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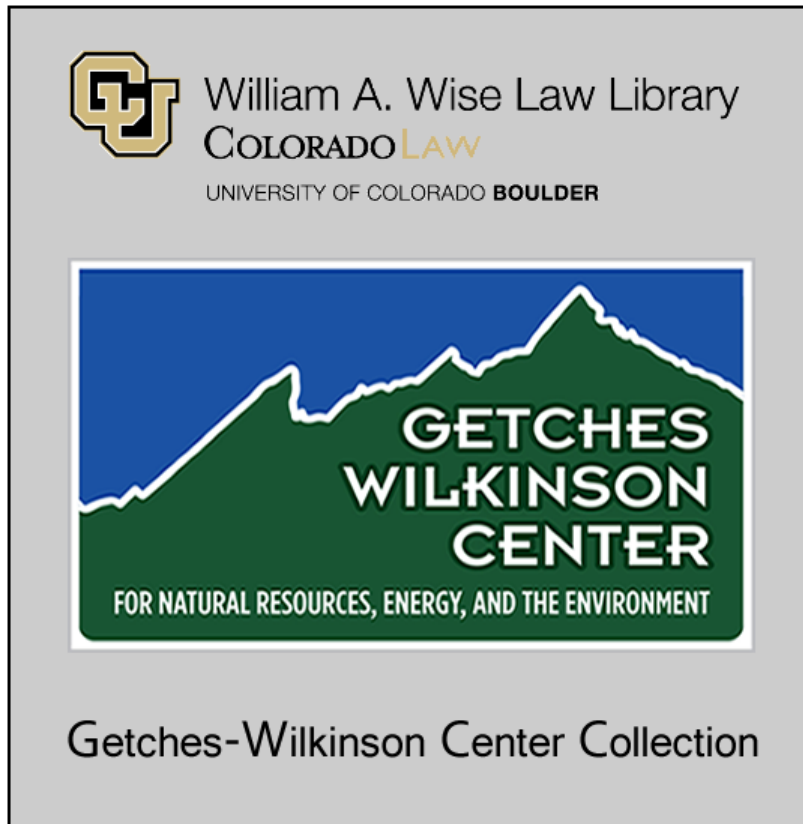
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**SCIENTIFIC AND SOCIAL LANDSCAPES—NEW FRAMEWORKS AND
FORUMS FOR WATER MANAGEMENT AND SUSTAINABILITY**

Christine Turner and Herman Karl

**INCLUDE
(Integrated science and Community-based values in Land-Use Decision making) Project
U.S. Geological Survey**

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SUMMARY

The scientific community faces new opportunities and challenges in its efforts to address increasing societal concern about sustainability. The concept of sustainability puts humans into the ecosystem by acknowledging the valid needs of humans and other life forms, for the present and for the future. The need for integrated science is intensifying because effective evaluation of tradeoffs in the choices that face society requires an understanding of the interconnectedness of natural processes. Also, the trend toward decentralization of the decision-making process, as reflected in the proliferation of stakeholder groups, requires scientists to present their information and knowledge in forms that specifically address the key regional land-use issues in ways that are understandable and accessible to the users of the information--be they local citizens, planners, or other stakeholders and decision makers. Scientists are responding to these challenges by developing ways to integrate scientific data that permit evaluation of a broader range of data at appropriate scales, and by developing approaches to take their science more effectively into the public arena.

Water is central to most land-use issues, and new system-level frameworks permit better conceptual and quantitative understanding of hydrologic processes at a regional scale. This coincides with an increasing focus of stakeholder groups on issues at a regional scale, often at

the scale of an individual watershed, as they recognize the need to evaluate many environmental issues on a regional scale. The opportunity therefore exists for citizen groups, decision makers, stakeholder groups, and scientists to engage collaboratively in a process that will likely lead to more informed decision making in a era when complex issues require the best effort of all concerned to ensure sustainability. Linking science and society in ways that increase the potential for making sustainable choices still presents a number of challenges, both scientific and cultural, to both scientists and decision makers. Collaborative efforts among federal agencies, stakeholders, citizen groups, and decision makers offer an approach that affords the opportunity for informed decision making, with all parties at the table.

SCIENTIFIC APPROACHES FOR SUSTAINABILITY

Essential to the implementation of sustainable land-use strategies is the availability of sound science to help inform decision making. The inherent interconnectedness of natural systems requires that the science be interdisciplinary in nature so that the linkages and interactions among physical, chemical, and biological processes can be evaluated. The ecosystem concept, when put in a spatial framework (ecoregions of Omernik, 1995) acknowledges the interconnectedness of natural systems from a biological perspective.

Although the ecosystem concept is often viewed as a conceptual framework for landscape analysis, it is also important to understand the lifeblood of the ecosystem—water—and how it affects all aspects of the natural system. Water management concerns are often at the heart of sustainability issues, and thus are essential to land use decisions in which ecosystem concerns are addressed. Whether the issue concerns wildlife habitats, sufficient water to support

human needs, or acceptable surface and ground water quality, central to societal concerns are water distribution, flow paths, and chemical characteristics.

A recent conceptual framework for hydrologic systems, one that integrates concepts of surface- and ground-water flow, has been proposed by Winter (2001). This new framework addresses a long-standing need to understand how surface waters interact with underlying aquifers, an outgrowth of the recognition that many societal issues require an understanding of this hydrologic connectivity. Although drainage basins are fundamental hydrologic units for understanding surface-water systems (Chorley et al, 1964), and aquifers are fundamental hydrologic units for ground-water systems, a conceptual framework was needed that considers the complete hydrologic system in order to reflect the realities of hydrologic connections. The “hydrologic landscape units” defined by Winter, based on these connections, do not necessarily coincide with drainage basins or watersheds, but the new conceptual framework now makes it possible to evaluate the regional flow of both surface water and ground water, and how they interact (Winter, 2001).

The complexity and interdisciplinary nature of problems facing society require that modeling approaches incorporate knowledge from a broad range of scientific disciplines. Although biology and hydrology are two important components of an ecosystem, the role of meteorological variables, including precipitation, temperature, and solar radiation, and the interaction of these variables with the spatial distribution of landscape characteristics such as topography, soils, vegetation, and geology, are equally important. Thus a need exists for computerized physical-process models that can address a wide range of issues on a regional scale, with a hydrologic component central to the modeling effort. Recent advances resulting from a cooperative effort between the U.S. Geological Survey (USGS) and the Bureau of

Reclamation (BOR) include development of an operational, database-centered decision support system for application to complex water-management issues. The decision support system couples the U.S. Geological Survey's Modular Modeling System (MMS) (Leavesley et al., 1996a; Leavesley et al., 1996b) with the BOR's RiverWare tools (Fulp et al., 1995) through use of a shared relational database. The modular approach provides an adaptable set of water-resource management tools that permits users to address a broad range of societal issues (Leavesley et al., 1998).

LINKING SCIENCE TO SOCIETY— THE SOCIAL LANDSCAPE OF SUSTAINABILITY

The recent trend to decentralize the decision-making process (devolution) through active involvement of stakeholder groups across the nation has two notable attributes. First, community-based partnerships afford the opportunity to engage a wide range of concerned parties in the decision-making process. Those who live in the region, in particular, are also those who are largely responsible for the ultimate sustainability of that region, as they make decisions that either support or undermine its sustainability. The opportunity to move toward sustainability is improved if citizens become engaged in the process and begin to recognize the tradeoffs and consequences, both short-term and long-term, of the various choices before them. A second aspect of community-based partnerships is that they offer an alternative to litigation as a way to resolve land-use disputes. The Enlibra Doctrine of the Western Governors' Association (1998) captures the essence of devolution and the importance of incorporating local concerns in

the decision-making process when they embraced the concept of “National Standards: Neighborhood Solutions”.

Many federal agencies have recently adapted to devolution, and are incorporating and experimenting with approaches that accommodate this trend in their operations. The Bureau of Land Management (BLM), U.S. Forest Service (USFS), and Environmental Protection Agency (EPA) are among the Federal Agencies who are adapting to this growing decentralization of the decision process.

The U.S. Geological Survey (USGS), although neither a land-management nor a regulatory agency, is investigating, through its INCLUDE (Integrated science and Community-based values in Land-Use Decision making) project, how its science can be used more effectively in the public policy arena, especially with respect to community-based collaborative efforts. The goal of the INCLUDE project is to explicitly link science to societal needs by understanding the decision process and designing science efforts to address societal needs. The premise is that the science needed to address the environmental, resource, and land-use decisions that confront society is best determined by scientists working in partnership with citizens and decision makers—the people who need the science to help make informed decisions. The cornerstone of the INCLUDE effort is collaboration among scientists, stakeholder groups, and decision makers to identify the regional scientific issues of concern and then to design the scientific investigations to address these concerns. This cornerstone is laid upon a foundation of taking a problem-focused, rather than a discipline-focused, approach to contributing scientific information toward the resolution of environmental and land use issues.

The INCLUDE approach, conceptualized three years ago at the USGS, is at the vanguard of the evolving new field of sustainability science (Kates et al., 2001). The INCLUDE approach

offers a way to implement an idea embraced by proponents of sustainability science, namely that “participatory procedures involving scientists, stakeholders, advocates, active citizens, and users of knowledge are critically needed...” (Kates et al., 2001, p. 641). The INCLUDE approach also explores the role of science and cultural values in informing decisions, with the intent of offering perspectives that will help decision makers achieve balanced solutions to environmental resource management and land use issues. This is in accord with both the holistic ecosystem approach and tenets of sustainability science, which view understanding and working with the character of nature-society interactions as critical to achieving sustainability.

An ongoing study in the San Francisco Bay area exemplifies the USGS INCLUDE approach of issue-driven, citizen-centered science. This INCLUDE community-based project, “An integrated study of an urbanized watershed—the Creek Project”, is examining issues of flooding, water quality, landscape change, invasive plant species, and threatened/endangered species with respect to land use planning and environmental policy in the San Francisquito Creek watershed in Menlo Park, California. To address the full range of issues, the project consists of four elements: (1) hydrologic and biologic studies, (2) geographic studies, (3) social dynamics studies, (4) communication and learning. An interdisciplinary team that includes scientists; educators; practitioners and theorists of consensus building and environmental negotiation; urban and land use planners; and community leaders and decision-makers has been assembled to work on this project.

An outgrowth of issue-driven, citizen-centered science is the potential for an increased understanding by citizens of the nature and limitations of science. Adaptive management is an implicit admission of the uncertainty of scientific information and understanding. New knowledge about the role of complexity theory and chaos theory in natural systems requires

scientists to find ways, when engaging with users of their information, to communicate the uncertainty inherent in their scientific analyses.

Interestingly, sociological analyses of communities has resulted in recognition of “human geographic units” (Kent and Preister, 1984) that commonly coincide with watersheds or river valleys. “Human geographic units” are cultural units that define geographic areas in which some cultural commonalities can be identified. The coincidence between cultural and natural subdivisions of the landscape hints at the possibility of developing resource management approaches that accommodate conceptual “landscape units” that are both culturally and scientifically meaningful geographic subdivisions. This possibility is intriguing because decision making involves more than scientific information and perspectives. It typically involves a complex range of human concerns, ranging from socioeconomic values, which are often locally distinctive, to such intangible, but real, concerns as aesthetics. Development of a single geographic or landscape unit that at least minimizes both the scientific complexity and the social complexity would improve prospects of developing natural resource management approaches that accommodate both the citizens’ sense of “place” and scientifically viable scales for integration.

The BLM Partnership Series captures the essence the citizen-based approach to stewardship. By emphasizing the importance of integrated science to address environmental issues of concern, and by involving local communities in the decision process, a likely result is that, over time, science will become part of the “local wisdom”. Then, sustainability may become as much a local responsibility as a mandated outcome. It is through such partnerships, and a sense of shared responsibility, that sustainability is likely to be a national goal embraced by the citizenry.

CONCLUSIONS

Conceptual hydrologic frameworks and new modular approaches to modeling are two of the recent scientific advances that integrate the essential hydrologic component into ecological landscape analysis, particularly at scales that are appropriate for many natural resource management concerns. The concept of sustainability, which acknowledges humans as an integral part of the landscape, and the trend toward decentralization of the decision process, increases the responsibility of the citizens who inhabit the landscape. The challenge to scientists is to tailor scientific studies more closely to societal needs and to make the scientific understandings accessible to a broad range of users in many sectors of society. Increased collaborative efforts among federal agencies, citizens, stakeholder groups, and decision makers offer a way to provide an interface between scientific perspectives and the decision process, while increasing a sense of shared responsibility for land-use decisions and the ultimate sustainability of a region.

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