

## Is ecohydrology one idea or many?

### Discussion\* by WILLIAM K. NUTTLE

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Examples cited by Kundzewicz (2002) to provoke discussion of ecohydrology reveal divergent notions of the fundamental nature of the concept. At issue is the answer to this question—does the term “ecohydrology” refer to a single idea or does it encompass many different ideas? Here, I argue that ecohydrology encompasses diverse ideas at the interface between hydrology and ecosystem science.

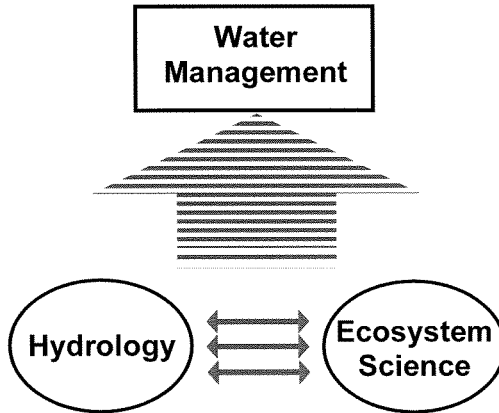
Zalewski's (2000) definition captures the competing views of ecohydrology, even as it attempts to reconcile them; “Ecohydrology, the study of the functional interrelationships between hydrology and biota at the catchment scale, is a new approach to achieving sustainable management of water.” First, ecohydrology is introduced as an area of study directed toward understanding the interdependence of hydrological and ecological processes. Next, ecohydrology provides a single, overarching paradigm for water management based on a holistic vision of water's role in the environment. Can ecohydrology be both of these things?

Traditional water management depends on information derived from hydrological science. A holistic approach to water management similarly depends on integrated study of hydrological and ecological processes (Fig. 1). However, science alone does not determine management. Other factors, besides scientific knowledge, combine to determine the overall approach to water management. Therefore, ecohydrology is either an overarching paradigm for water management, or it is the study of the interaction of hydrological and ecological processes. It cannot be both.

I suggest that ecohydrology is the sub-discipline shared by the ecological and hydrological sciences that is concerned with the effects of hydrological processes on the distribution, structure, and function of ecosystems, and on the effects of biotic processes on elements of the water cycle (Nuttle, 2002). This combines Rodriguez-Iturbe's (2000) view of ecohydrology as “the science which seeks to describe the hydrological mechanisms that underlie ecologic pattern and processes” with his subsequent observation that “the connection between the role of plants in the water balance is central to ecohydrology” (Rodriguez-Iturbe *et al.*, 2001).

This definition focuses on the role of hydrological processes in ecosystems, consistent with Rodriguez-Iturbe's reference to “ecologic pattern and processes.” As Kundzewicz (2002) observes, the etymology of “ecohydrology” links hydrology with the relatively broad field of ecology. However, the study of hydrological processes makes little or no contribution in some areas of ecology, e.g. population ecology.

\* Discussion of: Ecohydrology—seeking consensus on interpretation of the notion by Z. W. Kundzewicz, this issue.



**Fig. 1** The integration of hydrology and ecosystem science involves different concepts for each type of ecosystem. Sustainable water management relies on this information, but other factors also contribute to determine the management approach taken.

Therefore, the narrower interpretation linking hydrology specifically to ecosystem science (Fig. 1), provides a more accurate description of the field.

Thus defined, ecohydrology necessarily encompasses many different ideas. Both fields, hydrology and ecosystem science, share an approach based on applying concepts of mass and energy conservation to study the mechanics of environmental processes in various settings (Hatton *et al.*, 1997). Zalewski (2000) observes that four factors, climate, geomorphology, the plant community and its dynamics, and the influence of human activities, determine the dynamics of water in each setting. This assures that there will be great variety in the interactions between hydrological and ecosystem processes found in different settings.

As Kundzewicz (2000) notes, the search for solutions to practical problems has played a central role in the development of hydrology. Groffman & Pace (1998) make the same observation of ecosystem science. Perhaps this is why Zalewski's more inclusive definition does not immediately strike one as odd. In both fields, progress is driven by the interplay between innovation in research techniques with their application to solve specific problems, whether arising from the traditional approach to water management, e.g. Zalewski's (2000) "hydrotechnical approach", or environmental problems such as eutrophication and mitigating the effects of acid rain.

Yet, the conflation of an area of scientific study with an approach to water management confuses the tools of a craft with its practice. By "craft" I wish to refer to the process of forming a relationship with the Earth's natural processes that is capable of sustaining us now and also future generations. The practice of any craft requires tools, materials and the skills to apply them creatively.

Despite some notable successes (e.g. Pace & Groffman, 1998), it is evident that we have yet to develop the full set of skills necessary to implement sustainable management of natural resources. Adaptive environmental assessment (Holling, 1978) was an early attempt to construct an approach for applying scientific knowledge to the task of implementing sustainable management strategies, including water resources (Walters *et al.*, 1992). Experience shows that skill in the design and implementation of sustainable management practices is at least as important to success (Walters, 1998).

Public institutions, law, policies and regulations comprise the materials for fashioning a sustainable approach to water management. It is hardly necessary to mention that these differ greatly from region to region. The general outline for an approach to sustainable resource management began to take shape in the United States in 1969 with passage of the National Environmental Policy Act. Policies derived from this act and other legislative directives, such as the Clean Water Act and the Water Resources Development Act of 2000, pursue the goal of sustaining natural systems. These explicitly recognize the need for taking an integrated ecosystem approach (cf. Jackson *et al.*, 2000).

Scientific knowledge supplies the analytical tools that water managers use to shape and evaluate management practices. Zalewski (2000) describes the shift underway in water management practice away from a “hydrotechnical approach” toward one that recognizes the “holistic integration” of hydrological processes with valued ecosystem services. This shift in practice requires the development of new analytical tools. Ecohydrology, as I have defined it above, refers to the general area of scientific study from which these new tools will emerge.

The paradigm of sustainable water resource management recognizes implicitly that the primary resource is the natural endowment of climate, geology and ecosystem processes in each region. These attributes determine the quantity, quality, timing and spatial distribution of water readily available to us. Ecohydrology, the science, seeks knowledge that we need to understand the influence of human activities on this resource. As such, ecohydrology embraces a range of topics as varied as the Earth’s ecosystems and the human activities that will determine their, and our, future.

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