1999. How habitat edges change species interactions. American Naturalist. 153:165-182.

Foster, D.R., D.H. Knight and Jerry F. Franklin. 1998. Landscape patterns and legacies resulting from large, infrequent forest disturbances. Ecosystems 1: 497-510.

Gomulkiewicz, Richard , R.D. Holt, and M. Barfield, M . 1999. The effects of density dependence and immigration on adaptation and niche evolution in a black-hole sink environment. . Theoretical Population Biology 55:283-296.

Hanski, I. and M. Gyllenberg. 1997. Uniting two general patterns in the distribution of species. Science 275:397-400.

Hawkins, B.A., C.Cornell and M.E. Hochberg. 1997. Predators, parasitoids, and pathogens as mortality agents in phytophagous insect populations. Ecology 78:2145-2152.

Jackson, R.B., H.A. Mooney and E.D. Schulze, E.D. 1997. A global budget for fine root biomass, surface area, and nutrient contents. Proceedings of the National Academy of Sciences 94:7362-7366.

Kendall, B.E., J. Prendergast and O.N. Bjornstad. 1998. The macroecology of population dynamics: taxonomic and biogeographic patterns in population cycles. Ecology Letters 1:160-164.

Micheli, F. 1999. Eutrophication, fisheries, and consumer-resource dynamics in marine pelagic ecosystems. Science 285: 1396-1398.

Micheli, F., K.L. Cottingham, J. Bascompte, O.N. Bjornstad, G.L. Eckert, J.M. Fischer,

T.Keitt, B.E. Kendall, J.L. Klug and J.A. Rusak. 1999. The dual nature of community variability. Oikos 85:161-169.

Osenberg, C.W., O. Sarnelle, S.D. Cooper and R.D. Holt, Robert D. 1999. Resolving ecological questions through meta-analysis: goals, metrics, and models. Ecology 80: 1105-1117.

Palmer, M. A., R.F. Ambrose, R.F. Poff and N. Leroy. 1997. Ecological theory and community restoration ecology. Restoration Ecology 5(4):291-300.

Parmesan, C. 1996. Climate and species' range. Nature. 382:765-766.

Parmesan, C., N. Ryrholm, C. Stefanescu, J. Hill, C. Thomas, C ; H. Descimon, L. Huntley, L. Kaila, J. Kullberg, T. Tammaru, J. Tennent, J. Thomas and M. Warren. 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. Nature 399:579-583.

Shea, K. and NCEAS Working Group On Population Management. 1998. Management of populations in conservation, harvesting and control. Trends in Ecology & Evolution 13:371-375.

Thompson, J.N. 1999. Specific hypotheses on the geographic mosaic of coevolution. American Naturalist 153, Suppl:S1-S14.

Waide, R.B., M.R. Willig, G. Mittelbach, C. Steiner, L. Gough, S.I. Dodson, G.P. Juday and R. Parmenter. 1999. The relationship between primary productivity and species richness. Annual Review of Ecology and Systematics 30:257-300.

Weathers, K.C. and G.M. Lovett. 1998. Acid deposition research and ecosystem science: synergistic successes. In M. Pace and P.M. Groffman, editors, Successes, limitations and frontiers in ecosystem science. Springer-Verlag. New York, U.S.A.

Table A3-3. Review of selected research papers resulting from NCEAS activities (prepared by Nancy Grimm, Chair, NCEAS Science Advisory Board).

Twenty-eight papers were read by 4 groups of Science Advisory Board members (SAB). Each group considered seven questions in reading the papers, and discussed and arrived at consensus on their answers to these questions. In addition, the groups considered the entire list of NCEAS publications and unanimously felt that the journals involved are well-respected, high-quality publications (note: by my quick (and probably uninformed in some areas) count, 28% in top tier, 44% in 2nd tier, and 18% in other journals; NBG).

1. Is the work generally of high caliber?

19 YES; 4 MAYBE; 4 NO

2. Is there something distinctive about the results or papers that seems related to the NCEAS model of research?

13 YES, 2 MAYBE, 13 NO

[Things cited as distinctive: opinion paper by junior scientists (Micheli et. al., 1999), creative and novel analysis methods (meta-analysis WG, Cottingham & Carpenter), also breadth of examples in some review-type papers.]

3. Could the same work have been done as effectively or as quickly without NCEAS?

13 YES, 2 MAYBE, 13 NO

[My guess is the 13 NO's are EXACTLY the same papers as the 13 YESes for #2!. In general, what is therefore unique about the NCEAS model is that the analysis and synthesis that is viewed as distinctive may be viewed thus because it is more efficient or rapid than could be hoped for in a standard research situation.]

4. Are any of the papers "breakthroughs"?

10 YES, 18 NO

[Note that groups differed in how stringent they were about applying the term "breakthrough" - some said yes if they considered the paper an important contribution; others restricted "yes" answers to papers likely to completely change the direction of a sub-discipline...]

5. Do any of the papers indicate a change in the way we conduct our science?

6 YES, 1 MAYBE, 18 NO

[I'm surprised at the low number of YESes here, and can only guess that groups differed in the stringency with which that judged a "change in the way we conduct our science". Personally, I thought all could apply because of the culture shift accompanying increased use of mined data as opposed to primary data collection, etc.]

6. Have any of them been important for resource managers or policy makers?

12 YES, 1 MAYBE, 15 NO

7. Does anything in the publications indicate improvements that could be made in the NCEAS approach?

17 YES, 1 MAYBE, 10 NO

[Note that responses to this question reflected the idea that if a paper was viewed as a mediocre contribution, it was suggested that the activity that led to it (often, a workshop) was not a good way to spend NCEAS money. YESes were also models of how NCEAS research should be done. This question is probably difficult to assess because groups interpreted it differently. However, often the papers groups did not like were products of workshops or symposia.]

Appendix 4. Draft Report on Collaboration at NCEAS, by Edward Hackett.

Summary of survey results.

We distributed a brief questionnaire (appended, with means and frequencies) to all 131 participants in NCEAS working groups during the summer of 1999. We received 91 completed questionnaires (68 men, 19 women, 4 unknown), for an overall response rate of 69%. Results are presented in a series of tables, accompanied by brief commentaries, that provide a sketch of the NCEAS experience and its potential influence in the field of Ecology.

Table A4-1. Orientation toward integrative work **Agree (%)**

Synthesis of theoretical ideas across fields of science is crucial to further knowledge.	93% (75% strongly)
Integrative work is essential for the development of Ecology.	97% (76% strongly)
Was Ecology more specialized in the past than it is today?	33% (29% disagree)
Sharing ideas is risky for people at my career stage.	2% (81% disagree)
It's best for someone at my career stage to specialize.	2% (77% disagree)

Much of this is motherhood and apple pie: working group (WG) participants overwhelmingly support synthesis and theoretical integration. Views differ quite sharply about whether Ecology is now more specialized than it was in the past. Chances are the field has become more specialized or differentiated over time, as indicated by specialized journals, conferences, skills and so forth, so it is somewhat surprising that views vary so much.

Perhaps the most striking result in the table is respondents' overwhelming <u>rejection</u> of the notion that sharing ideas is risky and that specialization is advisable.

Table A4-2. Group process

	Agree (%)
The group worked well as a team	92%
All group members did their fair share of work	86%*
Group discussion invited sharing of ideas	91%
All group members had adequate time to express their ideas	90%*
Ideas presented were sufficiently considered by the group	91%*
The scientific diversity of the group contributed to its effectiveness	86%*
The group did a good job synthesizing ideas from various specialties	77%*
A few group members made exemplary contributions	66% (8% disagree)
Certain group members dominated discussion	41%*
Competition hindered the group	3% (87% disagree)
The group agreed on standards of data quality and evidence	62% (13% disagree)
The group agreed on suitable methods.	56%*
The group agreed about what would constitute a scientific contribution	63% (15% disagree)
The group is contributing to scientific knowledge	97%
The group's work will contribute to policy or management practice	54% (17% disagree)
The group achieved the goals set forth in the proposal	80%
* The percents are based on a four-point unipolar scale. The top two categories, representing strong agreement, are reported here.	

Working groups work well. Teamwork is high; ideas are expressed, shared and considered by the group; there is diversity and integration of diverse contributions. About two-thirds of respondents thought a few members made exemplary contributions to the group's work and, perhaps a necessary accompaniment to that sort of excellence, a significant fraction of respondents (41%) also thought a few members dominated group discussion. Competition, however, was not a problem.

Agreement on standards of evidence, suitable methods and what constitutes a scientific contribution is substantial but not universal. (But disagreement is not very high, either.) These sorts of judgments are at the core of integrative work and hard to achieve. We would expect rising agreement as collaboration across specialties continues. This sort of agreement is especially important for coauthorship, as collaborating authors must first agree among themselves about such matters, then convince reviewers and editors.

Working groups are generally viewed as quite successful, especially in their contributions to science but also, to a much lesser extent, in contributions to policy and practice (admittedly <u>not</u> the purpose of many groups). Some 80% think groups achieved what they had proposed to do, suggesting that a significant amount of some groups' success arises from modifying their objectives in light of group advice and expertise.

Table A4-3. Satisfaction

How satisfied are you with…	Dissatisfied (%)	Satisfied (%)	Very satisfied (%)
the overall working group experience?	1	43	55
the scientific product of your group?	3	59	28
the quality of the group’s scientific work?	1	56	40
arrangements for allocating authorship credit?	3	44	27
the group’s pre-meeting preparation?	9	47	17
the quality of NCEAS facilities?	2	39	57

Satisfaction is high, with 98% satisfied with the overall working group experience. The areas of some concern are authorship arrangements and pre-meeting preparation. Arranging suitable authorship credit for a group of ten or so scientists is a difficult matter, especially if the goal of the group is to produce work that integrates a range of diverse contributions. Perhaps new standards for recognizing intellectual contributions in collaborative work will arise within the field, assuring participants of appropriate credit for their work. Till then, applying traditional standards of credit allocation to papers with many authors will surely shortchange some.

Pre-meeting preparation may improve with experience, or may be endemic (and a reason for working groups to exist). Perhaps specific homework assignments to particular members of working groups will insure adequate preparation. Or it may be that demands are so great at scientists' home institutions that they cannot concentrate on the working group task until they are at NCEAS.

Table A4-4. Influences of NCEAS experience on individual research behavior

	Not at all (%)	Slightly (%)	Substantially (%)	Very likely (%)
Would you be more willing to share data with other researchers?	24	27	35	15
Would you be likely to collaborate with working group members in the future?	1	11	33	55
Would you encourage others to participate in an NCEAS working group?	0	1	13	86

NCEAS is expected to influence the research process, the social organization and the intellectual substance of Ecology. The process of research is expected to become more integrative in theory, method and data. The social organization of Ecology is expected to show more collaboration and interaction, particularly across specialties and across the fundamental science/application divide. And the intellectual substance of Ecology should display more synthetic theory, more integrative modeling and more breadth and diversity of data. Good measures of such effects at the disciplinary level will take significant time and resources to develop. As a quick approximation, working group members were asked to report how their experience would influence relevant aspects of their research behavior.

Virtually all would encourage others to participate in a working group, and the great majority would collaborate with working group members in the future. About half would share data with other researchers, while a quarter would not and another quarter seem reluctant to do so.

Data-sharing appears to strike close to scientists' self-interest and to existing norms governing rights to intellectual property. Federal funding agencies generally require of sharing data gathered with public funds, but mechanisms for doing so--and doing so effectively--probably lag behind the directive. NCEAS can help here as a force for normative change, encouraging Ecologists to archive their data after taking a reasonable time to publish from them, and also as a clearinghouse for such data.

Table A4-5. Influences of NCEAS on Research Behavior

As a result of my NCEAS experience, I expect my work will be more…	Not likely (%)	Somewhat likely (%)	Probably (%)	Highly likely (%)
Collaborative	4	23	41	33
Informed by literature from other specialties	9	20	27	44
Comprehensive in its use of data	18	20	40	22
Theoretically integrative	21	22	35	22
Attentive to issues of fundamental science	26	27	31	17
Concerned with a greater variety of species	32	21	27	20
Mathematically sophisticated	36	19	33	13
Concerned with a larger spatial area	36	20	18	26
Concerned with a different time scale	38	25	17	21
Empirical	47	16	24	13
Focused on applied problems	43	26	19	12

Table 5 displays, in descending order of likelihood (the sum of the two right-hand columns), a variety of ways that a scientist's research might change in response to the NCEAS experience. More than 70% said their work would probably become more collaborative and more informed by literature from other specialties. More than half said they would use more comprehensive data and more integrative theory, but 20% indicated that such changes were not likely in their work. We might think of these four items--collaboration, increased scope of literature consulted, more comprehensive data and integrative theory-- as the core of the NCEAS mission. If so, then the majority of working group participants reported that their work would probably change in the desired ways, and only a minority would not change at all.

About 40% of participants reported that they would move in the direction of the next set of possible changes in a scientist's work, which includes increased diversity of species, spatial range and temporal scale. The level of resistance to such changes rises, too, with more than a third indicating that their work would not change in such ways.

Finally, some indicated that their work would become more empirical, and a minority would focus more on applied problems.

Table A4-6. Further influences on research

As a result of my NCEAS experience, I expect that my research will …	Not likely (%)	Somewhat likely (%)	Probably (%)	Highly likely (%)
Use more primary data	46	26	17	10
Use more secondary data	34	21	25	20
Use more diverse explanatory models	21	21	40	19

Table 6 shows that the NCEAS experience will cause only about a quarter of participants to use more primary data in their future work, while 45% will use more secondary data. More than half will use more diverse explanatory models.

To put these findings in perspective, an index of NCEAS's influence on research was constructed by averaging scores on the 14 items reported in Tables 5 and 6. Scores filled the entire range, with a mean and median of 2.4. About a third of all respondents scored below 2.0, indicating change that is "somewhat likely" or less, while about 29% scored 3.0 or more, indicating aggregate change that is probable or highly likely. More striking, 71% indicated that change on at least one dimension was "highly likely," and an additional 20% said that change on at least one dimension was "probable." So the great majority of scientists who participated in a working group indicated a strong influence on some aspect of their work.

A factor analysis (principal components with varimax rotation) helps to simplify the fourteen dimensions. Two main factors are found, and the first factor is by far the strongest (eigenvalue = 6.5, accounting for 46% of the variance). This is a general factor that captures fundamental change in scientific work, with strongest loadings for such items as mathematical sophistication, theoretical integration, an orientation toward fundamental science, more use of primary data and more empirical work. The second factor (eigenvalue = 1.5, 10% of variance) captures diversity, with high loadings for species diversity (.713), spatial diversity (.858), and temporal scale diversity (.832). In brief, the first factor seems to represent the main mission of NCEAS, while the second is a "spillover" effect of intellectual broadening.

Who changes?

Aggregate change scores are unrelated to age, sex and tenure status (whether a person is tenured or not). But some notable influences can be found.

Of 50 scientists who reported that they never or only sometimes develop **synthetic theory** in the current work, 25 (50%) probably will be more integrative in their future work. Of 31 scientist who often or always develop synthetic theories, 20 (65%) will be more integrative in the future.

Of 31 scientists who never or sometimes use **primary data** in their work, 7 (23%) probably will do so in the future. Of 43 who often or always use primary data, 14 (33%) will use more primary data in the future.

Of 26 scientists who never or sometimes use **secondary data**, 10 (38%) probably will use more in the future. Of 49 who often or always use secondary data, 23 (47%) will use more.

Of 49 scientists who often or always use **secondary data**, 14 (29%) say they will use more **primary data** in the future. And of 43 who often or always use **primary data**, 20 (47%) will use more secondary data.

Finally, of 23 scientists who never or only sometimes use **mathematical or statistical modeling**, 6 (26%) indicated that they would probably use more. While of the 61 who often or always use such models, 32 (52%) said they would use more.

Appendix 5. Postdoctoral Fellowships at NCEAS: The Inside Story

The postdoctoral experience is a challenging and potentially trying time (see Science 1999 and Chronicle of Higher Education 1998). NCEAS postdoctoral appointments have unique features that make the experience more rewarding and more challenging than a typical position. The current cohort of NCEAS posdocs initiated a discussion to summarize the postdoc experience at the Center. We distributed a survey to current and past NCEAS postdocs to produce some quantitative measures of professional success attributable to NCEAS (Table 1) and identified several distinctive features about NCEAS. We have produced this document to summarize the benefits and limitations of our experiences at NCEAS. In doing so, we hope to inform the SAB about the postdoctoral program (from the inside) and help prospective postdoctoral applicants decide whether an NCEAS postdoc is a position they desire.

Benefits of the NCEAS postdoc experience

NCEAS postdocs have unique opportunities for meeting a diversity of leading scientists

Most postdoctoral positions are isolating. At NCEAS the world comes to you. NCEAS postdocs get exposure to a broad range of people and ideas than one could ever get in a single local institution, given all the visitors coming through and diversity of postdoc backgrounds. We also get exposure to Center Fellows (Sabbatical Visitors) from different disciplines who are more focused and accessible than professors with diverse interests located in their home departments. The result is broad exposure to a diversity of ideas and opinions.

NCEAS postdocs have a community of young scientists with whom to work and exchange ideas.

At NCEAS is that there is a community of young scientists who are in similar stages in their careers. There is a much larger postdoc cohort than in most academic departments, and hence more advice from peers on both scientific and career fronts.

NCEAS postdocs have great freedom

The NCEAS postdoc experience is particularly valuable for it's independence. Here, you're on your own to choose important problems and tackle them in the way you best see fit. There is none of the typical "working on your advisor's problem that he/she doesn't have time to work on" that postdocs experience elsewhere.

A NCEAS postdoc clearly helps in getting a job.

On average, every postdoc who applied for a faculty job got at least one interview, and about half of those interviewed were offered positions. NCEAS postdocs have been offered faculty positions at Dartmouth, Stanford, University of California at Santa Barbara, University of Chicago and University of Texas at Austin.

NCEAS postdocs diversify their research experience .

One consequence of the melding of postdocs and Sabbatarians from diverse fields is that we wind up diversifying in our research interests, and taking on side-projects. Some interesting case studies of interdisciplinary projects include ecological economics, community variability, and spatial synchrony. Based on our survey results, NCEAS postdocs became involved with an average of 2.5 working groups during their stay, and produced an average of 1.2 papers from side projects.

Limitations of the NCEAS postdoc experience

NCEAS postdocs do not have mentors

NCEAS postdocs have no formal mentors with whom we can discuss science or career choices. A high level of self-motivation and sense of direction is required develop and maintain relations with mentors (Center Fellows, SAB members, and Working Group members are some potential mentors). Also, to mitigate the lack of mentorship, funding is available to work with individuals in their lab for extended periods (2-3 weeks).

No experiments are done and no primary data are collected.

Experimental ecologists should think twice before applying for a position as an NCEAS postdoc. The mission of NCEAS, synthesis and analysis, offers a lot of unique opportunities, but may be confining to some.

Work at NCEAS is generally collaborative and multi-authored.

Research at NCEAS is generally collaborative, often involving more than two authors. Although the research that done in this manner is often very productive, acceptance of this research style in ecology today still seems quite limited. NCEAS postdocs must be careful to maintain a research program that they can call their own. This may be especially important in applying for jobs.

In sum, NCEAS postdocs are not ideal positions for all ecologists, such as strictly experimental ecologists. However, the emphasis on Aanalysis and synthesis≅ at NCEAS provides a stimulating atmosphere in which the postdocs have achieved high productivity and success on the job market.

Literature Cited

Magner, D.K. 1998. 'Postdocs,' Seeing Little Way Into the Academic Job Market, Seek Better Terms in the Lab. The Chronicle of Higher Education. 1998 (Aug. 7); Section: The Faculty; Page: A10.

Mervis, J., ed. 1999. Postdocs working for respect. Science 285(5433): 1513-1533.

Table 5-1. Quantitative measures of academic success (Mean ± SE) for NCEAS postdocs*

	Current Postdocs	Previous Postdocs
NCEAS papers in press	3	1.3
NCEAS papers submitted	2.3	0.5
NCEAS papers 1st author in press	2.2	.8
NCEAS papers 1st author submitted	1.6	.35
NCEAS papers in key journals	.64	.13
Job interviews while at NCEAS**	1.37	1.6
Job offers while at NCEAS**	.84	.56

* Results based on a survey of nine of the twelve previous postdocs and ten of the fifteen current postdocs. Each metric was scaled by ratio of the duration of the stay at NCEAS to the total length of stay at NCEAS (e.g., number of NCEAS papers/(nine months/twelve months).

** The number of job interviews and offers were calculated only those postdocs who applied for jobs during their tenure at NCEAS. Postdocs who had been at the Center for less than 4 months and those that opted not to apply for jobs were not considered in this calculation.

Appendix 6. NCEAS Datasets. Note: Restricted distribution status indicates that permission must be obtained from the project leader
before data sets can be distributed. In a few cases, data are proprietary and cannot be distributed without permission from the relevant
organization or agency.

Project Leader	Project ID	Dataset Title	Originator/ Owner	Contact Person
Costanza & Farber	2058: Natural Capital	Summary of average global value of annual ecosystem services	Costanza et. al.	Costanza: costza@cbl.umces.ed u
Costanza & Farber	2058: Natural Capital	Summary of maximum global values of ecosystem services	Costanza et. al.	Costanza: costza@cbl.umces.ed u
Costanza & Farber	2058: Natural Capital	Summary of minimum global values of ecosystem services	Costanza et. al.	Costanza: costza@cbl.umces.ed u
Costanza & Farber	2058: Natural Capital	International values of ecological and economic resources and processes	Costanza et. al.	Costanza: costza@cbl.umces.ed u
Costanza & Farber	2058: Natural Capital	U.S. ecosystem service values by habitat type	Costanza et. al.	Costanza: costza@cbl.umces.ed u
Ives & Frost	2244: Community Dynamics	Intrinsic and Extrinsic Variability in Community Dynamics (for Little Rock Lake, Cascade and LTER sites)	Ives et. al.	CottinghamKathryn. Cottingham@Dartmo uth.edu
Ives & Frost	2244: Community Dynamics	Intrinsic and Extrinsic Variability in Community Dynamics (for Dorset, Ela and Mono Lake sites)	Ives et. al.	Cottingham Kathryn.Cottingham @Dartmouth.edu
Gower & McMurtrie	2018: Productivity Decline	Decline in Carbon Assimilation of Forests: Australia (BFG)	McMurtrie	Jeffreys: m.jeffreys@unsw.edu .au
Gower & McMurtrie	2018: Productivity Decline	Decline in Carbon Assimilation of Forests: Colorado (FEF)	Ryan	Jeffreys: m.jeffreys@unsw.edu .au
Gower & McMurtrie	2018: Productivity Decline	Decline in Carbon Assimilation of Forests: Florida (Gainesville)	Luxmoore	Jeffreys: m.jeffreys@unsw.edu .au
Gower & McMurtrie	2018: Productivity Decline	Decline in Carbon Assimilation of Forests: Hawaii	Ryan	Jeffreys: m.jeffreys@unsw.edu .au
Gower & McMurtrie	2018: Productivity Decline	Decline in Carbon Assimilation of Forests: N. Carolina (SETRES)	Talbaugh	Jeffreys: m.jeffreys@unsw.edu .au
Gower &	2018: Productivity	Decline in Carbon Assimilation of Forests:	Linder	Jeffreys:

McMurtrie	Decline	N. Sweden (Flakaledin)		m.jeffreys@unsw.edu .au
Gower & McMurtrie	2018: Productivity Decline	Decline in Carbon Assimilation of Forests: N. Wisconsin	Gower	Jeffreys: m.jeffreys@unsw.edu .au
Jackson	2178: Root Models	Global compilation of fine-root nutrient concentrations and root diameter	Jackson et. al.	Jackson: rjackson@mail.utexas.edu
Jackson	2178: Root Models	Global root distributions	Jackson et. al	Jackson: rjackson@mail.utexas.edu
Kareiva	2049: Habitat Conservation	Answers to plan-based questions asked o 43 focal Habitat Conservation Plans	Kareiva et. al.	Regetz regetz@nceas.ucsb.edu
Kareiva	2049: Habitat Conservation	Answers to Species based questions asked of 43 focal Habitat Conservation Plans	Kareiva et. al.	Regetz regetz@nceas.ucsb.edu
Kareiva	2049: Habitat Conservation	Answers to questions of 208 Habitat Conservation Plans	Kareiva et. al.	Regetz regetz@nceas.ucsb.edu
Liebhold & Gurevitch	2162: Spatial Analysis	Exhaustive map locations and status of desert plants sampled in Colorado 1984	Liebhold et. al.	Liebhold: sandy@gypsy.fsl.wvu .edu
Liebhold & Gurevitch	2162: Spatial Analysis	Exhaustive map locations and status of desert plants sampled in Colorado 1989	Liebhold et. al.	Liebhold: sandy@gypsy.fsl.wvu .edu
Liebhold & Gurevitch	2162: Spatial Analysis	Exhaustive map locations of tupelo trees sampled in bottomland forests.	Liebhold et. al.	Liebhold: sandy@gypsy.fsl.wvu .edu
Liebhold & Gurevitch	2162: Spatial Analysis	Exhaustive map and gridded maps of locations of isopod burrows and environmental variables in in Israel	Liebhold et. al.	Liebhold: sandy@gypsy.fsl.wvu .edu
Liebhold & Gurevitch	2162: Spatial Analysis	Breeding bird survey data: European starling	Marie Miriti	Liebhold: sandy@gypsy.fsl.wvu .edu
Liebhold & Gurevitch	2162: Spatial Analysis	Breeding bird survey data: Mourning dove	Marie Miriti	Liebhold: sandy@gypsy.fsl.wvu .edu
Liebhold & Gurevitch	2162: Spatial Analysis	Breeding bird survey data: American robin	Phil Dixon	Liebhold: sandy@gypsy.fsl.wvu .edu
Liebhold & Gurevitch	2162: Spatial Analysis	Oribatid mite data set	Steven Citron-Pousty	Liebhold: sandy@gypsy.fsl.wvu .edu
Liebhold &	2162: Spatial	Basal area of oaks in Pennsylvania	Breeding	Liebhold:

Gurevitch	Analysis		Bird Survey	sandy@gypsy.fsl.wvu .edu
Liebhold & Gurevitch	2162: Spatial Analysis	Remotely - sensed data: NDVI data derived from AVHRR imagery from Northern Washington	Breeding Bird Survey	Liebhold: sandy@gypsy.fsl.wvu .edu
Liebhold & Gurevitch	2162: Spatial Analysis	Counts of gypsy moths in pheromone traps in the Central Appalachian Mountains	Breeding Bird Survey	Liebhold: sandy@gypsy.fsl.wvu .edu
Micheli	2234: Marine Communities	Marine mesocosm experiments on phytoplankton and zooplankton responses to manipulations of nutrients and food-web structure	Pierre Legendre	Micheli: f.micheli@trident.net tuno.it
Micheli	2234: Marine Communities	Time series data of nitrogen concentrations, primary productivity, Phytoplankton, zooplankton and fish abunda	US Forest Inventory & Analyisis data	Micheli: f.micheli@trident.net tuno.it
Murdoch	2264: Complex population Dynamics	Global Population Dynamics Database	Various	Center for Population Biology http://cpbnts1.bio.ic.a c.uk/gpdd/
Lubchenco, Palumbi &Gaines	2080: Marine Reserves	Species Occurence Data for Eastern Pacific Coastal Marine Communities	Sharov, Liebhold & Robert	Ginny Eckert eckert@lifesci.ucsb.e du
Bjornstad	2146: Recruitment Variability	Japanese Forestry Agency's Hokkiado rodent census	Bjornstad	Takashi Saitoh bedford@fsm.affrc.g o.jp
Bjornstad	2146: Recruitment Variability	The Floedevigen census of Norwegain coastal cod	Bjornstad	Jakob Gjoesaeter jakob.gjoesaeter@im .no
Amaraseka re and Possingha m	2073: Amarasekare Postdoc	Longevity and maturation rate of Florida rosemary scrub (Eryngeum cuneifolium) and the frequency of fires in the Florida scrub habitat.	Murdoch	Menges
Andelman	2002: Biological Diversity	Species and rare plant community occurrences and plant coverages: Columbia Plateau	Ginny Eckert	Andelman: andelman@nceas.ucs b.edu
Andelman	2002: Biological Diversity	Species and rare plant community occurrences and plant coverages: Sierra Nevada	Takashi Saitoh	Andelman: andelman@nceas.ucs b.edu
Andelman	2002: Biological Diversity	Species and rare plant community occurrences and plant coverages: Idaho Batholith	Jakob Gjoesaeter	Andelman: andelman@nceas.ucs b.edu
Andelman	2002: Biological	Time series of plant population abundances	Menges,	Andelman:

	Diversity		Kimmich, and Kohfeldt	andelman@nceas.ucsb.edu
Boersma & Kareiva	2179: Recovery Plans	Recovery Plan data	Boersma	Boersma
Ojima & Mosier	2267: Trace Gasses	Analysis and Synthesis of Trace Gas Fluxes	Ojima et. al.	Mosier: amosier@lamar.colostate.edu
Prince	2017: Worldwide NPP	International Biological Program (IBP) Woodland data	DeAngelis et.al.	Daolan Zheng dzheng@Glue.umd.edu
Prince	2017: Worldwide NPP	Osnabruck NPP data	Esser & Lieth	Esser
Prince	2017: Worldwide NPP	Oregon Transect Ecosystem Research Project NPP dataset	Boersma et. al.	Waring
Prince	2017: Worldwide NPP	Siberian Scotts Pine database	ORNL	Krankina
Prince	2017: Worldwide NPP	Terrestrial Ecosystem Model dataset	ORNL	Kicklighter
Prince	2017: Worldwide NPP	Net primary production (NPP) database for 14 forest types at 673 sites in CHINA	ORNL	Daolan Zheng dzheng@Glue.umd.edu
Prince	2017: Worldwide NPP	Biomass, NPP Data, env. variables, from Canada, Finland, USA, Russia, Siberia, Flakaliden, Sweden	NCEAS	Apps: mapps@nofc.forestry.ca
Prince	2017: Worldwide NPP	Crop NPP from harvest inventory data in Iowa, USA	Prince et. al.	Haskett jh248@umail.umd.edu
Prince	2017: Worldwide NPP	Biomass increment for hardwood and softwood forests in the eastern US	Prince et. al.	J.S. Kern (541)754-4494
Prince	2017: Worldwide NPP	Global NPP values	Prince et. al.	dkick@lupine.mbl.edu
Prince	2017: Worldwide NPP	Average ANPP values from the US Great Plains grasslands	Sala et. al.	Daolan Zheng dzheng@Glue.umd.edu
Prince	2017: Worldwide NPP	Vegetation Map	Prince et. al.	Kicklighter dkick@lupine.mbl.edu
Prince	2017: Worldwide NPP	NPP data in Panama, Brazil, Puerto Rico, Venezuela, and Costa Rica	Prince et. al.	Daolan Zheng dzheng@Glue.umd.edu
Prince	2017: Worldwide NPP	Extrapolation of NPP in grassland regions for remote sensing and model validation	Prince et. al.	Coughenour
Prince	2017: Worldwide NPP	Biomass and NPP data for boreal forests, grasslands, and tropical forests	Prince et. al.	Daolan Zheng dzheng@Glue.umd.edu

Prince	2017: Worldwide NPP	Mean Belowground NPP 1958-98 based on 9 months rainfall, Sept.-May, Queensland, Australia	Prince et. al.	Ken Day ken.day@dnr.qld.gov .au
Prince	2017: Worldwide NPP	Annual growth (g/m2) 1982, 83, 84 with and without trees, and MEAN ANPP (g/m2), 1955-95 in Queensland, Australia	Prince et. al.	Ken Day: ken.day@dnr.qld.gov .au
Russell & McKinney	2066: Sampling Curves in Ecology	Common Birds Census of the UK	British Trust for Ornithology	Russell: grussell@utk.edu
Russell & McKinney	2066: Sampling Curves in Ecology	1996 Red Data List of Endangered Animals with Taxonomy	Wilson and Reeder Sibley and Monroe	British Trust for Ornithology: info@wcmc.org.uk
Smith	2182: Body Size	Macroecological Database: species compositon, abundance, body-size on all vertebrate taxa, some inverts such as molluscs and insects, and plants	Smith et. al	Haskell : jhaskell@unm.edu
Damuth	2041: Mammal Communities	Climatic and Habitat Inference from Features of Mammalian Paleocommunities	Damuth et. al.	Damuth: damuth@lifesci.ucsb. edu
Elser & Fagan	2154: Ecological Stoicheometry	Ecological Stoichiometry of Plant-Herbivore Interactions	Elser et. al.	Fagan: bfagan@asu.edu
Kaufman	2084: Biodiversity Gradient	Body masses for North and South American mammals	Kaufman	Kaufman: kaufman@ nceas.ucsb.edu
Kaufman	2084: Biodiversity Gradient	Latitudinal distribution extents and range-edge characterization metrics for a subset of temperate mammals from North and South America	Kaufman	Kaufman: kaufman@ nceas.ucsb.edu
Kaufman	2084: Biodiversity Gradient	Latitudinal distribution extents and range-edge characterization metrics for a subset of tropical mammals from South America	Kaufman	Kaufman: kaufman@ nceas.ucsb.edu
Kaufman	2084: Biodiversity Gradient	Latitudinal distribution extents for North and South American mammals	Kaufman	Kaufman: kaufman@ nceas.ucsb.edu
Kaufman	2084: Biodiversity Gradient	Rank-abundance data for small mammals for several sites of differing latitudes in North America	Kaufman	Kaufman: kaufman@ nceas.ucsb.edu
Michener	*2091: Managed Floods*	Large-scale synthesis of controlled and natural floods	Michener:	Michener: wmichene@jonesctr. org
Parker	2117: Invasion	Metaanalysis of ecological effects of	Parker	Parker:

	Impacts	invasive species in several taxonomic groups		parker@biology.ucsc edu
Burton	2090: Project 2090	Trapping locations animal body mass, and breeding conditions of Neotoma fuscipes	Burton amd Gerber	Burton: burton@nceas.ucsb.edu

American Academy of Arts & Sciences
American Agricultural Economics Association
American Arachnological Society
American Association for the Advancement of Science
American Association for University Women
American Association of Environmental and Resource Economists
American Association of Geographers
American Association of Naturalists
American Association for the Advancement of Science
American Association of Stratigraphic Palynologists
American Economic Association
American Educational Research Association
American Elasmobranch Society
American Evaluation Association
American Fisheries Society
American Genetic Association
American Geophysical Union
American Institute of Biological Sciences
American Institute of Fishery Research Biologists
American Mathematical Society
American Meteorological Society
American Ornithological Union
American Phytopathological Society
American Political Science Association
American Psychological Association
American Quaternary Association
American Society for Limnology and Oceanography
American Society of Agronomy
American Society of Human Genetics
American Society of Ichthyologists and Herpetologists
American Society of Limnology and Oceanography
American Society of Mammalogists
American Society of Microbiologists
American Society of Naturalists
American Society of Photogrammetry and Remote Sensing
American Society of Plant Physiologists
American Society of Zoologists
American Statistical Association
Animal Behavior Society
Arctic Institute of North America
Arctic Research Consortium of the U.S.
Arizona Riparian Council
Asociacion Argentina de Ecologia
Asociación Latinoamericana de Botánica
Asociación Venezolana para el Avance de la Ciencia.

Association Argentina de Ecologia
Association Canadienne Française pour l'Avancement des Sciences
Association for Tropical Biology
Association for Women in Science
Association of American Geographers
Association of College and University Biology Educators
Association of Environmental and Resource Economists
Association of Southeastern Biologists
Association of Tropical Biologists
Australasian Mycological Society
Australasian Wildlife Management Society
Australian Coral Reef Society
Australian Ecological Society
Australian Marine Sciences Association
Australian Pollination Ecology Society
Australian Rangelands Society
Australian Society for Limnology
Australian Systematic Botany Society
Biological Society of Washington
Biometric Society
Birds Australia
Botanical Society of Switzerland
Botanical Society of America
British Ecological Society
British Mycological Society
British Society of Plant Pathology
British Society of Soil Science
California Botanical Society
California Native Plant Society
Cambridge Philosophical Society
Canadian Agricultural Economics Society
Canadian Association of Geographers
Canadian Botanical Association
Canadian Society for Limnologists
Center for the Study of the Evolution and Origin of Life
Chinese Professionals in Geographical Information Systems.
Coast and Wetlands Society
Colegio de Egresados de Ciencias
Commission on Ecosystem Management-UICN (Latin America Region)
Cooper Ornithological Society
Crop Science Society of America
Crustacean Society
Desert Fishes Council
Dragonfly Society of America
Ecological & Evolutionary Plant-Pathogen Systems Co-operative

Ecological Associates of China
Ecological Society of America
Ecological Society of Australia
Entomological Society of America
Entomological Society of Canada
Environmental and Resource Economists
Estuarine & Coastal Sciences Association
Estuarine Research Federation
Europal
European Palaeontological Association (France)
European Society for Ecological Economics
European Society for Evolutionary Biology
Fauna and Flora International
Fauna and Flora Preservation Society
Finnish Society of Sciences and Letters
Fisheries Society of the British Isles
Fishery Society of the British Isles
Florida Academy of Sciences
Florida Exotic Pest Plant Council
Florida Native Plant Society
Forest History Society
Genetics Society of America
Geological Society of America
Geological Society of Finland
George Wright Society
Herpetologists League
Indian Academy of Sciences
Indian Academy of Social Sciences
Indian Association of Soil and Water Conservationists
Indian Botanical Society
Indian National Science Academy
Indian Science Congress Association
Indian Society of Tree Scientists
Indiana Academy of Science
Institute for Operations Research and Management Sciences
Institute of Mathematical Statistics
International Society for Plant Molecular Biology
INTECOL
International Abalone Society
International Association for Plant Taxonomy
International Association for Vegetation Sciences
International Association for Ecology
International Association for Landscape Ecology
International Association for Vegetation Science
International Association of Astacology

International Association of Landscape Ecologists
International Association of Mycorrhizologists
International Association of Wildland Fire
International Society for Behavioral Ecology
International Society for Ecological Economics
International Society for Ecological Modeling
International Society for Ecosystem Health
International Society for History, Philosophy, and Social Studies of Biology
International Society for Mangrove Ecosystems
International Society for Reef Studies
International Society for Theoretical and Applied Limnology
International Society for Tropical Ecology
International Society of Cryptozoology
International Society of Ecological Economics (ISEE)
International Society of Genetics
International Society of Limnology
International Society of Soil Science
Italian Society of Ecology
Koninklijk Nederlands Geologisch en Mijnbouwkundig Genootschap
Latin America Society of Botany
Linnean Society
Linnean Society of London (United Kingdom)
Linnean Society of New South Wales
Marine Biological Association of the United Kingdom
Mexican Academy of Sciences
Mexican Botanical Society
National Academy of Education
National Academy of Sciences
National Association for Environmental Professionals
National Association of Science Writers
National Center for Science Education
National Council of University Research Administrators NCURA
Natural Areas Association
New York Academy of Sciences
New York Entomological Society
New Zealand Grassland Association
New Zealand Institute of Agricultural Science
Nordic Benthological Society
North American Benthological Society
North American Council on Geostatistics
North American Lake Management Society
Oceanography Society
Organization for Tropical Studies
Organization of Biological Field Stations OBFS
Ornithological Societies of North America

Paleontological Association
Paleontological Society
Phi Kappa Phi Honor Society
Plant Society of China
Primate Society of Great Britain
Resource Modeling Association
Rhode Island Natural History Society
Royal Society of Chemistry (UK)
Royal Society of South Africa
Royal Swedish Academy of Agriculture and Forestry
Sigma Xi, The Scientific Research Society
Society for Integrative Comparative Biology
Sociedad Argentina de Mastozoologia
Sociedad Argentina de Paleontologia
Sociedad Botánica de Venezuela
Sociedad de Ciencias La Salle (Miembro Correspondiente por Designación).
Sociedad Venezolana de Ciencias Naturales
Sociedad Venezolana de Ecología.
Societas Internationalis Limnologiae
Societas pro fauna et flora Fennica (Finland)
Society for Advancement of Botany
Society for Conservation Biology
Society for Ecological Restoration
Society for Economic Botany
Society for Environmental Toxicology and Chemistry
Society for Industrial and Applied Mathematics
Society for Integrative and Comparative Biology
Society for Integrative Biology
Society for Marine Mammalogy
Society for Mathematical Biology
Society for Multivariate Experimental Psychology
Society for Range Management
Society for Restoration Ecology.
Society for Systematic Biology
Society for the Study of Evolution
Society for the Study of Mammalian Evolution
Society for the Study of Reptiles and Amphibians
Society for Vector Ecology
Society of American Foresters
Society of Nematologists
Society of Population Ecology
Society of Systematic Biology
Society of Systematic Zoology
Society of Vertebrate Paleontology
Society of Wetland Scientists

Society of Wetland Scientists, Venezuela
Society. for the Study of Evolution
Soil Ecology Society
Soil Science Society of America
Soil Science Society of China
South African Institute of Ecologists
Southern African Society of Aquatic Science
Southern Appalachian Botanical Society
Southern California Academy of Sciences
Southwestern Naturalists
Spanish Ecological Society
Statistical Association
Swedish Ecological Society OIKOS
Torrey Botanical Society
Tropical Grassland Society of Australia
Tropical Science Center
Union of Concerned Scientists
Union Québécoise pour la Conservation de la Nature (UQCN)
Virginia Natural History Society
Water Environment Federation
Western Forest Genetics Association
Western Society of Malacologists
Western Society of Naturalists
Wildlife Society
Willi Hennig Society
Wilson Ornithological Society
Wisconsin Academy of Arts & Letters
Wisconsin Phenological Society
Xerces Society
Zoological Society of London
Zoological Society of Southern Africa.

Figure 6. Annual publications from NCEAS activities. The number of book chapters declined in 1999 and 2000, relative to the previous two years. In contrast, the number of journal articles has continued to increase. We expect this pattern to continue, as the number of work shops (which tend to result in edited books or book chapters) continues to decline.

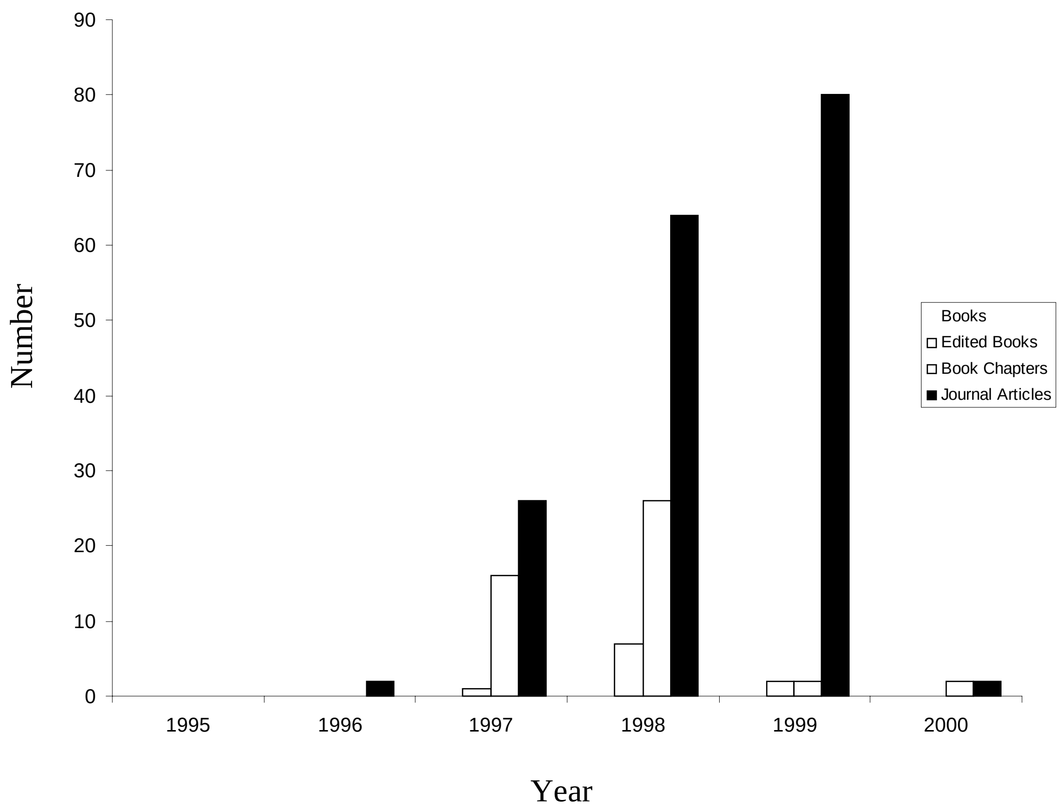


Figure 3. Academic ranks of NCEAS faculty participants. Approximately 56% of participants are faculty. The remainder comprise postdoctoral researchers, students, administrators, and agency and NGO scientists and managers.

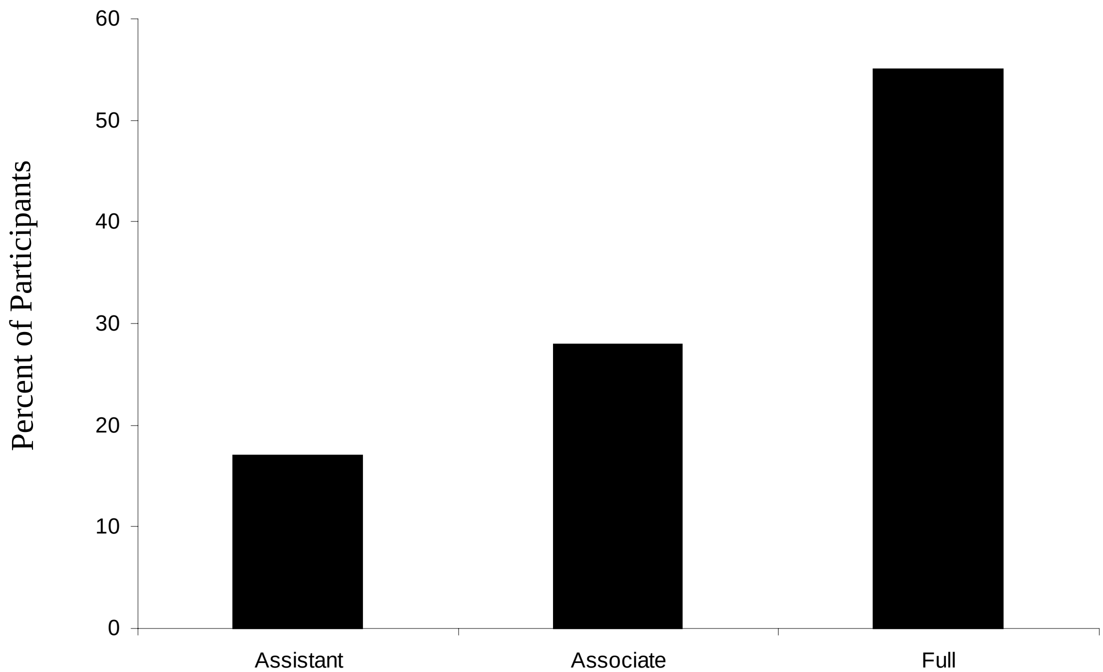


Figure 5. Mean length of stay for NCEAS Working Group participants, Years 2 - 5 (1996 - 1999). The mean length of stay is declining, however, the number of participants in Year 1 (123) was small relative to the other years. Note that we intend to actively encourage longer stays and smaller group sizes.

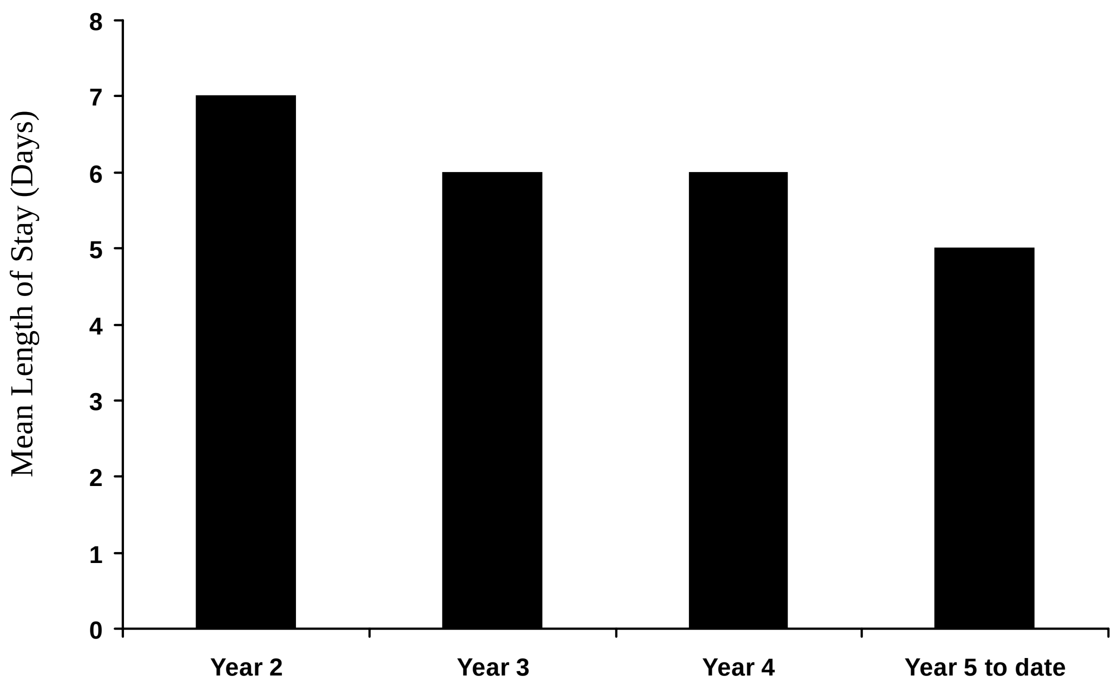


Figure 2. NCEAS Participants, Years 1 - 5. The line indicates cumulative number of participants. Numbers of participants reflect multiple visits by some of the 1706 unique participants. Note that the number of participants has increased each year, and the cumulative number of participants doubled from Year 3 to Year 5.

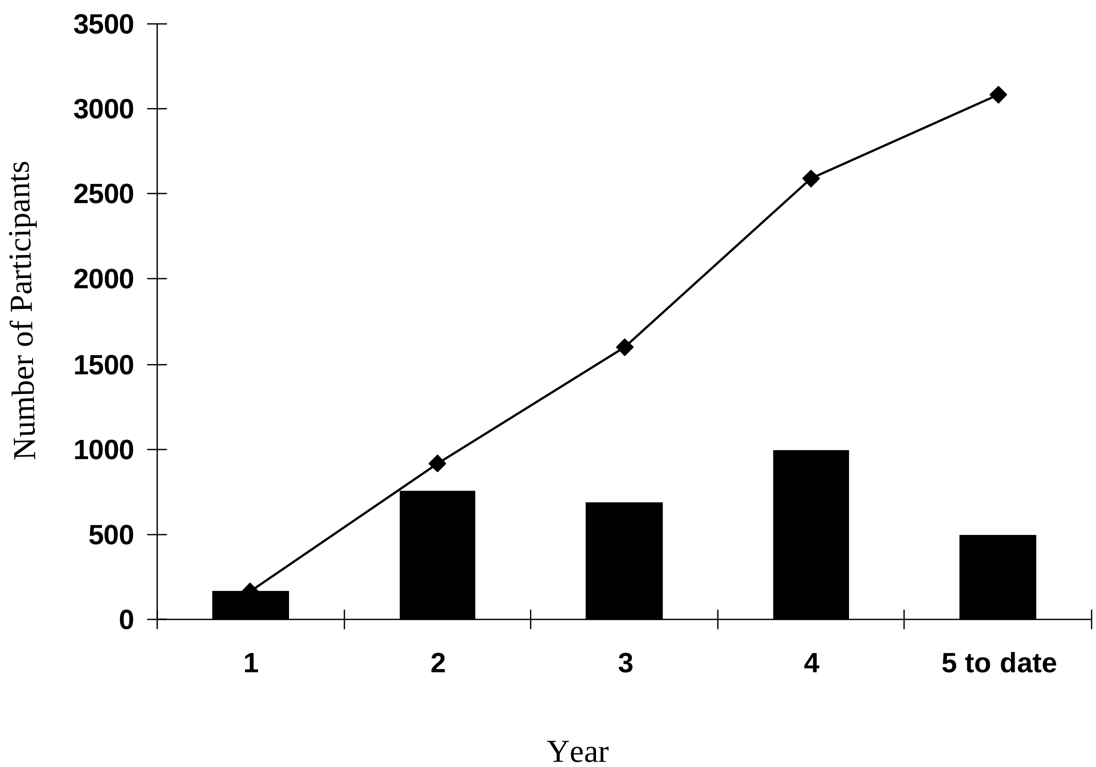


Figure 7. Participation by women in NCEAS activities, compared with UCSB faculty, Ecological Society of America membership and authors of papers in the August, 1999, issue of *Ecology*. Women appear to be well-represented in NCEAS activities, relative to UCSB faculty and ESA membership and publications. Note that nearly half of all Postdoctoral Associates at NCEAS are women.

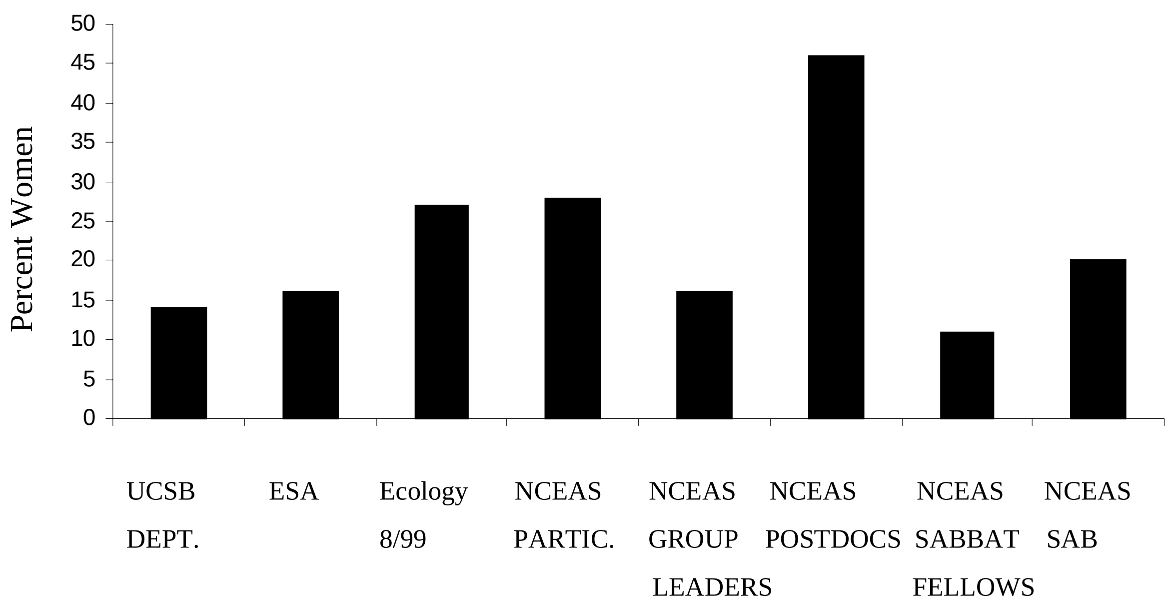


Figure 1. Proposals Received/Funded, 1995-1999. The average number of proposals submitted is 28. On average, 49% of proposals received are funded.

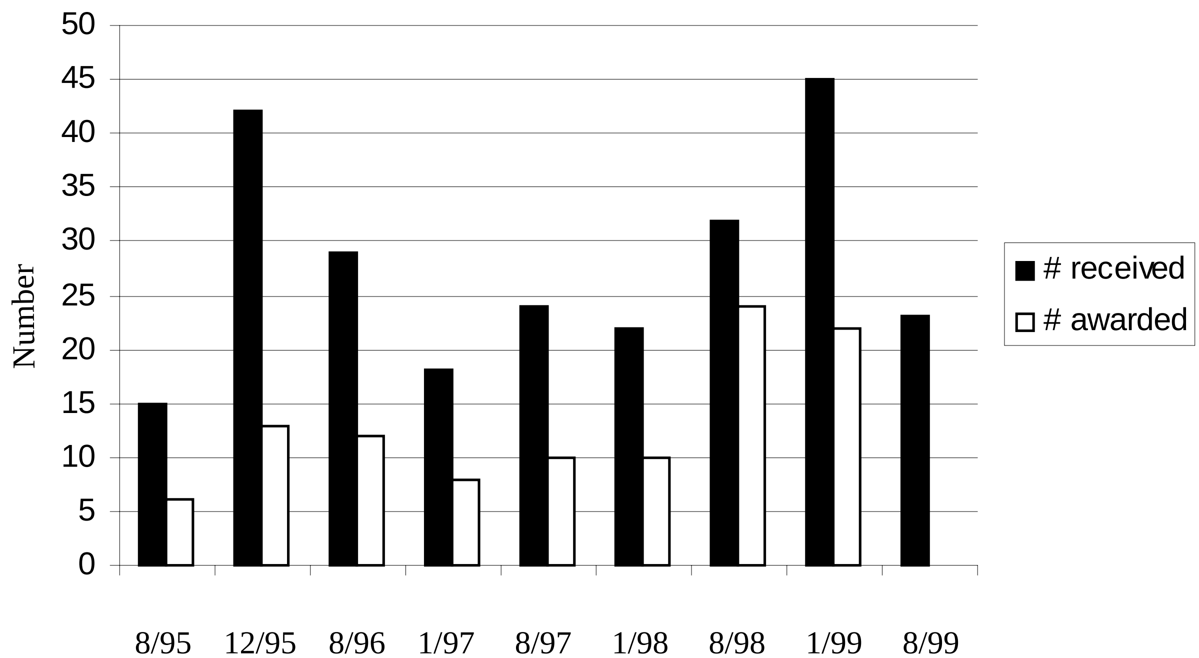
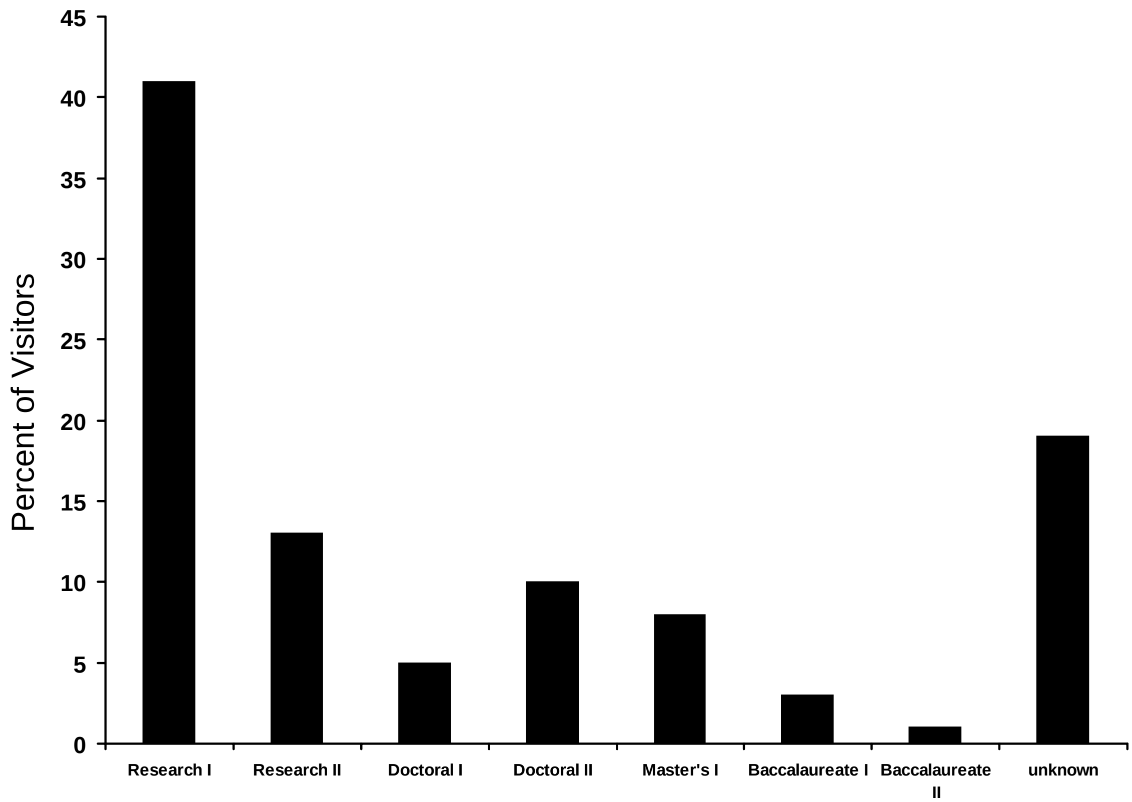


Figure 4. Percentage of academic visitors (U.S.) To NCEAS by University Type (Carnegie classification), 1995 - 1999. An explanation of the Carnegie classification is provided on the following page. More than 10% of visitors come from non-research or doctoral institutions.



Journal Publications:

Collins, Scott L., "Disturbance Frequency and Community Stability in Native Tallgrass Prarie", The American Naturalist, vol. 155, (2000), p. 311. Published

Gomulkiewicz, Richard; Thompson, John N.; Holt, Robert D.; Nuismer, Scott; Hochberg, Michael., "Hot Spots, Cold Spots, and the Geographic Mosaic Theory of Coevolution.", The American Naturalist, vol. 156, (2000), p. 156. Published

Crandall, Keith A.; Bininda-Emonds, O.R.P.; Mace, G.M.; Wayne, R.K., "Considering evolutionary processes in conservation biology", Trends in Ecology and Evolution, vol. 15, (2000), p. 290. Published

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