November sediment supply, which in turn is instrumental in the spawning success and recruitment of the endangered humpback chub. Seasonal predictive climate information thus holds promise for proactive decision-making for the AMP, if applied at the right time and appropriate entry points for decision-making, session participants agreed.

Effective Use of Information in Applications Research

One of the goals of this session was to address the problem of an inadequate fit between what the research community knows about the physical and social dimensions of uncertain environmental changes and what society chooses to do with that knowledge. There is the need to move beyond the integration of physical and societal dimensions to focus on practice and evaluation: How are impediments to the flow of information created? Where are the impediments, and how are they to be overcome? How are they defined among differentially vulnerable groups?

As noted within this session, and elsewhere, adaptability within a natural or managed system is generated through major events at smaller, faster scales, such as flooding, whereas resilience resides in slowly changing variables such as social, climatic, and landscape processes, which provide system memory. Present adjustments to hurricanes, floods, and droughts can constrain or enable vulnerability to longer-term risks induced by climate and global changes. An even larger challenge is to consider how different systems of knowledge about the physical environment and competing systems of action can be brought together in pursuit of resilience and of the processes to make such management possible. This session was an initial step in addressing the challenge.

The session, "Integrated environmental and water decision-making in a changing climate" was held on 7 December at the 2005 AGU Fall Meeting in San Francisco, Calif. A complete list of presentations given at this session is available on the AGU Web site at http://www.agu.org/meetings/fm05/fm05-sessions/fm05_GC31A.html and http://www.agu.org/meetings/fm05/fm05-sessions/fm05_GC33B.html

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LETTERS

On Quantifying Freshwater Sustainability Through Multiscale Mapping

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We agree with Kanivetsky and Shmagin (*Eos, 86*(50) 2005) that better accounting of flows comprising the hydrologic cycle is needed and that better quantification of recharge (into groundwater) and discharge (i.e., streamflow) is important from human and environmental perspectives. However, because these authors promote their approach as being useful in assessing "sustainability," we feel compelled to offer words of caution about its applicability.

The authors suggest that the ratio of renewable water supply to water use by humans and the environment is a "key indicator" of sustainability. We think that these authors got it half right. The ratio described above is a useful indicator because it quantifies how much strain a natural system may be experiencing. However, all ecosystem water is not equivalent. The river science literature strongly indicates the need for the full range of natural intra-annual and inter-annual variation of river flows, along with associated characteristics of timing, duration, frequency, and rate of change, to sustain the biotic integrity of aquatic ecosystems [*Postel and Richter,* 2003]. In this context, only when an adequate assessment of ecosystem needs is performed and compared to net water availability after subtracting human uses will we know if we are truly managing for sustainability.

Understanding how much water (and its associated temporal pattern) a river ecosystem needs—essential in managing for true ecological sustainability—will require assessments with much finer degrees of spatial and temporal resolution than that provided by the approach of Kanivetsky and Shmagin. For example, the authors suggest that St. Louis County, Minnesota's use of only 8.1% of the renewable water supply is "sustainable." However, if all of that water were taken from a single or even a few small streams, the ecological effects would likely be devastating. Our point is that hydrologic accounting methods based on spatially averaged conditions across geographic areas the size of counties or ecoregions provides only a coarse-scale indication of the potential for human impacts on natural ecosystems. These results can be very misleading because water extractions and other hydrologic alterations are not spatially uniform.

The science of determining water flows needed to sustain healthy river ecosystems, known as 'instream flow science,' is a rapidly evolving field driven by the urgent need to provide defensible guidelines in a highly charged sociopolitical context in which stakeholders often hold opposing views of what constitutes the 'beneficial' use of surface water and how much, if any, water needs to be left in the river for ecological purposes. Many rivers have been altered to the point where it may be biologically, socially, or financially impossible to restore their ecological health, and significant legal obstacles exist in many places to retain water in rivers for its ecological purpose. While scientific emphasis needs to be placed on better accounting of water flows through hydrologic cycles, we want to emphasize that the dearth of information relating flow regimes to biological processes is also a significant hindrance to the attainment of sustainability. Everyone interested in promoting ecologically sustainable water management will benefit from more research focused on relating hydrology, geomorphology, and water quality to aquatic and riparian biology.

Reference

Postel, S., and B. Richter (2003), *Rivers for Life: Managing Water for People and Nature,* Island Press, Washington, D.C.

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We appreciate comments from Gordon, who offers a word of caution about the applicability of our approach. We stated that the ratio of renewable water supply to water use by humans and the environment is a key indicator for freshwater sustainability, and we resolutely stand by this statement. However, we readily admit that there is no information presently available to quantify environmental needs. Indeed, we are making a call in this comment, as we did in our feature article, for ecologists and hydrologists to address this issue.

We agree with Gordon that the subject of adequate assessment of ecosystem needs must be tackled soon. However, our approach is legitimate and credible, showing the limit of natural system, as sustainability of freshwater resources. Given the geographical variation through space and across time of that natural limit, and quantifying it through renewability, the multi-scale mapping program is essential to address the challenge of freshwater sustainability. Furthermore, we should point out that we are not speaking about "availability" as Dr. Gordon described, but the "sustainability," which requires that consumption of water by humans and environment must not cause a decline or liquidation of freshwater resources.

With respect to "much finer resolution," Gordon should be reminded of the scale factor and the title of the article. The example (St. Louis and Ramsey counties) in our article was used simply to illustrate the point of contrast between two counties. It was not intended for management purposes at a county level. At county levels, we must quantify resources at a finer resolution and we have done so for the Twin Cities metropolitan area.

The issue of freshwater sustainability is increasingly recognized as a key component in the quest for transition toward sustainable development. The U.S. Congress and federal government repeatedly request federal water agencies to provide a full picture of freshwater sustainability. However, federal agencies (i.e., U.S. Geological Survey) collect and report only the information on water use by humans. That information is not enough to meet the freshwater sustainability challenge.

To achieve it, the information on water use by humans (available) as well as the environment (unavailable) must be compared with freshwater supplies that are sustainable. Our mapping program will fill this gap by quantifying sustainable freshwater resources. What is more, it could be done at any scale—national, regional, basin, local.

At a scientific level, we would like to call attention to the critical issue of hydrologic informatics. Recently, the main effort has been focused on advances in information technology, such as space imaging. For example, Web design and other advanced technologies and development of Consortium of Universities for the Advancement of Hydrologic Sciences, Inc.'s Hydrologic Information Systems Project. (*Eos 87*(1) 2006) is undeniably a great tool for various applications, including proposed here mapping program. Yet, without the urgent implementation of the latter program, the challenge of freshwater sustainability cannot be confronted.

In conclusion, we support the call from Gordon for better assessment of environmental needs. However, the subjects of scientific inquiry must be more inclusive than what was suggested by the author. The full picture of freshwater sustainability requires the collaboration not only of hydrologists and ecologists, but also economists and social, political, environmental, and other scientists. However, the mapping program is indeed a key component to address the challenge of freshwater sustainability at a practical level. The program could put the nation in the position finally to answer the fundamental question: Does the United States have enough water?

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ABOUT AGU

Outstanding Student Papers: 2005 Fall Meeting

The following members received Outstanding Student Paper Awards at the 2005 Fall Meeting in San Francisco, Calif. (Winners in other sections and focus groups will be announced in subsequent issues of Eos*).*

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Cryosphere Focus Group

Jeremy Bassis, University of California, San Diego, *New insight into ice shelf rift propagation from geodetic and seismic monitoring.*

Jeffrey Deems, Colorado State University, Fort Collins, *Spatial structure differences in snow depth distributions between forested and open sites.*

Mark Flanner, University of California, Irvine, *Snowpack radiative heating: Influence on Tibetan Plateau climate.*

Leigh Stearns, University of Maine, Orono, *Rapid changes of large tidewater glaciers in SE Greenland.*

Nonlinear Geophysics Focus Group

Brian Brugman, University of California, Los Angeles, *Nonlinear beat-wave interaction between shear Alfvén waves in a laboratory plasma.*

Dong-Hoon Sheen, Seoul National University, South Korea, *Improved implementation of seismic waveform inversion using Gauss-Newton method in elastic media.*

Jeffrey Smigelski, Wright State University, Dayton, Ohio, *Scaling analysis of water level records from the North American Great Lakes.*

Paleoceanography and Paleoclimatology Focus Group

Mea Cook, Massachusetts Institute of Technology/Woods Hole Oceanographic Institution Joint Program in Oceanography, *Evidence of methane outgassing during MIS 3 in the Bering Sea.*

Eric Galbraith, University of British Columbia, Vancouver, Canada, *Millennial-scale variations of nitrogen isotopes and export proxies in the subarctic Pacific during MIS 3: Evidence for an oceanic fertility switch?*

Heather McCarren, University of California, Santa Cruz, *Long-term paleoceanographic variability across the Paleocene-Eocene Boundary: Correlating orbital scale trends in the North Pacific and South Atlantic.*