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### **Limnology's Second Century: New Challenges and Opportunities**

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Limnology is among the oldest of the fields of study that comprise the water resources sciences. Its founding usually is associated with two late-19th century publications: Stephen Forbes' 1887 essay "The Lake as a Microcosm" and Francois Forel's massive *Le Lemman*, a three-volume treatise on the limnology of Lake Geneva, published over the period 1892 to 1904. Although the early history of limnology is associated most closely with lakes as the objects of study, modern limnology is defined more broadly as the science of all inland waters: lakes and reservoirs, rivers and streams, and wetlands. More precisely, it is a multidisciplinary science that includes all the basic sciences relevant to understand the physical, chemical and biological behavior of these water bodies and an interdisciplinary science that integrates the information from various disciplines into a holistic understanding of inland water bodies.

In the field's first century, limnologists made tremendous advances in our fundamental understanding of how inland waters function as ecosystems and how they interact with their terrestrial watersheds. Especially since the advent of the "environmental era" in the 1960s, limnologists have contributed greatly to our understanding of the impacts of pollutants on inland water ecosystems and to the scientific basis for managing and solving water pollution problems. As the need for clean and safe water continue to grow in the face of increasing populations and increasingly intensive use of the landscapes in which inland water reside, the need for limnological knowledge and research should continue to grow. The field thus would appear to have a bright future.

However, not all is well in limnology as it enters its second century, and the field is somewhat at a crossroads. For the past five years or so, growing numbers of limnologists have expressed concern about the status of their field, especially within higher education. Many issues contribute to a lengthy list of challenges for the future health of the field. In general, these problems and concerns can be grouped into six major areas:

- (1) inadequacy or instability of research support, especially in certain subfields;
- (2) loss of academic positions, especially in biological limnology;
- (3) growing fragmentation in academic programs, an ironic situation for an inherently interdisciplinary field,
- (4) inadequate educational programs, both at the general education level and at the professional level;
- (5) growing professional separation among various kinds of limnologists; and
- (6) poor public understanding of limnology and failure to identify it as a field that can contribute to the solution of aquatic problems important to human society.

Insofar as recognition of a problem is the first step in articulating solutions, the self-criticism that has occurred within the field is a healthy sign. Discussions on these issues have appeared in limnological journals over the five years, most notably in *Limnology* and *Oceanography*. These discussions have led to several initiatives dedicated to critical examination of the field and to developing of recommendations to overcome the perceived deficiencies and problems. These initiatives include (1) a review and assessment by leading scientists within the American Society of Limnology and Oceanography (ASLO), (2) an agenda-setting initiative for freshwater research called the Freshwater Imperative, and (3) a study by the National Academy of Sciences-National Research Council that is focusing on educational issues in limnology. The authors of the five articles in this issue of *Water Resources Update* all have been active in these initiatives, and the articles are summaries of the initiatives with which they have been associated.

The ASLO review resulted in a report, "Challenges for Limnology in North America: An Assessment of the Discipline in the 1990s" (*ASLO Bulletin*, in press), that describes the problems facing limnology and places them in a historical

context. It contains a broad range of recommendations to re-invigorate the field and reverse the trend toward fragmentation among its component disciplines and subject areas. The lead author of the "challenges report", William Lewis, University of Colorado, describes the work of his committee in the first article of this issue.

The Freshwater Imperative is an initiative of a diverse group of aquatic scientists from government agencies, academic institutions, and the private sector to address research needs in limnology and to develop plans for government-supported interdisciplinary research programs or freshwater ecosystems. The article authored by John Magnuson, University of Wisconsin, Robert Naiman, University of Washington, Penny Firth, National Science Foundation, Diane McKnight, U.S. Geological Survey, and Jack Stanford, University of Montana, describes the first tangible project of the Freshwater Imperative, a soon-to-be-published book edited by these individuals (The Freshwater Imperative: A Research Agenda, Island Press, Washington, D.C., in press) that summarizes the results of an agenda-setting workshop involving a wide array of aquatic scientists. A companion article by Penny Firth describes recent developments at the National Science Foundation to provide substance (i.e., research programs and funds) to the recommendations of the Freshwater Imperative. In particular, she describes the recently announced joint grant competition of NSF and the Environmental Protection Agency called "Water and Watersheds." The broadly stated goal of the competition is to support interdisciplinary research aimed at improving our understanding of the principles for protecting and managing water resources in the United States. The two agencies have committed a minimum of \$10 million to this effort in fiscal year 1995, a not insignificant stimulus for freshwater research in a period of fiscal austerity for government programs, and certainly a positive sign for the future of research on inland freshwaters.

The National Research Council's study committee "Future of the Science of Inland Aquatic Ecosystems," established in 1994, has undertaken a broad review of the problems confronting limnology, but it is devoting special attention to educational and professional concerns. Its report, expected to be published by National Academy Press by the end of 1995, will include recommendations to improve the graduate training of limnologists, to lessen the fragmentation and separation that exists among subfields of the profession and within education programs in limnology, and to integrate academic limnology better with professional practice. In preparation for a week-long workshop of the committee, which I have the honor of chairing, committee members prepared a series of background and position papers last summer on topics related to the committee's charge. Summary versions of two of these papers are included in this issue of . Robert Wetzel, University of Alabama, presents a strong critique of the current status of limnological training in the United States and offers a vision for creating more rigorous, comprehensive, and integrated education programs. Wayne Minshall, Idaho State University, discusses the renaissance of biological considerations and measurements in water quality assessments and describes the expanded role that biologists and biological concepts must play in making integrated aquatic ecosystem management a reality rather than a distant goal.

It has been a pleasure putting this issue of *Update* together. I appreciate very much the cooperation of the authors in their willingness to take the time from their busy schedules to participate in this forum and in the timely submission of their manuscripts. The subjects they discuss have broad importance to the future of limnology in this country and, in turn, to the well-being and wise management of our critically important inland water resources.

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