

Nature and Society: An Imperative for Integrated Environmental Research

EXECUTIVE SUMMARY

Steering Committee

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Several studies have concluded that the current level of federal support for scientific research is insufficient to meet the national and international environmental challenges of the coming century.¹ To reach a comprehensive understanding of crucial human-environment interactions, disciplinary analysis must be complemented by interdisciplinary research—spanning the natural, social, behavioral, and engineering sciences. Scientists must participate in setting priorities for a new interdisciplinary environmental research program, and policymakers and agency representatives must seize the opportunities for promoting such research.

As part of that process, forty-five scientists convened in June of 2000 for a four-day workshop sponsored by the National Science Foundation (NSF). Attendees came from over a dozen different fields, and represented thirty-one institutions. This report summarizes their findings and recommendations.

¹ Sustainable Biosphere Initiative 1991, The House Committee on Science 1998, President's Committee of Advisors on Science and Technology 1998, National Science Board 1999

A striking feature of this meeting was that none of the participants called explicitly for more funding for her or his discipline. Instead, all participants affirmed that a bold departure from the status quo of disciplinary science was needed to address pressing national needs (see Box 1). Interdisciplinary research will represent one of the frontiers of scientific inquiry in the 21st century, as scientists elucidate the dynamics of complex and interdependent social and natural systems, and extend existing, discipline-based theories and paradigms to new conditions and circumstances. A fundamentally new level of integration in research across disparate fields is thus required.

Five research areas are in particular need of increased attention:

- ◆ Evolution and Resilience of Coupled Social and Ecological Systems
 - ◆ Ecosystem Services
 - ◆ Coping with Uncertainty, Complexity, and Change
 - ◆ Environmental Dimensions of Human Welfare, Health, and Security
 - ◆ Communicating Scientific Information
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Box 1: National & International Benefits of Increased Interdisciplinary Environmental Research

Increased investments in interdisciplinary environmental research will provide the information and understanding needed to

- ◆ Sustain delivery of economically important and societally beneficial ecosystem goods and services
- ◆ Increase scientific and institutional capacity to anticipate and cope with environmental change at all scales—local to global—with reduced social and economic disruption
- ◆ Reduce the incidence and spread of human diseases caused by ecological change
- ◆ Anticipate and reduce resource-driven conflict, both inter- and intra-nationally
- ◆ Develop indicators of human welfare and environmental quality, and warnings of potential and irreversible damage to important social and ecological systems
- ◆ Enhance development pathways that provide alternatives to economically costly and socially detrimental environmental degradation

Two criteria were employed in choosing these priorities: relevance in addressing urgent societal challenges, and intellectual merit. Further details on these research recommendations can be found in Box 2.

The disciplinary foundations are in place to support productive research in many of these areas, and insipient efforts at integration are underway. The vast majority of research, however, continues to be largely disciplinary, or integrated only narrowly across closely related fields within the natural, social, behavioral, or engineering sciences. Workshop participants affirmed that scarce funding, institutional traditions and structures, inadequate training, and insufficient rewards for interdisciplinary pursuits all contribute to diminishing or discouraging more extensive interdisciplinary collaborations. Thus, participants also made several implementation recommendations in:

- ◆ Education and training;
- ◆ Research infrastructure; and

- ◆ Institutional changes at the National Science Foundation

Details of the implementation recommendations can be found in Box 3.

After careful review of existing programs, the authors of this Executive Summary recommend that ten to twenty percent of environmental research budgets be devoted to broadly interdisciplinary research of the kind described here. This allocation emphasizes both the importance of interdisciplinary research as well as the need to maintain the disciplinary foundations upon which such research is built. Assuming increases in NSF budgets consistent with the findings of the recent NSB report, the authors recommend minimum additional funding for interdisciplinary research at an annual level of \$125 million dollars beginning in 2002 and reaching \$240 million dollars by 2006. In addition, the Steering Committee recommends minimum investments of \$45 million dollars annually for

education and training, and \$7.5 million annually to achieve other implementation goals.

Implementation recommendations should receive full funding from the inception of a new interdisciplinary environmental program, in order to increase the capacity—among researchers and within institutions—to conduct fundamentally new integrated research. Re-

search funding should increase in accordance with the growing capacity, reaching full funding levels in 2006. Finally, the National Science Foundation's newly established interdisciplinary environmental advisory board should conduct ongoing evaluations of interdisciplinary research achievements and priorities, and ascertain progress in effective implementation of the recommendations outlined here.

Box 2: Summary of Research Recommendations

Increased interdisciplinary environmental research is needed in the following five areas:

The Evolution and Resilience of Coupled Social and Ecological Systems

The ways in which human social and economic systems evolve will depend on the ecological endowments of a region. The changes in these ecological systems over time will in turn depend on the extent, intensity, and types of human activities. This “coevolution” will determine the trajectories and resilience of social and ecological systems. Thus, integrated analysis of these systems is required if we are to improve our ability to forecast and respond to environmental change. Possible research areas in this category include:

- ◆ The evolution of social norms regarding the environment
- ◆ Understanding past and predicting future land-use change
- ◆ Feedback loops in social and ecological systems
- ◆ Disturbance and resilience in social and ecological systems
- ◆ Developing coupled models of social and ecological systems

Ecosystem Services

Healthy ecosystems provide numerous economically important and societally beneficial services. Substantially more interdisciplinary research is required to advance our understanding of the key ecosystems and ecological structures required to sustain these services, the ways in which human activities alter these systems, the approaches for their proper valuation, and the institutions required for realizing this value. Possible research areas in this category include:

- ◆ Human impacts on ecological structures and ecosystem-service delivery
- ◆ Valuation of ecosystem services
- ◆ Variations in ecosystem-service delivery and valuation from local to global scales
- ◆ Assessing manufactured or managed substitutes for ecosystem services

Coping with Uncertainty, Complexity, and Change

Social and ecological systems are sufficiently complex that our knowledge of them, and our ability to predict their future dynamics, will never be complete. We must work to reduce uncertainties when possible, improve assessments of the likelihood of various important future events, and learn—scientifically, socially, and politically—to cope with environmental change that may elude precise prediction. Possible research areas in this category include:

- ◆ Indicators of human welfare and environmental change
- ◆ Risk assessment and risk reduction for technology deployment
- ◆ Governance and management of common-pool resources
- ◆ Adaptive institutions and social learning

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Box 2: Summary of Research Recommendations (continued)

Environmental Dimensions of Human Welfare, Health, and Security

There is increasing recognition that local and regional environmental quality can significantly influence human welfare, including health and security. Human social arrangements—including the degree of political democracy or socioeconomic equity—can in turn profoundly influence welfare-environment interactions. Significantly more interdisciplinary analysis is required to assess the dynamics of these interactions, and to identify the approaches that can simultaneously improve human welfare and environmental quality. Possible research areas in this category include:

- ◆ Environmental change and human health
- ◆ Environmental justice, poverty, and inequity
- ◆ The environmental dimensions of human conflict

Communicating Scientific Information

Interdisciplinary environmental research will not serve society unless the knowledge gained can be communicated effectively to policymakers and stakeholders at all levels of the social and political spectrums. At the same time, scientists must be responsive to society's articulations of goals and perceived national challenges. Yet there are significant differences in the ways in which different social and political groups access, interpret, and use scientific information, and influence the scientific process. Research is required to better understand the ways in which scientific information is constructed and communicated, and to improve the process of information dissemination, from scientist to citizen and vice versa. Possible research areas in this category include:

- ◆ The effects of disparate access to science and scientists
- ◆ The impacts of information technology and non-governmental organizations on flows of scientific information
- ◆ Stakeholder participation in natural-resource management and policy formulation
- ◆ Effectiveness of interdisciplinary training

Our nation is enjoying unprecedented economic prosperity. The environmental underpinnings of that prosperity are, however, threatened, both by the magnitude of human activities across the planet, and by our incomplete understanding of the complex social and ecological systems that make up our world. If we are to sustain economic prosperity, improve environmental integrity, and advance human well being in the 21st century, we, as a nation, must make the requisite investments in a more vigorous interdisciplinary scientific program.

Policymakers and agency representatives should seize the opportunity to promote such an environmental research program. The disciplines that provide the needed foundations

for integrated research have advanced sufficiently to allow rigorous and informative interdisciplinary advances. There is increasing bipartisan and public support for scientific research, and a growing recognition of the role that scientific advances play in improving the national welfare and economy. The National Science Foundation, as one of the primary stewards of basic and cutting-edge research, must expand its interdisciplinary research program if it is to continue to define and enlarge the frontiers of scientific inquiry, and effectively address cross-disciplinary problems of increasing societal importance. The intellectual challenges of the research program outlined here are immense, but society's need for such a program is even greater.

Box 3: Summary of Implementation Recommendations

Increased research activity alone will not suffice to adequately promote interdisciplinary collaborations. Parallel increases in training and infrastructure must occur in the following areas:

Education and Training

The National Science Foundation should ensure an increased capacity for effective interdisciplinary communication and collaboration, among today's policymakers and scientists, and tomorrow's. The NSF should therefore:

- ◆ Promote research to identify effective approaches in interdisciplinary education
- ◆ Increase resources for development of interdisciplinary environmental courses or programs
- ◆ Increase funding for innovative graduate and post-graduate interdisciplinary fellowships
- ◆ Offer greater opportunities and resources for faculty sabbaticals that promote interdisciplinary training and collaboration
- ◆ Develop new programs and workshops to promote exchange among the nation's researchers, decisionmakers, and media professionals.

Research Infrastructure

The fundamental features of interactions among social and ecological systems, or the ways in which ecological status and dynamics can influence human welfare, can span generations and continents. This creates research challenges at unprecedented spatial and temporal scales. Many earlier reports have also shown that the organizations of existing research institutions tend to promote inward-looking disciplinary exchange while inhibiting interdisciplinary collaboration. The National Science Foundation should therefore:

- ◆ Promote long-term interdisciplinary environmental research, perhaps by increasing integrated and interdisciplinary research within the existing national and international LTER networks
- ◆ Establish a national center for interdisciplinary environmental research
- ◆ Strongly encourage research-project designs that incorporate outreach considerations and requirements from project inception
- ◆ Promote scientific assessments, particularly at relevant regional scales, as a way of synthesizing and disseminating crucial, policy-relevant scientific conclusions.

The National Science Foundation

The National Science Foundation has proven extraordinarily effective in promoting discipline-based research, but modifications to existing programs and approaches will be required for greater promotion of interdisciplinary environmental research. We therefore recommend that the National Science Foundation:

- ◆ Establish a unit with explicit budgetary authority for promoting interdisciplinary research and for facilitating cross-directorate research
- ◆ Ensure that the existing peer-review process promotes equitable and effective review of interdisciplinary proposals while maintaining standards of intellectual quality
- ◆ Charge the interdisciplinary environmental research advisory board with continued development of research priorities and assessment of progress in promoting interdisciplinary research.

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White Papers prepared for the workshop

Antle, John, Susan Capalbo, Edward Elliot, William Hunt, Sián Mooney, and Keith Paustian. *Understanding and predicting the behavior of managed ecosystems: Lessons from agroecosystem research.*
Ascher, William. *Coping with complexity and organizational interests in natural-resource management.*
Brock, William A. *White paper for NSF workshop.*
Ewel, Katherine C. *Resource management: The need for interdisciplinary collaboration.*
Hanna, Susan. *Managing the human and ecological interface: Marine resources as an example laboratory.*
Ludwig, Don. *The era of management is over.*
Oppenheimer, Michael. *Anticipating rapid change: Insights from non-linear geophysical systems.*
Root, Terry L. *Some thoughts—focusing on animals—concerning developing a research agenda for management.*

The full report upon which this Executive Summary is based can be found at <http://lweb.la.asu.edu/akinzig/report.htm>. White papers commissioned in advance of the meeting will be appearing in a special issue of *Ecosystems* in the latter half of 2001. The Steering Committee wishes to thank the National Science Foundation for funding this workshop (DEB-9910620 and 0073653), and to acknowledge the contributions of Greg Guibert in workshop planning and preparation.

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