NATIONAL CENTER FOR ECOLOGICAL ANALYSIS AND SYNTHESIS
COLLABORATION, DISCOVERY, AND IMPACT
NCEAS ANNIVERSARY REPORT
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Frank Davis has been the director of NCEAS since 2011. He is also a professor at the Bren School of Environmental Science & Management at the University of California, Santa Barbara. Frank served as the first Deputy Director of NCEAS between 1995 and 1998. His research interests are in landscape ecology, biogeography, and conservation planning. He is the founder and director of the UCSB Biogeography Lab. Frank earned his B.A. in Biology from Williams College in 1975 and Ph.D. in Geography and Environmental Engineering from The Johns Hopkins University in 1982.

NCEAS IS BUILDING ON ITS STRENGTHS AND EXPANDING ITS MISSION TO:

- Rapidly advance ecological knowledge through collaborative analysis and synthesis to address critical environmental challenges for the benefit of nature and the well-being of people;
- Enable scientific collaboration by providing computing solutions which leverage NCEAS’ innovation and leadership in informatics;
- Promote the skills, knowledge, and collaborative culture among scientists, policy-makers, and resource managers that are necessary for transformative research and rapid adoption.
Dear Friends and Colleagues,

Welcome to the NCEAS Anniversary Report. You will find us looking forward but also pausing to look back as we celebrate our 20 years (!) as a synthesis center.

If you are not familiar with the term “synthesis center,” think of NCEAS as a high-tech facility where some of the world’s best researchers team-up in Working Groups to tackle significant questions in ecology and environment to rapidly advance scientific understanding and benefit society.

Synthesis research is not easy, but it can be incredibly productive and rewarding. Collaborations are forged among researchers from different scientific cultures and disciplines; existing data are melded together from multiple places and studies; disparate concepts and theories are contrasted and creatively combined. Sparks fly.

Since 1995, NCEAS has been catalyzing and accelerating this collaborative mode of scientific research. We will share some of our success stories here, although our impact is only partly captured by the number of visitors and publications. Perhaps even more important are the enduring collaborations and friendships that have originated here over the years. Much credit is due to the vision of founding director Bill Murdoch, who launched NCEAS, and Jim Reichman, who led its growth from 1996-2007. Over the years, our incredible Science Advisory Boards, Sabbatical Fellows, and Postdoctoral Associates (pictured on the cover) have not only helped shape NCEAS, they have gone on to influence the field of ecology long after their residency has ended.

Former NOAA Administrator and NCEAS collaborator, Jane Lubchenco, remarked in 2012 that many NCEAS Working Groups “have delivered spectacular science that is immediately relevant to society’s challenges.” She challenged us to redouble our efforts to support “use-inspired” research that both advances basic understanding and is immediately useful for addressing major environmental challenges. We have done just that.

Launched in 2013, Science for Nature and People (SNAP), the brainchild of longtime NCEAS collaborator Peter Kareiva, is a new initiative with The Nature Conservancy and the Wildlife Conservation Society. SNAP projects are bringing together researchers from academic, non-profit, public, and private sectors, and applying the NCEAS synthesis research model to rapidly find practical conservation interventions that benefit wild species and human society. SNAP is broadening the diversity and international scope of ongoing Working Groups at NCEAS.

To support synthesis research scientists need access to data, but they face the “dark data” challenge - the large pool of potentially valuable historical research data that is inaccessible, unavailable to other researchers, and at risk of being lost forever. Bringing dark data into the light has always been an important part of NCEAS’ mission. Mark Schildhauer and Matt Jones pioneered our informatics work, providing tools and training that promote data archiving and sharing. Through national and international collaborations, they are keeping NCEAS at the leading edge of the ongoing revolution in open data and open science.

Practicing open science, where the products (and data) of one’s research are freely shared, represents a shift in cultural norms for ecologists and requires new technical skills. There is a large unmet demand in ecology for training in everything from data discovery to data and software publication. Under Stephanie Hampton’s leadership, as deputy director, NCEAS offered summer institutes in 2013 and 2014 that provided early-career researchers immersive training in open science for synthesis. In both years we had far more applicants than we could accommodate, but everyone who participated gave the experience a resounding thumbs-up. We are more committed than ever to finding the means to scale up our training efforts in open science for synthesis.

Lastly, I want to thank the Gordon and Betty Moore Foundation for their generous support over the past three years as NCEAS has transitioned from NSF center funding. We would not be here without them. I also want to thank the State of California, the leadership of University of California, Santa Barbara, and others who are recognized at the end of this report, for their financial support of NCEAS. Our mission is as important today as it was in 1995, and I deeply appreciate your continued confidence in NCEAS and commitment to ecological analysis and synthesis.

Please enjoy our Anniversary Report and see where we have been, the impact we have made in the past year and over the past 20 years, and where we are headed!

Sincerely,

Frank Davis, NCEAS Director
IMPACT 2014 PUBLICATIONS SNAPSHOT

Seeking New Insights

Science at NCEAS starts with a core inquiry – a question or challenge that can best be addressed by an interdisciplinary group of experts and a combination of disparate existing datasets. Over the course of a few years, teams of researchers - Working Groups - collaborate periodically at NCEAS to collaboratively synthesize and analyze existing data and evidence, looking for new insights. As they wrap up their analyses, strong and articulate peer-reviewed publications begin to emerge, formalizing the data-informed knowledge that has been generated within the group and offering it up for critique by the scientific community. While only one type of product resulting from NCEAS Working Groups, publications are instrumental to the sharing and vetting of new concepts and conclusions.

20 YEARS OF NCEAS SCIENCE

Since 1995, NCEAS has supported more than 500 scientific projects and nearly 6,000 unique visitors from 73 countries. NCEAS has hosted roughly 20,000 visits associated with Working Groups, graduate and undergraduate distributed seminars, events, our resident Sabbatical Fellows, Center Associates, and Postdoctoral Associates.

Together we have published more than 2,400 peer-reviewed publications (that we know of) and changed the way ecologists think about synthesis and the value of collaboration.

NCEAS has been ranked in the top 1% of institutions in terms of total citations in ecology and environmental science.

Following is a snapshot of some of the publications appearing in 2014, highlighting the impact of NCEAS science. Findings range from global projections of the effects of climate change on people and our environment, to recommendations for coexisting with fire, to a quantification of the amount of plastics entering our global ocean. The top 20 most highly-cited NCEAS publications are listed at the end of this report.

PUBLICATIONS AND IMPACT

How will climate change affect the distribution of people, plants, and animals?

In Nature, Michael Burrows et al. used the velocity of climate change to predict the speed and direction of changes in species distributions on land and in the oceans, highlighting areas that will gain and lose species richness. These results, and others generated by this international Working Group (see map above), were incorporated into the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report – Climate Change 2014: Impacts, Adaptation and Vulnerability.

Not only do NCEAS Working Groups contribute to our base knowledge and ability to anticipate future outcomes, they are also developing new methods of analysis and frameworks for communicating climate science. For example, to increase confidence in climate change impact science writ large, this same Working Group, “Towards understanding marine biological impacts of climate change,” also published a framework to help other scientists assess the strength of inferences in climate impact assessments (O’Connor et al., Global Ecology and Biogeography).
Are citizen science observations useful for “real science”?

Former NCEAS postdoc Jarrett Byrnes and Working Group collaborators launched the Floating Forests Project to engage Internet users in identifying kelp forests in Landsat imagery, a task for which the human eye is still more reliable than a computer. The findings will help the team answer the question, “Is climate change impacting giant kelp forests and the ecosystems that rely on them?”

David Marsh led 200 undergraduates in a multi-university research seminar to analyze citizen observations of amphibians in the central and eastern US, asking “what is the effect of land use on amphibians?” Bradley Cosentino’s et al. results, published in Biological Conservation, demonstrate that roads have a broad influence on spatial distribution and local diversity, and effective landscape management will be critical for reversing widespread amphibian declines.

HOW MUCH PLASTIC DEBRIS IS IN THE OCEAN?

Reported in the Wall Street Journal, Time, BBC News, The New York Times, and many other international media outlets, the NCEAS Marine Debris Working Group’s paper in Science is the first to quantify the amount of plastic entering the ocean in a given year. The study’s lead author, Jenna Jambeck from the University of Georgia, said, “Our estimate of 8 million metric tons going into the oceans in 2010 is equivalent to five grocery bags filled with plastic for every foot of coastline in the world.” Earlier in the year, fellow collaborators Kara Lavender Law and Richard C. Thompson wrote in Science that the threat of marine debris is more than unsightly pollution—it is a threat to ocean health and potentially human health posed by larger plastic products breaking down into microplastic particles, being consumed, and accumulating up the food chain.
Can humans coexist with wildfires?

Max Moritz et al., writing in Nature, argued that as climate change and development in fire-prone areas exacerbate the effects of wildfire, we must adopt a view of fire as a natural socioecological system to help mitigate risk. In the Journal of Biogeography Christopher I. Roos et al. also encouraged a more holistic view of human-fire relationships, an approach they call “pyrogeography,” and called for a cross-disciplinary approach to understanding fire regimes.

Moritz is now leading a new SNAP Working Group focused on finding common ground among fire scientist about how much high-severity fire should be considered “natural” in conifer forests of the Western US, a debate that has created a roadblock for resource managers.

How can new spatial models improve resource management?

NCEAS is an ideal place for scientists to bring the best available science together to create new models that improve management decision-making. For example, the “Spatial statistical models for stream networks” group led by Erin Peterson published several papers in PNAS, Environmentrics, and other journals employing new methods to analyze common types of stream data to improve predictions and develop more efficient monitoring strategies.

A team led by Brian McGill developed innovative remote sensing-based models for global elevation, regional air temperature predictions, and the relationship between surface temperature and the distribution of C3 and C4 grasses, among others. These models are all important tools for building the knowledge base about environmental controls on the distribution and abundance of organisms – important considerations for conservation decisions.

How should managers assess and policy makers respond to the invasion of a destructive species from a foreign land?

In Ecological Applications, Ines Ibáñez et al. developed methods to help resource managers predict the vulnerability of their region to invasions of nuisance species. Other publications from NCEAS Working Groups that focused on invasive species included, for example, analysis of the effectiveness of U.S. policy in reducing the risk of wood-borer insects introduced through international trade. These publications encompassed a wide range of interdisciplinary approaches.
What factors control global patterns of biodiversity?

NCEAS continues to contribute to a broad understanding of global biodiversity. Publications in 2014 considered a range of controls on patterns of biodiversity, from past glaciation to marine dissolved oxygen to the emerging field of functional biogeography, which examines the geographic distribution of species traits. Gross et al. (American Naturalist) considered the effects of biodiversity on the stability of ecosystems as they respond to stressors like climate change, while Byrnes et al. (Methods in Ecology and Evolution) researched its link to ecosystem functionality, and Arsonson et al. (Proc. R. Soc. B.) found that anthropogenic factors like landcover explain species density and distribution in urban areas better than natural factors like climate and topography.

What is the value of ecosystem services globally?

Robert Costanza’s Working Group at NCEAS was the first to calculate the value of the world’s ecosystem services and natural capital on a global basis, publishing their work in Nature in 1997. This paper was controversial and stimulated a great deal of community discussion, and it has become one of the most highly-cited publications in ecology. In 2014, Costanza and another Working Group published updates to their 1997 estimates in Global Environmental Change, looking at the impacts of land use changes. They calculated a total value of $125 trillion per year and a loss of up to $20 trillion per year in ecosystem services since 1997. Klain et al. (Ecological Economics) and Gould et al. (Ecology and Society) went beyond considering ecosystem processes to address the challenge of incorporating cultural services into these value estimates, applying interview-based methods in communities in British Columbia and Kona, Hawaii.
OCEAN TIPPING POINTS

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Tipping points occur when small shifts in human pressures or environmental conditions bring about large, sometimes abrupt changes in a system – whether a human society, a physical system, an ecosystem or our planet’s climate. The Ocean Tipping Points program seeks to characterize tipping points in ocean ecosystems and inform management of marine ecosystems.

Halfway through this four-year program, the team, led by NCEAS associate Carrie Kappel, has made significant progress in assembling the evidence and improving our understanding of tipping points, their potential impacts, and their relevance to ocean resource management. In 2014, the team published five new studies, including three papers in a special issue titled “Thermocline shifts around the globe: Theory, drivers, and impacts” in Philosophical Transactions of the Royal Society—Biological Sciences.

Over the next two years, the team will work with partners in two case study sites, Haida Gwaii (in British Columbia) and Hawaii, to formulate and test various approaches for management of ecosystems prone to tipping points. The project team’s ultimate goal is to disseminate a management toolbox to enable managers to identify the “safe operating space” for decision making in order to avoid undesirable tipping points, monitor using early warning indicators, and evaluate progress toward ecosystem objectives.

CURRENT NCEAS WORKING GROUPS

INNOVATIVE WORKING GROUPS
NCEAS does not rely on permanent research faculty. Our innovation stems from a global network of thousands of researchers. Through open Calls for Proposals, NCEAS solicits project ideas for Working Groups focused on core scientific inquiries that range from questions at the heart of ecology to some of the most pressing environmental issues.

NEW IDEAS, NOT NEW DATA
NCEAS Working Groups focus on generating new ideas and knowledge. Rather than collecting new data in the laboratory or field site, NCEAS adds value by supporting our collaborative Working Groups, integrating existing datasets and models, and combining different perspectives and methods to create new scientific insights.

PRODUCTIVE AND RESPECTED
NCEAS has earned a reputation as one of the most productive and impactful institutions in ecology and environmental sciences in the world, delivering impartial science to address critical decisions on global environmental issues.

Gulf of Alaska
Following the 1989 Exxon Valdez Oil Spill, the Gulf of Alaska has been extensively monitored to examine the spill’s effects on ecosystems and to assess the recovery of impacted species. NCEAS has helped to collate 25 years of historical data from these studies. In 2014, we selected two Working Groups and two Postdoctoral Associates to synthesize the data to better understand the cumulative effects of the spill on Prince William Sound as well as the post-spill recovery of impacted ecosystems.

Predicting physiological and ecosystem changes in the future will require far more detailed data on functional diversity than exists today. With NASA support, a NCEAS Working Group is investigating the use of advanced sensor technologies for supporting global biodiversity research. The team is identifying priorities for future satellite technologies and strategies for integrating image-based data with ground-based information.

Remote Sensing for Biodiversity
The Earth’s rapidly changing environment is putting critical ecosystem services at risk. Over the past 10 years, a team at NCEAS has led efforts to synthesize and map cumulative human impacts in the ocean. In a highly-cited Science publication (2008), Halpern et al. found that no patch of ocean

Mapping Cumulative Impacts
Over the past 10 years, a team at NCEAS has led efforts to synthesize and map cumulative human impacts in the ocean. In a highly-cited Science publication (2008), Halpern et al. found that no patch of ocean...
The NCEAS process and its results have transformed scientific culture, informed environmental policy, and directly helped to shape complex natural resource management decisions.

**Toads, Roads, and Nodes**

NCEAS led nearly 200 undergraduate students from a network of universities in an analysis of the effects of land-use change and roads on the distribution and richness of pond-breeding frogs and toads across the central and eastern U.S. The distributed seminar culminated in a face-to-face Working Group at NCEAS with representatives from each university. Twenty-four of the undergraduates reported their findings in a co-authored paper published in the prestigious journal *Biological Conservation* – an invaluable first experience in preparing a manuscript for peer review.

**Steelhead Conservation**

NCEAS partnered with the National Marine Fisheries Service to host a scientific workshop to explore research issues associated with the recovery of two species of threatened and endangered steelhead in South-Central California. Representatives from federal, state, and local governments joined with non-governmental organizations and academics to set the research and monitoring agenda in support of steelhead conservation.

**Gray Wolves: Endangered Species Status**

As a result of controversy around the US Fish and Wildlife Service’s proposed delisting of the gray wolf from the Endangered Species List, the Service asked NCEAS to lead an impartial peer-review process of the scientific basis for the proposed ruling. The reviewers unanimously decided that the proposed delisting was not well supported by the available science. USFWS recently placed the Mexican gray wolf on the endangered species list, partly as a result of the reviewers’ recommendations.

**Arctic Options**

As climate change diminishes sea ice across the Arctic, interest is growing in exploiting energy reserves, fish stocks, new shipping routes, and tourism. The potential for political, economic, cultural, and environmental instabilities is rising. Using the best available science, this international collaboration is identifying infrastructure development and governance options that holistically balance economic, social, and environmental interests across Arctic coastal and marine systems.
NCEAS is partnering with The Nature Conservancy (TNC) and Wildlife Conservation Society (WCS) in a new scientific collaboration called Science for Nature and People (SNAP). The inspiration for SNAP grew out of the knowledge that no one group can tackle our growing environmental challenges alone. Long recognized in ecology and conservation circles for our success in creating fruitful collaborations, accelerating scientific insights, and inspiring open science, NCEAS became the go-to partner for helping to forge an ever stronger link between academia and conservation. Now SNAP brings together scientists, policymakers, and field practitioners from around the world to bridge the gap between analysis and action. SNAP Working Groups tackle some of the world's biggest challenges like food security, clean water, and disaster risk reduction by identifying ways in which conserving nature can create a net benefit to human well-being.

“The SNAP partnership is building on the successful NCEAS Working Group model with using multi-disciplinary teams of top-notch scientists and practitioners in an evidenced-based approach to develop innovative conservation strategies and actions. Although engineers, economists, foresters, cultural anthropologists, and ecologists of all ilks may make for strange bedfellows, they are working together as a team – inspired by the opportunity to synthesize science from across their disparate disciplines – to find solutions that benefit nature and people.”

—Craig Groves, SNAP Executive Director

Starting with the NCEAS model for soliciting open scientific Calls for Proposals for collaborative, interdisciplinary Working Groups, the SNAP program goes one step further by involving TNC and WCS practitioners as well as context-specific decision makers in the Working Groups from the start to create a clear and rapid pathway to implementation of findings. NCEAS engages its community of more than 6,000 scientists to help provide scientific rigor in SNAP Working Groups.

SNAP recently named its first full-time Executive Director, Craig Groves, a well-known NCEAS collaborator and conservation innovator. As of January 2015, SNAP has completed two Call for Proposals and has 19 Working Group projects underway engaging over 400 participants from 34 countries. A new Call for Proposals is issued each year in March. For more information visit www.snap.is.
FOOD SECURITY

Data-Limited Fisheries
How can we create practical, affordable, and scientifically-sound solutions for assessing small fisheries for more sustainable management?
Jono Wilson—University of California, Santa Barbara: TNC and Carmen Revenga—TNC

Fisheries Measures
What factors lead to good fisheries management outcomes?
Ray Hilborn—University of Washington

Ridges to Reef Fisheries
What information is needed to influence land-use decisions in order to reduce the impacts of extraction and development on fisheries?
Carissa Klein and Hugh Possingham—University of Queensland

Sustainable Agricultural Intensification
How can we minimize the impacts on biodiversity, sensitive habitats, and small scale farmers of agricultural intensification in Tanzania’s Southern Agricultural Growth Corridor?
Felix Kamau—TNC and Lucy Magembe—TNC

Sustainable Offshore Aquaculture
What are the best practices and standards to support sustainable and conservation-friendly offshore aquaculture?
Ben Halpern—University of California, Santa Barbara, and Dietmar Grimm—TNC

SNAP EARLY RESULTS: WESTERN AMAZONA

The Amazon Basin is the largest river system in the world and its waters and wetlands provide millions with drinking water, fish protein, and employment in subsistence and commercial fisheries. This Working Group is creating the information that decision-makers need to balance conservation of Amazonia’s wetlands and fisheries with large-scale infrastructure development (dams, roads, mining, etc.). As one of the first SNAP projects, the Western Amazonia Working Group is already delivering preliminary results.

A new spatial framework will support integrated river basin management decisions and, by extension, fisheries and wetlands management in the Amazon. By integrating and layering spatial data within a river basin context, it will now be possible for stakeholders to understand the realistic geographical scale at which major management decisions need to be made. Basins at various levels can now be viewed dynamically in terms of their hydrology, wetlands, fisheries, political units, protected areas, indigenous areas, dams and mining development, and possible impacts of climate change. This will promote cooperation between interstate and across international governmental agencies at basin levels, and thus lead to better policy decisions based on the appropriate scale.

To advance the science of the Western Amazon, the team is preparing several papers for peer-review on topics including: Conservation of Amazon catfish, the longest freshwater fish migrations in the world; A framework for managing commercially important migratory species in the Amazon Basin; Potential impacts of Andean dams on Amazon aquatic ecosystems; Amazon river flood pulse influence on fish yields; and Climate change effects on the Amazon River Basin.

SNAP WORKING GROUPS

For the first time, the lifecycle of two long-distance migratory catfishes (dorado and mota flemosa) was identified by basins and size classes.
SNAP SCIENCE for NATURE and PEOPLE

SNAP EARLY RESULTS: COASTAL DEFENSES

There is mounting evidence that coastal habitats such as reefs, wetlands, and mangroves can form an effective first line of defense against extreme events like storm surges, sea level rise, and other natural hazards driven by climate change. By exploring how natural habitats can help protect coastal communities from extreme events, this team is building the case for coastal habitat restoration that can help improve resilience to disasters along with other valuable ecosystem services.

As one of the first two SNAP Working Groups, Coastal Defenses is delivering results. A global map of nature-based defenses with detailed risk reduction and cost-effectiveness parameters is now freely available at maps.coastalresilience.org/global/. This new application was recently presented at the AAAS Symposium in San Jose, CA and at the World Congress on Disaster Risk Reduction in Sendai, Japan on a panel with the First Lady of Japan. Analysis continues, but early indications suggest that natural coastal ecosystems can reduce wave heights by up to 70%, with coral reefs being most effective followed by mangroves and marshes/seagrass.

These promising early results have been used when mobilizing the SNAP Recovery, Restoration, and Rebuilding team post-Hurricane Odile to support TNC’s Mexico program in meeting with senior government officials about the use of nature-based defenses in their recovery and re-building plans after the worst storm season on record. While officials are opting for traditional sea walls for protection, the support of SNAP was invaluable in getting the local conservation teams engaged with local, state, and national officials and opening up the possibilities for future nature-based solutions.

ECONOMICS OF NATURE CONSERVATION

Forest Sharing or Sparing?
Are there ways in which we can improve outcomes for carbon sequestration, biodiversity, and water availability while maintaining timber production?
Mark Ashton—Yale University, Francis “Jack” Putz—University of Florida, and Bronson Griscom—TNC

Natural Capital Accounting
Can we guide natural resource management and the policy agenda for Rwanda by establishing a direct relationship between the economy and natural capital?
Janaki Alavalapati—Virginia Tech, Glenn-Marie Lange—World Bank, and Michel Masozera, WCS

Better Land-Use Decisions
Can land-use decisions lead to better outcomes for biodiversity, ecosystem services, and economic returns in Brazil and the U.S. using improved trade-off models?
Stephen Polasky—University of Minnesota, Derric Pennington—World Wildlife Fund, Joe Fargione—TNC, and Carlos Cesar Durigan—WCS

Making Ecosystems Count
What practical, but scientifically meaningful, indicators of ecosystem health and biodiversity could be deployed in support of the United Nations’ Sustainable Development Goals?
Fabrice DeClerck—Bioversity International and David Cleary—WCS

Recently launched, the Natural Defenses database maps 67 case studies of natural coastal defenses around the globe. The studies cover a range of habitats such as coral reefs, mangroves, salt marshes, seagrass, and wetland habitats.
Fire Research Consensus
How can we reach consensus on fire regimes in mixed conifer forests among debating fire researchers, and what resource management decisions can we make based on the resolved science?
Max Moritz—University of California, Berkeley and Chris Topik—TNC

Ecological Drought
What ecosystem-based management strategies will help us cope with and adapt to the many ecosystem stresses created by prolonged and widespread water shortages?

Gaming the Future of Climate Communications
Can video games succeed where traditional climate communications have failed?
Josh Lawler—University of Washington

Hydraulic Fracturing
What are the impacts of fracking on water quality and quantity for people and biodiversity, and how can this knowledge better inform policy and waste management plans?
Sharon Baruch-Mordo—Colorado State University; TNC, Joe Kiesecker—TNC, Anne Trainor—Yale University, Joe Fargione—TNC, and Joe Ryan—University of Colorado

Water Sharing
Can innovative water transactions enhance streamflow, water supply reliability, and economic viability in the western United States?
Andrew Purkey—National Fish and Wildlife Foundation and Eloise Kendy—TNC

Western Amazonia
How can conservation of the Amazon’s wetlands and fisheries be balanced with large-scale infrastructure development to improve economies and living conditions for the region’s growing populations?
Michael Goulding—WCS, Mariana Varese—WCS, Craig Groves—TNC

Economics of the Chinese Ivory Trade
What would an economically rational Chinese ivory trade policy look like?
Li (Aster) Zhang—Beijing Normal University and Aili Kang—WCS China

Evidence-Based Conservation
What does the evidence for how nature conservation affects social outcomes tell us about the key ingredients for success?
Madeleine (Bottrill) McKinnon—Conservation International and David Wilkie—WCS

CLIMATE CHANGE RISK REDUCTION

Coastal Defenses
How can we use natural habitats to help protect coastal populations from storm surges?
Michael Beck—University of California, Santa Cruz; TNC and Jane Carter Ingram—Columbia University; WCS

Water Security
Where should we prioritize investments in watershed restoration to meet water security needs for Latin American cities?
Goldstein—TNC and Elizabeth Tellman—Arizona State University
INFORMATICS RESEARCH and APPLICATION

ENABLING ROBUST AND REPRODUCIBLE SCIENCE

In the era of “Big Data” and expanding computational power, ecological synthesis is rapidly changing. Data and code sharing and immersive collaboration methods are enabling research to proceed at unprecedented geospatial and temporal resolutions. Effective use of these new technologies requires new standards and software solutions for data discovery, integration, and analysis, as well as expanding many researchers’ analytical and informatics skillsets.

Since its outset, NCEAS has promoted the optimal use of technology. NCEAS residents and Working Group participants have access to a dedicated staff of scientific computing technologists who assist in supporting online collaborations, locating and preserving data, and optimizing analytical code. We have advised hundreds of researchers in the use of scientific computing solutions based on the principles of “Open Science” that encourage transparency and sharing of scientific methods and data.

NCEAS’ Informatics Research Program has also become a leader in creating new solutions to address the unique challenges of synthetic work. Our approach is strongly collaborative, bringing together the best scientific and technological minds in the earth, environmental, ecological, and conservation sciences to create new platforms to enhance data accessibility and enable more robust and reproducible science. We have established broadly adopted standards for describing ecological metadata (EML) and internationally deployed frameworks for preserving scientific research data (KNB, DataONE). NCEAS has created applications for building and sharing complex scientific workflows (Kepler) and we are developing new approaches to facilitate code-sharing and workflow interpretation and visualization.

Ultimately, these advances in eco-informatics are having a large impact on our knowledge and understanding of ecosystems and our ability to apply that knowledge to the world’s most pressing conservation and resource management issues.

Data Preservation and Interpretability

NCEAS’ widely used KNB Data Repository (Knowledge Network for Biocomplexity) facilitates data sharing and long term archival for ecological and environmental research, and currently hosts over 21,000 datasets from both within and outside NCEAS. We recently launched a major redesign and the new KNB has optimized search functionality, vastly improved ergonomics, and added the ability to publish datasets with a citable digital object identifier (DOI).

Building on our experience with the KNB Data Repository, NCEAS and collaborators (University of New Mexico, Oak Ridge National Laboratory, California Digital Library, NESCent, and others) envisioned and developed DataONE, a distributed cyberinfrastructure that has increased the accessibility of diverse environmental science data and enhanced the efficiency of research. 2014 marked renewed NSF funding for DataONE and the beginning of the second phase of development, which will significantly expand the volume and diversity of data available to researchers. NCEAS is leading the effort to incorporate innovative features to track data provenance...
and dramatically improve data discovery through semantics technologies. We are leveraging our experience in developing Semantic Tools for Data Management (Semtools), the Science Environment for Ecological Knowledge (SEEK) workflow modeling with advanced semantics, and the semantic modeling of observational data in Scientific Observations Network (SONet) and Global Biodiversity Information Facility (GBIF).

NCEAS is also a partner in the NSF-sponsored GeoLink project, a collaboration bringing together the biological oceanographic data housed in DataONE with complementary resources housed in repositories at the Lamont-Doherty Earth Observatory and the Woods Hole Oceanographic Institution. GeoLink is extending semantic approaches that link resources across repositories to help researchers in the geosciences effectively locate relevant data across the web, regardless of which specific repository it is held in.

Targeted Database Solutions

NCEAS’ programmers have built several database applications that enable large groups of researchers to address critical environmental issues at large scales. For example, research predicting shifts in species’ abundance and ranges due to climate change benefits from large-scale, integrated datasets on taxonomic occurrences, integrated with environmental features such as mean monthly temperature. The Botanical Information and Ecology Network (BIEN) Working Group is integrating the most significant existing sets of vegetation data spanning North and South America, resulting in the largest assembly of data on plant diversity and distribution for both tropical and temperate plant species yet created. This dataset is enabling researchers to address fundamental questions about the controls on biodiversity, species range sizes, abundance, and extinction risk. Earlier collaborative NCEAS products include: VegBank with a large number of extant North American vegetation plot datasets; JEDI, a database that enables researchers to explore patterns of abundance of jellyfish species on a global basis; and the SANParks Data Repository that was adopted at each of the twenty-two South African National Parks (SANParks) for data collection and to support research and decision-making.

Collaborative Software Development

Software is used throughout the scientific lifecycle, from initial data acquisition in sensor systems to data integration, analysis, and synthetic modeling. Despite the fact that software touches every activity in science, it is often not well managed or shared, either for re-use by others or for validating existing work. With a planning grant from NSF, the NCEAS team led a group of collaborators to clarify the needs of the earth and environmental science community for an Institute for Sustainable Earth and Environmental Software (ISEES). We are seeking creative funding sources to launch ISEES to coordinate development and sustainable support of innovative scientific software tools and enable researchers to collaboratively address the entire software lifecycle.

In support of open science, NCEAS spearheaded the first-ever Open Science Codefest in 2014. Codefest brought together more than 70 computer programmers and environmental scientists, who typically work independently, to brainstorm, share skills, and jointly develop or extend software codes that address a number of common analytical needs in the earth sciences. The unconventional, unstructured “unconference” format of the event encouraged creativity, rapid prototyping, and synergies to emerge between attendees, many of whom had not worked together prior to the event.
NCEAS is committed to increasing the scientific community’s skills and abilities to participate in data-intensive ecological research by providing state-of-the-art learning opportunities. To this end, we have supported an array of formal and informal training programs to teach software and informatics skills that support open, collaborative, and reproducible synthesis science. We also include training in communications to help researchers reach broader audiences.

NCEAS’ technologists have provided tutorials and training workshops on fundamental informatics skills in various venues for many years. In response to community demand for more intensive and comprehensive training in these areas, in the summer of 2013, NCEAS hosted the Summer Institute, a three-week long workshop in ecological analysis and synthesis for early-career researchers. From over 300 applications, we selected twenty-three individuals to participate in the training. These scientists engaged in hands-on guided research, learning best practices in data discovery and integration, analysis and visualization, and techniques for working collaboratively in geospatially distributed teams.

Building on this success, in 2014, we partnered with the Renaissance Computing Institute (RENCI) at the University of North Carolina, Chapel Hill, and offered Open Science for Synthesis (OSS 2014) a 3-week long, bi-coastal software skills training event for early-career scientists. More than 40 participants received hands-on training in software development with real world application of skills to synthesis group projects. NCEAS trainings offer ecologists unique opportunities to connect with other members of their community facing similar challenges and to learn skills that can revolutionize how they advance their science.

“What we learned in Open Science for Synthesis training really ought to be taught to every incoming PhD student in an ecology program, but it just isn’t. I feel incredibly lucky to have had the opportunity to learn it now!”

—Julia Buck—Sam Houston State University
“The Summer Institute students did not know that version control was about to revolutionize their collaborative workflow, but after they started having problems in their group work, it caught on like wildfire. Many people indicated that it was the best tool they learned, but they would never have known to ask for it.”

—Instructor, Stephanie Hampton—Director, Center for Environmental Research, Education, and Outreach, Washington State University

TESTIMONIALS

“I just wanted to let you know that our small group project from the Summer Institute (2013) has actually turned into a funded working group with NIMBioS! I am positive that the synthesis skills that we learned at NCEAS contributed to our success, and now we have a manuscript in prep! So, I speak for the group when I say that being at NCEAS will definitely help us advance our careers.”

—Brittany J. Teller—Utah State and Cornell University

“I really value the knowledge and experience I gained at OSS 2014. It is my first day back in the office today and I’ve already found myself using a number of the skills I learned—I cloned my Git repo onto my desktop, wrote a loop for resampling some data, met with a collaborator and discussed communication norms, met with another collaborator and discussed data sharing and open data, and convinced my lab mate to learn Git! Good day!”

—Mary Donovan—University of Hawaii, Manoa

“Being home a few weeks now, I’m thinking more than ever about the reproducibility of what I’m doing. While I felt great about the workshop when I was there, I feel even better now, using the skills I picked up. Thanks again.”

—Mike Treglia—University of Tulsa
SPECIAL THANKS
to the scientists who have been in-residence at NCEAS over the years. Your influence has helped shape our past and pointed the way to an exciting future. You are the current and future leaders in Ecology.

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We are grateful for the financial support of NCEAS’ operations and research activities over the past 20 years provided by the foundations and institutions listed below.

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We are excited to welcome our new NCEAS Science Advisers, a group of leading thinkers in ecology and environmental science who will help the Center anticipate important emerging areas for research, informatics, and training, and help us assess new funding opportunities that will enable NCEAS to continue to serve our research community.

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TOP 20 OVER 20 YEARS
THE MOST HIGHLY-CITED NCEAS PUBLICATIONS OVER THE PAST 20 YEARS ARE AMONG SOME OF THE MOST INFLUENTIAL PAPERS IN ECOLOGY

1. The value of the world’s ecosystem services and natural capital
   NATURE 387 (1997). Costanza, R; dArge, R; deGroot, R; Farber, S; Grasso, M; Hannon, B; Limburg, K; Naeem, S; O’Neill, RV; Paruelo, J; Raskin, RG; Sutton, P; vandenBelt, M

2. Biodiversity - Global biodiversity scenarios for the year 2100
   SCIENCE 287 (2000). Sala, OE; Chapin, FS; Armesto, JJ; Berlow, E; Bloomfield, J; Dirzo, R; Huber-Sanwald, E; Huenneke, LF; Jackson, RB; Kinzig, A; Leemans, R; Lodge, DM; Mooney, HA; Oesterheld, M; Poff, NL; Sykes, MT; Walker, BH; Walker, M; Wall, DH

3. Historical overfishing and the recent collapse of coastal ecosystems
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4. Extinction risk from climate change
   NATURE 427 (2004). Thomas, CD; Cameron, A; Green, RE; Bakkenes, M; Beaumont, LJ; Collingham, YC; Erasmus, BFN; de Siqueira, MF; Grainger, A; Hannah, L; Hughes, L; Huntley, B; van Jaarsveld, AS; Midgley, GF; Miles, L; Ortega-Huerta, MA; Peterson, AT; Phillips, OL; Williams, SE

5. Novel methods improve prediction of species’ distributions from occurrence data
   ECOGRAPHY 29 (2006). Elith, J; Graham, CH; Anderson, RP; Dudik, M; Ferrier, S; Guisan, A; Hijmans, RJ; Huitzmann, F; Leathwick, JR; Lehmann, A; Li, J; Lohmann, LG; Loiselle, BA; Manion, G; Moritz, C; Nakamura, M; Nakazawa, Y; Overton, JM; Peterson, AT; Phillips, SJ; Richardson, K; Scachetti-Pereira, R; Schapire, RE; Soberon, J; Williams, S; Wisz, MS; Zimmerman, NE

6. Using stable isotopes to estimate trophic position: Models, methods, and assumptions
   ECOLOGY 83 (2002). Post, DM

7. Ecology - Biodiversity and ecosystem functioning: Current knowledge and future challenges
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8. Mechanisms of maintenance of species diversity
   ANNU. REV. OF ECOLOGY AND SYSTEMATICS 31 (2000). Chesson, P

9. Climate extremes: Observations, modeling, and impacts
   SCIENCE 289 (2000). Easterling, DR; Meehl, GA; Parmesan, C; Changnon, SA; Karl, TR; Mearns, LO
10. Agricultural sustainability and intensive production practices

*NATURE 418 (2002).* Tilman, D; Cassman, KG; Matson, PA; Naylor, R; Polasky, S

11. Impacts of biodiversity loss on ocean ecosystem services

*SCIENCE 314 (2006).* Worm, B; Barbier, EB; Beaumont, N; Duffy, JE; Folke, C; Halpern, BS; Jackson, JBC; Lotze, HK; Micheli, F; Palumbi, SR; Sala, E; Selkoe, KA; Stachowicz, JJ; Watson, R

12. The metacommunity concept: a framework for multi-scale community ecology

*ECOLOGY LETTERS 7 (2004).* Leibold, MA; Holyoak, M; Mouquet, N; Amarasekare, P; Chase, JM; Hoopes, MF; Holt, RD; Shurin, JB; Law, R; Tilman, D; Loreau, M; Gonzalez, A

13. A global map of human impact on marine ecosystems

*SCIENCE 319 (2008).* Halpern, BS; Walbridge, S; Selkoe, KA; Kappel, CV; Micheli, F; D’Agrosa, C; Bruno, JF; Casey, KS; Ebert, C; Fox, HE; Fujita, R; Heinemann, D; Lenihan, HS; Madin, EMP; Perry, MT; Selig, ER; Spalding, M; Steneck, R; Watson, R

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*SCIENCE 292 (2001).* Tilman, D; Fargione, J; Wolff, B; D’Antonio, C; Dobson, A; Howarth, R; Schindler, D; Schlesinger, WH; Simberloff, D; Swackhamer, D

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16. Effects of size and temperature on metabolic rate

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17. Poleward shifts in geographical ranges of butterfly species associated with regional warming

*NATURE 399 (1999).* Parmesan, C; Ryrholm, N; Stefanescu, C; Hill, JK; Thomas, CD; Descimon, H; Huntley, B; Kaila, L; Kullberg, J; Tammaru, T; Tennent, WJ; Thomas, JA; Warren, M

18. Climate warming and disease risks for terrestrial and marine biota

*SCIENCE 296 (2002).* Harvell, CD; Mitchell, CE; Ward, JR; Altizer, S; Dobson, AP; Ostfeld, RS; Samuel, MD

19. Considering evolutionary processes in conservation biology

*TRENDS IN ECOLOGY & EVOLUTION 15 (2000).* Crandall, KA; Bininda-Emonds, ORP; Mace, GM; Wayne, RK

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