

The Freshwater Imperative: A Research Agenda and Beyond

by

John J. Magnuson, University of Wisconsin, Madison, Robert J. Naiman, University of Washington, Penny Firth, National Science Foundation, Diane M. McKnight, U.S. Geological Survey, and Jack A. Stanford, University of Montana

This century has seen changes in the distribution, abundance, and quality of water and freshwater sources that represent a strategic threat to the quality of human life, the environmental sustainability of the biosphere, and the viability of human cultures. The United States is facing, in a real sense, a freshwater imperative. Freshwater sciences will play a role in facing these issues. Are we ready to meet this challenge?

Scientists and managers are increasingly called on to provide a predictive understanding of freshwater ecological systems but are unable to respond effectively at a scale commensurate with the issues. Exigencies of funding and inadequate infrastructure for freshwater research are part of the problem. In addition, the current dependence on short-term studies does not allow separation of human-caused changes from natural environmental change. As a result, unambiguous criteria for management and policy decisions are generally lacking.

These concerns inspired a group of scientists to provide leadership for an effort to further environmental sustainability in the freshwater area. The heritage of this effort, known as the Freshwater Imperative or FWI, is described in another article in this issue (Firth). It is important to note that the leaders of the FWI effort have constantly sought review and input from the scientific community. They sent their initial defining document to 60 aquatic scientists for comment, and ultimately chose the following science-based goal:

to provide a predictive understanding of freshwater ecosystems and resources that can be used to improve detection, assessment and prediction of environmental effects, and to develop management and mitigation alternatives for potential environmental changes scenarios.

The essence of this goal persists through the present.

The Research Agenda

The first area of emphasis for the FWI effort was to prioritize research needs and articulate the interdigitation of research and management. A process of workshops and consultations beginning in 1990 was punctuated by a book in press (Naiman, Magnuson, McKnight and Stanford 1995) titled *The Freshwater Imperative: A*

Research Agenda. The research agenda, with a foreword by Kathryn D. Sullivan, chief scientist, NOAA, will be published in June 1995 by Island Press in cloth (\$35.00) and paperback (19.95). Island Press's flyer describes the book as follows:

"Fresh water is a source of energy, an avenue of transportation, and habitat for myriad organisms. It structures the physical landscape, is a central feature of climate, and exerts major influences on economic growth and demographic patterns. Yet in the United States, funding and infrastructure for freshwater sciences have dwindled, while a dependence on short-term studies has resulted in a dangerous lack of knowledge upon which to base management and policy decisions.

Against this background, NSF, EPA, NASA, TVA, and NOAA sponsored a working group of leading aquatic scientists to identify research opportunities and frontiers in freshwater sciences for this decade and beyond. This volume summarizes their two-year effort. The research agenda outlined in *The Freshwater Imperative* focuses on issues of water availability, aquatic ecosystem integrity, and human health and safety. It is a consensus document that has been endorsed by all of the major professional organizations involved with freshwater issues, including the International Association of Great Lakes Research, the North American Benthological Society, the Ecological Society of America, and others."

The Process

The workshop and process to develop a research agenda was planned and co-chaired by Robert J. Naiman and John J. Magnuson with the assistance of a steering committee broadly based in freshwater sciences. The members of the Steering Committee were: G. Ronnie Best (University of Florida), Elizabeth R. Blood (University of South Carolina, now at the Joseph W. Jones Ecological Research Center), Nelson G. Hairston, Jr. (Cornell University), Gene E. Likens (Institute of Ecosystems Studies), Sally MacIntyre (University of California), Diane M. McKnight (U.S. Geological Survey), Jeffrey E. Richey (University of Washington), Jack A. Stanford

(University of Montana), and Robert G. Wetzel (University of Alabama). Penelope L. Firth participated in Steering Committee meetings as an observer for the National Science Foundation, and as liaison to the FWI Coordinating Council. The committee met two times prior to and once after workshop held in January 1993 at the Friday Harbor Marine Laboratory (University of Washington).

This was the principal workshop for the activity. The 36 participants (in addition to the Steering Committee) included scientists from 25 U.S. research institutions and professional organizations, six foreign institutions, and five federal agencies. The process was open and encouraged debate in an atmosphere of respect. The Steering Committee was also sensitive to professional conflicts, and from the beginning included all aspects of limnology, freshwater ecology, and inland water ecology in its charge. Our view included the recognized need to understand inland lakes, ponds, reservoirs, rivers, streams, wetlands, and groundwater as ecological systems interacting with each other and the landscape in which they are imbedded. Limnology is inherently multidisciplinary, involving all viewpoints that can be brought to bear on understanding the nature of freshwaters (Edmondson 1994).

The openness of the process is a high priority. Following the Friday Harbor workshop, discussion of the FWI recommendations was placed on the programs of major scientific and professional societies related to freshwater ecology. The draft executive summary of the FWI was presented and comments were received. By Spring 1994, the Steering Committee had made presentations and sought comments at the annual meetings of the American Fisheries Society, the American Society of Limnology and Oceanography, the Ecological Society of America, the International Association of Great Lakes Research, the North American Benthological Society, the Society of Wetland Scientists, the Hydrology Section of the American Geophysical Union, and the North American Lake Management Society. The draft document from the workshop has evolved from a first draft by Naiman, and successive editings by members of the steering committee. The book represents a consensus of participants at the workshop with extensive input from the limnological community at large.

The Priorities

The research agenda ranked six interdisciplinary areas as priorities.

- 1) Ecological Restoration and Rehabilitation

- 2) Maintaining Biodiversity
- 3) Modified Hydrologic Flow Patterns
- 4) Ecosystems Goods and Services
- 5) Predictive Management
- 6) Solving Future Problems

The goal was to link research, management and policy with emphasis on an adaptive management approach. We also recognized that a regional scale was the most effective arena for integrating research and management. Regional objectives were to: (1) predict effects on freshwater ecosystems of regional changes in climate and landscape; (2) develop an approach where natural and social scientists work together to understand and resolve aquatic problems; and (3) achieve an understanding of the underlying systemic factors.

Implementation of the FWI research priorities and their integration with management and policy involves institutional changes as well as improvements in infrastructure. The centerpiece is a coordinated, interagency initiative with private-sector partnerships that draws on the expertise of agency scientists and managers, academic researchers, and the private sector. Many agencies are moving toward an ecosystem management approach. The FWI supports this movement and encourages the incorporation of an integrated watershed management perspective into programs.

Implementation of the FWI research program is expected to cost \$200 million per year, which is less than 1% of what the United States spends annually on procurement regulation and remedial protection of its waters. Institutional support for the FWI can be provided by:

Enhancing existing programs of government agencies with water resource responsibilities to support innovative research and technology development and transfer (\$60 million/year).

Establishing regional institutions to provide interdisciplinary research integrating human sciences and natural sciences, and bringing together managers from government, academia, and the private sector (\$60 million/year).

Initiating an integrated National Science Foundation program to promote effective multidisciplinary research on a scale commensurate with contemporary issues in limnology (\$10 million/year).

The anticipated immediate benefits from enhanced institutional support for freshwater science include: strengthening the research, education, and technology

needed to respond effectively to critical issues; ensuring that issues are evaluated at scales commensurate with the problems; and developing multidisciplinary approaches to increasingly complex problems. Anticipated long-term benefits include: increased health and safety of U.S. Citizens; less waste and more efficient use of the nation's resources; greater responsiveness of management to societal needs; a greater ability to respond to future threats; and increased environmental security.

The physical and intellectual infrastructure for the FWI can be enhanced through:

Establishing a freshwater biodiversity center to provide factual data on freshwater biodiversity, develop sensitive biotic indices on environmental change, and enhance predictability and accuracy in monitoring programs (\$15 million/year).

Establishing an array of long-term and altered research sites with specific fresh water emphases (\$20 million/year).

Strengthening education and communication to provide innovative and broad-based training above and beyond traditional efforts for students and professionals in the freshwater disciplines (\$15 million/year).

Anticipated benefits from an enhanced physical and intellectual infrastructure include: factual data and innovative approaches to biodiversity issues, an ability to address linkages between human and environmental sustainability, and a continued high-level of literacy about freshwater ecosystems and their management.

The Future

The FWI research agenda should become an integral component of the management and rehabilitation of the nation's freshwaters. Future activities of the FWI are consistent with the themes developed earlier and continue with activities of implementation, outreach, and further planning in federal agencies, scientific societies, and elsewhere (Firth, this issue). An assessment of decision maker's needs is underway. This assessment will identify decision makers at several levels (policy, management, corporate, municipal etc.) who are using freshwater science information, and through a process of interviews and

meetings, determine their information needs as well as the timing and form in which the information is needed. The assessment will be sponsored by several federal agencies and the private sector, and will take place during 1995. A

workshop on an International FWI effort for the East Asia/Pacific Rim region will be held at the summer meeting of the American Water Resources Association in Honolulu in June. The contact person is Dr. Bill Chang, NSF, wychang@nsf.gov. Collaborative relationships are being developed with the Water Resources and Environmental Management Consortium (WREMC), which is a consortium of 21 historically black colleges and universities and minority educational institutions dedicated to improving and developing research, education, and outreach activities in the focus areas of water resources and environmental management.

The FWI Research Agenda has a future. Although it will soon appear in book form, it is in many ways a living document. It will be brought back to the meetings of various scientific societies and other venues for information and comment. Its implementation will be the focus of ongoing efforts in the public and private sectors.

Authors' affiliations. J. J. Magnuson is director of the Center for Limnology at the University of Wisconsin-Madison. R. J. Naiman is director of the Center for Streamside Studies at the University of Washington. P. Firth* is Program Director for Special Projects, Division of Environmental Biology, National Science Foundation. D. M. McKnight* is research hydrologist with the U.S. Geological Survey in Boulder, Colorado. J. A. Stanford is director of the Flathead Lake Biological Station at the University of Montana.

*Any opinions, findings and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily represent the views of the National Science Foundation or U.S. Geological Survey.

References

- Edmondson, W.T. 1994. What is limnology? pp. 547-553, in R. Margalef (Ed.), *Limnology Now: A Paradigm of Planetary Problems*. Elsevier Science B.V., New York.
- Naiman, R.J., J.J. Magnuson, D.M. McKnight, and J.A. Stanford. 1995. *The Freshwater Imperative: A Research Agenda*. Island Press, Covelo, CA. 200 p.