

# Ecosystem Management and Its Role in Linking Science, Policy, and Management

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**Abstract**—The scientific community has recently emphasized the importance of ecological process, structure, and scale in the maintenance of biological diversity. Humans have affected most natural landscapes, and many naturally occurring processes, structures, and species may not rebound to naturally sustaining function without intervention. Ecosystem management relies on science and its transcendence into public policy to assure long-term ecosystem sustainability. This approach is defined, implemented, and understood in vastly different ways. This paper (1) summarizes ecosystem management history and intent, (2) assesses divergent interpretations of ecosystem management, and (3) offers insight into its use and effectiveness in maintaining sustainable ecosystems.

## Introduction and Historical Context

### *Ecology and Ecosystems*

In 1935, the British plant ecologist Arthur Tansley introduced the concept of an ecosystem as “the whole system including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment of the biome—the habitat factors in the broadest sense” (Tansley 1935). This new definition departed from traditional biological sciences viewpoints that saw natural processes as separable, distinct functions. As a basis of the Evolutionary-Ecological Land Ethic, the functioning of ecosystems on broad temporal and spatial scales was later emphasized by Aldo Leopold in his classic 1949 “A Sand County Almanac.” Since then, scientists have further recognized the importance of an ecosystem-level approach to wildlife management, conservation biology, population ecology, and restoration ecology (Ehrenfeld 1970, 1976; Noss 1983; Noss and Harris 1986; Noss and Cooperrider 1994; Odum 1971; Pickett et al. 1992; Soule and Wilcox 1980; Soule 1985).

Today, ecosystems are generally defined as “any unit that includes all of the organisms in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles” (Odum 1971). Instead of focusing solely on the needs of individual species, an ecosystem approach provides a better context in which to fit a broader array of species’ needs within a smaller package of information. In terms of biological conservation or management, ecosystems can vary greatly in spatial scale depending upon the specific question or goal stated—they are not limited by explicit boundaries.

### *Management*

For millennia, humankind has manipulated the natural environment to suit its needs, often with negative consequences. In conformation to Judeo-Christian philosophical underpinnings of land use (see Genesis 1:28), the production of food, fuel, and fiber has historically dominated the goals of land management. With population growth and new technological advances, timber companies traditionally clearcut forests for wood, replant the landscape with fast growing monocultures, then wait to cut the stand once again. Agriculture depends on chemicals to maximize crop yields, and rangelands are usually managed to maximize meat production. These narrowly focused management schemes benefit the consumptive needs of humans but often result in unstable ecosystem process or function, including the extirpation of species from their native ecosystems. Species loss is often attributed to habitat loss and fragmentation, disruption of disturbance regimes, stress-induced or introduced disease, pollution, and exotic species.

In addition, species perceived to hinder maximum production of goods are often purposefully eliminated. The wolf, grizzly bear, and prairie dog are victims of the deliberate hunting, trapping, and poisoning campaigns—the loss of these and other “unwanted species” has had devastating effects upon the natural composition of ecosystems (Leopold 1949; Meffe and Carroll 1997).

Wildlife management has also traditionally targeted huntable game or species that society finds endearing, beautiful, or socially important. Elk, eagles, deer, tigers, lions, elephants, and other large, charismatic species are often the focus of wildlife management (Noss 1999).

### *Policy*

Historically, government policy and social dogma have maintained traditional views of commodity production and

single species management. Government-funded campaigns in the early and mid-twentieth century effectively eliminated certain “pest” species from landscapes. The USDA Animal Damage Control (now Wildlife Services) and the now defunct Predatory Animal and Rodent Control (PARC) directed these extermination campaigns. In Arizona and New Mexico, grizzly bears were considered extirpated by 1935 and 1931, respectively (Brown 1985). PARC extermination campaigns helped extirpate wolves from these two States by the 1960s (Brown 1983). Other more subtle policies also led to the degradation of publicly owned lands (see Backiel et al. 1992), introduction of exotic species, and over utilization of croplands.

## The Dawn of Ecosystem Management

In the mid-1960s and 1970s, the United States Congress began to specifically protect roadless areas (1964 Wilderness Act) and threatened or endangered species (1973 Endangered Species Act (ESA)). In addition, new laws mandated environmental review of planned actions, examination of general ecological requirements, and input from other agencies (1976 National Forest Management Act, 1969 National Environmental Review Act, and 1976 Federal Land Policy and Management Act). The ESA was the first and only law that specifically mandated the conservation of “the ecosystems upon which endangered species and threatened species depend” (Sec. 2b). While welcomed by conservationists, the ESA alarmed industry and private property rights advocates. Ostermeier (1999) points out that this reaction was based on the ESA’s lack of consideration for social and economic issues. The ESA also does not provide management prescriptions for Threatened or Endangered species—it only provides very general direction.

With the dawn of conservation biology as a separate, distinct discipline in the early and mid-1980s, the linking of science, policy, and management began. The utilitarian concept, while encoded within the mission statements of public agencies, was starting to give way to a more evolutionary-ecological approach. Policy makers were seeking more consensus-based law, managers were hungry for more effective techniques, and scientists were trying to supply policy makers and managers with better information.

The term “ecosystem management” first appeared at a 1987 conference hosted by the University of Washington, the USDA Forest Service, and the National Park Service and was coined as “regulating internal ecosystem structure and function, plus inputs and outputs, to achieve socially desirable conditions” (Agee and Johnson 1988). Noss (1999) summarizes definitions below:

- ...the conservation and stewardship of large areas of land or water containing multiple species, habitats, resources, and (often) ownerships (Noss 1999).
- ...integrating scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long term (Grumbine 1994).

...the goal of the ecosystem approach is to restore and sustain the health, productivity, and biological diversity of ecosystems and the overall quality of life through a natural resource management approach that is fully integrated with social and economic goals (Interagency Ecosystem Management Task Force 1995).

...a resource management system designed to maintain or enhance ecosystem health and productivity while producing essential commodities and other values to meet human needs and desires within the limits of socially, biologically, and economically acceptable risk (American Forest and Paper Association 1993).

A comprehensive definition of ecosystem management comes from “The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management.” The authors of this 1996 article first state that ecosystem management is “... driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function.” The authors then further define ecosystem management as possessing (taken from Christensen et al. 1996):

*Sustainability.* Ecosystem management does not focus primarily on “deliverables” but rather regards intergenerational sustainability as a precondition.

*Goals.* Ecosystem management establishes measurable goals that specify future processes and outcomes necessary for sustainability.

*Sound ecological models and understanding.* Ecosystem management relies on research performed at all levels of ecological organization.

*Complexity and connectedness.* Ecosystem management recognizes that biological diversity and structural complexity strengthen ecosystems against disturbance and supply the genetic resources necessary to adapt to long-term change.

*The dynamic character of ecosystems.* Recognizing that change and evolution are inherent in ecosystem sustainability, Ecosystem management avoids attempts to “freeze” ecosystems in a particular state or configuration.

*Context and scale.* Ecosystem processes operate over a wide range of spatial and temporal scales, and their behavior at any given location is greatly affected by surrounding systems. Thus, there is no single appropriate scale or timeframe for management.

*Humans as ecosystem components.* Ecosystem management values the active role of humans in achieving sustainable management goals.

*Adaptability and accountability.* Ecosystem management acknowledges that current knowledge and paradigms of ecosystem function are provisional, incomplete, and subject to change. Management approaches must be viewed as hypotheses to be tested by research and monitoring programs.

Concurrently, Grumbine (1994) delineated ecosystem management themes: hierarchal context, ecological boundaries, ecological integrity, data collection, monitoring, adaptive

management, interagency cooperation, organizational change, humans embedded in nature, and values.

Today, almost every land management agency within the United States has adopted ecosystem management into its planning and regulatory activities. In 1992 at a Congressional hearing, Forest Chief Dale Robertson stated "Ecosystem management means that the Forest Service will use an ecological approach to achieve multiple-use management of the National Forests and Grasslands by blending the needs of people and environmental values to sustain diverse, healthy, and productive ecosystems. We will combine our scientific knowledge and experience about patterns of relationships among organisms and their environment with the 'land wisdom' of people from the many sectors and cultures of our society to care for the land and serve the people." The BLM, Natural Resources Conservation Service, U.S. Fish and Wildlife Service, and others have similarly followed suit.

One criticism of ecosystem management policy is that it may facilitate neglect of single species conservation requirements (Goldstein 1999). Definitions of ecosystem management are fuzzy and leave much to interpretation. Nevertheless, the integration of such principles, as general as they may be, into public policy and lands management elucidates the shift from strictly utilitarian-based management to an evolutionary – ecological land ethic.

## Discussion

Today, commodity-based industry emphasizes the integration of human needs in ecosystem management while conservationists stress ecological preservation aspects. Policy makers and practitioners stand at the sidelines trying to figure out which way the ball is rolling. Yaffee (1999) describes three different conceptualizations of ecosystem management that fit into the general boundaries described above:

*Environmentally sensitive, multiple-use management.* Realizing that traditional land management practices often failed to produce desired conditions or precipitated unwanted effects, industry, agriculturalists, and certain land management agencies find that managing lands within their ecological tolerances will result in more sustainable yields of goods and services.

*Ecosystem-based approaches to resource management.* Ecosystem management prescribes deeper understanding and explicit goals for improving the ecological integrity of lands. Often, whole ecosystems are not managed, but they influence planning activities, restoration methods, and collaborative communications with neighboring landowners/managers.

*Ecoregional management.* Projects such as Yellowstone to Yukon, The Sky Islands Wildlands Network (see Noss 1992), or other ecoregional plans emphasize restoring landscape-level processes, connections, and species compositions. Success depends on policy and management changes that better fit within a larger, ecoregional perspective.

People, however, are still part of the equation. Noss (1999) eloquently states, "a science based approach is not one that ignores other concerns, such as socioeconomic and cultural issues. Rather, it permits reasoned discussion of such concerns

against a backdrop of ecological reality." Ecosystem management clearly implies that collaboration and communication among interested parties is essential in promoting a more unified approach to managing landscapes on larger spatial and temporal scales. If this collaborative effort is to be successful in on-the-ground improvements of ecological components, science must not be simply an equal opinion among others, but the basis from which to start from.

## Conclusion

While ecosystems and ecosystem management are relatively new terms to policy makers, managers, and even ecologists, the fundamental concepts that these terms convey are popular and in-demand at all levels of biological conservation and management. Due to the inadequacy of traditional methods for approaching land management issues, ecosystem management has quickly risen as an answer to policy formation and land management decisions. The ambiguity of ecosystem management has resulted in different interpretations that sometimes conflict with one another, but the general theme of such management looks to forming a basis for how ecological processes and components are approached, and to defining the context surrounding sustainable human uses.

It is paramount that ecosystem management retain and grow its roots within the foundation of science. Scientists bear the heavy burden of clearly defining ecosystem management parameters, while taking into account social and economic considerations. Policy makers must realize that while ecosystem management may bring them more consensus-based, collaborative ideas on how policy might best serve the public, there are bottom lines that cannot be breached if true ecological sustainability is to be realized. Practitioners, land managers, and the public must realize that while ecosystem management will solicit their ideas for inclusion into the political and scientific formulation of land practices, there are also limitations to the flexibility of the land. Ecosystem management has the potential to become a highly effective vehicle for linking science, policy, and management. How effective it becomes will be decided on how willing scientists, conservationists, policy makers, industry, and practitioners are to use a new science that incorporates, to varying degrees, information from a wide variety of interests above a foundation of scientific principle.

## References

- Agee, J.; Johnson, D. 1988. Ecosystem management for parks and wilderness. Seattle: University of Washington Press.
- Backiel, Adela; Gorte, Ros W. 1992. Clearcutting in the National Forests. Congressional Research Service report 92-607 ENR. Washington, DC.
- Brown, David E. 1983. Wolf in the Southwest: The making of an endangered species. Tucson: University of Arizona Press.
- Brown, David E. 1985. Grizzly bear in the Southwest: The documentary of an extinction. Oklahoma City: University of Oklahoma Press.
- Christensen, N. L.; Bartuska, A. M.; Brown, J. H.; Carpenter, S.; D'Antonio, C.; Francis, R.; Franklin, J. F.; MacMahon, J. A.; Noss, R. F.; Parsons, D. J.; Peterson, C. H.; Turner, M. G.; Woodmansee,

- R. G. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. *Ecological Applications*. 6: 665-691.
- Ehernfeld, D. W. 1970. *Biological conservation*. New York: Holt, Rinehart and Winston.
- Ehernfeld, D. W. 1976. The conservation of non-resources. *American Scientist*. 64: 660-668.
- Goldstein, P. Z. 1999. Functional ecosystems and biodiversity buzzwords. *Conservation Biology*. 13: 247-255.
- Grumbine, R. E., ed. 1994. *Environmental policy and biodiversity*. Washington, DC: Island Press.
- Leopold, A. 1949. *A Sand County almanac*. New York: Oxford University Press.
- Meffe, G. E.; Carroll, C. R. eds. 1997. *Principles of conservation biology*. Sunderland, MA: Sinauer Associates.
- Noss, R. F. 1983. A regional landscape approach to maintain diversity. *BioScience*. 33: 700-706.
- Noss, R. F. 1992. The Wildlands Project land conservation strategy. *Wild Earth (Special Issue)*: 10-25.
- Noss, R. F. 1999. *A citizen's guide to ecosystem management*. Boulder, CO: Biodiversity Legal Foundation.
- Noss, R. F.; Cooperrider, A. 1994. *Saving nature's legacy: protecting and restoring biodiversity*. Washington DC: Defenders of Wildlife and Island Press.
- Noss, R. F.; Harris, L. D. 1986. Nodes, networks, and MUMs: Preserving diversity at all scales. *Environmental Management*. 10: 299-309.
- Odum, E. P. 1971. *Fundamentals of ecology*. Philadelphia: WB Saunders Co.
- Ostermeier, D. M. 1999. The role of institutions in ecosystem management. In: J. D. Peine, ed. *Ecosystem management for sustainability: Principles and practices illustrated by a regional biosphere reserve cooperative*. Boca Raton, FL: Lewis Publishers: 457-474.
- Pickett, S. T. A.; Parker, V. T.; Fiedler, P. L.. 1992. The new paradigm in ecology: Implications for conservation biology above the species level. In: P. L. Fiedler; S. K. Jain, eds. *Conservation biology: the theory and practice of nature conservation, preservation, and management*. New York: Chapman and Hall: 65-88.
- Soule, M. E.; Wilcox, B. A. eds. 1980. *Conservation biology: An evolutionary-ecological perspective*. Sunderland, MA: Sinauer Associates.
- Soule, Michael E. 1985. What is conservation biology? *Bioscience*. 35: 727-734.
- Tansley, A. G. 1935. The use and abuse of vegetational terms and concepts. *Ecology*. 16: 284-307.
- Yaffee, S. L. 1999. Three faces of ecosystem management. *Conservation Biology*. 13: 713-725.