

FORUM

Taking Stock of Water Resources

You can only manage what you measure. If this maxim is correct, then a recent report by the *U.S. Geological Survey* [2002] promises a vast improvement in water management in the United States. The report proposes a consolidated, national accounting of availability and use of fresh water. The proposed accounting clearly will be superior to the present absence of a nationwide assessment of fresh water resources. But is it enough?

Traditionally, water managers have measured the availability of fresh water by comparing the volume of water available from various sources against estimated demand. The proposed national assessment adheres to this approach. Gauging water by volume is fine if we are only interested in whether our glasses will be full or empty. But throw an endangered species or wetland preservation into the mix, and the picture becomes less clear.

Today, water managers are asked to save endangered species and restore failing ecosystems in addition to pursuing their traditional goals of assuring a supply of clean, fresh water and controlling floods. However, these new goals for water management require new types of information from the Earth sciences and ecology.

The following examples illustrate water managers' current dilemma. In spring of 2001, low flows in the Klamath River in Oregon led water managers to cut off supplies to farms to maintain stream flows needed to preserve populations of two endangered fish species in the basin. This decision precipitated a backlash by farmers, who diverted water to maintain irrigation in defiance of water management agencies. An external review of the underlying science questioned whether available knowledge about the water needs of the endangered species is adequate for the decisions that water managers must make [*National Research Council*, 2002a]. As if to drive home this point, it now appears that a subsequent decision by managers to restore water for irrigation during the summer of 2002 precipitated the massive fish kill that occurred in the river in September.

Coastal wetlands in Louisiana are breaking up and eroding at an alarming rate, and they are taking communities and livelihoods with them [*Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority*, 1998]. Flood control levees that have

restrained the Mississippi River within its banks for 50 years also interrupt the natural supply of fresh water, nutrients, and sediment needed to maintain the surrounding wetlands. These wetlands form the first line of defense for the city of New Orleans against disastrous flooding from hurricane-driven storm tides. Engineered breaches in the dikes now divert sediment-laden water into the wetlands surrounding the main channel of the lower Mississippi River, but these activities threaten to disrupt profitable estuarine fisheries. While the long-term consequences of continued land loss in coastal Louisiana are certain, nobody can say whether the proposed solutions will work and what the short-term cost to the fisheries will be.

The Comprehensive Everglades Restoration Plan (CERP; <http://www.evergladesplan.org/>), authorized by the U.S. Congress in the Water Resources Development Act [WRDA, 2000], directs water managers to "restore, preserve and protect the South Florida ecosystem." This \$8 billion public works program is aimed at reversing decades of ecological decline in a vast 10,000-km² area of fresh water and estuarine wetlands. Water managers are legally bound by WRDA 2000 and complementary Florida state legislation to set aside a portion of the regional water supply sufficient to provide the quantity, quality, timing, and distribution of water needed to restore the natural system. Beginning in 2005, managers must regularly document in reports to Congress the "benefits to the environment" of the restoration effort (WRDA [2000], sections 601 (h) and 601(i)). The water managers are left to determine how to quantify the natural system's water needs and conversely how to enumerate the environmental benefits accruing from each additional 1000 acre-feet delivered to the Everglades.

Water management is no longer concerned just with securing the benefits of water extracted from the natural water cycle to supply cities and farms and with intervening in this cycle to mitigate flood damage. Water in its natural cycle provides us with other benefits, by supporting ecosystems that constitute a valuable resource in their own right. To sustain these benefits, regional water managers already recognize the need to allocate a portion of the available water supply to meet the demand of so-called "in-stream" uses [*National Research Council*, 2002b]. The concept of in-stream use places natural systems on par with

other demands on available water supply in a basin, but this may not be sufficient to meet the goal of restoring ecosystems.

How much more water will it take to revive the Florida Everglades? How much of the Mississippi River flow must be diverted to reverse land loss in Louisiana? What characteristics of aquatic habitat must be provided to restore a sustainable salmon population in the Klamath River? These questions move beyond prophylactic measures designed simply to isolate and thus protect natural systems. Instead, they call for manipulating natural processes for the purpose of restoring the environment to a more desirable, past condition. Consequently, water managers now need a way to characterize the state of natural systems in their charge as well as the ability to forecast how these will respond to various water management activities.

For example, wading bird numbers have served as an indicator of the ecological health of the Everglades for over 100 years. Robust, quantitative relationships have been found that link wading bird numbers to a few critical characteristics of the seasonal pattern of water levels in the wetland [Russell *et al.*, 2002]. As well, managers regularly employ predictive hydrologic simulation models, including water levels in the wetlands, to guide regional water management system operations. From this point, there is a fairly direct path to combining this information and evaluating the relative ecological costs and benefits of altering water management practices, at least in terms of the impacts on wading bird numbers. Consideration of additional "ecological indicators" would allow a more balanced assessment of the effects of water management on the entire ecosystem.

Managing our water resources still requires that we track the amount of water in lakes, rivers, and aquifers, as proposed by the *U.S. Geological Survey* [2002]. Existing practice also recognizes the concept of "in-stream uses," and these must be considered in any comprehensive assessment of the availability and use of fresh water. However, goals for water management have expanded to include rebuilding collapsed fisheries; nurturing endangered species; sequestering hazardous substances such as arsenic; reversing salt water intrusion into rivers and aquifers; and reigning in galloping coastal land loss due to subsidence, sediment starvation, and consequent deterioration of coastal wetlands. Balancing these new goals with traditional goals requires managers to evaluate the requirements--in terms of water--for restoring and maintaining valued ecosystems.

Describing the connections between the water cycle and the ecosystems it supports and forecasting the consequences of human interventions in the water cycle present some new challenges for integrated Earth and ecological sciences. These goals also refocus the attention given to existing challenges. Meeting these challenges is essential for a full accounting and wise management of our water resources.

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Author

William Nuttle, Ottawa, Ontario, Canada

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