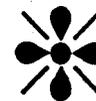


# The Role of ECOLOGICAL MONITORING in Managing Wilderness



by Peter B. Landres, Ph.D.

**G**ood management requires good information. Monitoring provides this information when it is structured into the process of management, well designed and executed. As federal and state agencies strive to implement a management paradigm based on sustaining ecosystems, ecological information becomes a vital part of managing natural resources. Inventory and monitoring programs can be bewilderingly complex, involving philosophical, scientific, statistical, economic, administrative and practical issues. This article explores a few of these issues. I discuss the general role ecological monitoring plays in protecting and preserving wilderness character, suggest some criteria for choosing among all the possible variables to monitor and close with some thoughts about what I believe are substantive emerging issues related to ecological monitoring in wilderness.

Although there are debates over definitions, the primary purpose of inventorying is simply determining the current location and condition of attributes of interest, be they trails, endangered plants or animals, administrative structures or fire regimes. Monitoring could be called "planned watching," repeatedly sampling attributes of interest to detect changes in location and condition. These changes could occur naturally, be caused by various threats or be caused by planned and unplanned conse-

quences of management actions. Together, inventorying and monitoring provide a wealth of information essential for protecting and preserving wilderness conditions, and for assessing the effectiveness of management actions.

Inventory and monitoring programs are now considered a crucial part of conserving biological diversity and assessing impacts from threats. The role monitoring plays in managing natural resources has also been the focus of several recent conferences. Many federal and state agencies, private groups and universities have inventorying and monitoring programs in wilderness and other protected lands for a variety of purposes. Systematic wilderness inventory and monitoring programs are being developed by the National Park Service and the Bureau of Land Management. The Environmental Protection Agency is establishing the continent-wide Environmental Monitoring and Assessment Program (EMAP) that includes many wilderness sites. Air pollution monitoring has received the most attention within wilderness, partly because of the "affirmative responsibility" mandate in the Clean Air Act to prevent deterioration in Class I areas. Systematic sampling protocols for monitoring "air quality-related values" in wilderness were developed, and specific standards and guidelines suggested for Pacific Northwest and California wildernesses.

Some wildernesses have recreation-based inventorying and monitoring programs, and monitor specific attributes of concern, such as water quality or livestock grazing impacts, when and where known problems occur. For ecological attributes, most wildernesses are "terra incognita" with incomplete and outdated information on ecological conditions, range of natural variation and threats to these conditions. In reviewing ecological monitoring activities in wilderness, Susan Bratton concluded that "... wilderness legislation has done little to encourage environmental monitoring. The sites which have extensive monitoring programs have them because of other legislation, or because of management histories which have little to do with the Wilderness Act."

## Why Monitor?

"Why monitor" is really two separate questions: what are the goals and management objectives of monitoring? and, how will monitoring improve wilderness management?

*Monitoring goals.* The process of making management decisions is often likened to an art, but this art must be based on a foundation of information. Monitoring is a structured process to develop the information base from which wilderness management decisions and actions are made and improved over time. To be an effective information

gathering tool, all inventorying and monitoring must be driven by clearly defined goals and objectives. Goals typically are statements of broad intent, such as "maintain natural conditions in wilderness," that provide only general direction for monitoring programs. Specific monitoring objectives then come from asking the "right" questions, that is, questions that yield precisely the information managers need to accomplish their goals. Generating these questions is often a difficult task because it requires translating broad, imprecise goals into precise, measurable units of information. For example, one monitoring objective might be to maintain native plant species composition, accomplished by determining current floristic composition of different vegetation types within the wilderness and monitoring for an influx of exotic plants.

Scientists at the Aldo Leopold Wilderness Research Institute developed a simple conceptual model for all wilderness monitoring that is composed of three basic goals. The first goal is to improve management of individual wildernesses. This goal drives two distinct types of monitoring: wilderness protection monitoring and wilderness use monitoring. Protection monitoring strives to detect "unnatural" change in ecological (e.g., plants, soil) and social (e.g., wilderness experience) attributes of wilderness character. Use monitoring strives to improve the ability of wilderness managers to provide for those purposes to which wilderness is devoted, e.g., recreational, scientific, educational, historical uses.

The second goal is to improve the acquisition and use of ecological knowledge derived from wilderness. This goal also drives two distinct types of monitoring. global change monitoring to detect subtle

and long-term change in environmental conditions, and ecological reference monitoring in which information and knowledge gained from wilderness ecosystems is used to improve management of non-wilderness lands. The third and last goal is to improve assessment of the status and trends of the National Wilderness Preservation System, providing information to legislators and administrators. Individual wildernesses, society-at-large and policy makers all benefit from collecting these three types of information

*Improving Wilderness Management.* Once an area is designated as wilderness, the task of wilderness management begins. Inventorying and monitoring can improve wilderness management in four relatively distinct ways: first, by establishing baseline conditions and their natural variation; second, by determining when a significant change in these conditions occurs that is beyond the range of natural variation; third, by identifying causes of change so corrective management actions can be taken; and fourth, and maybe most important, by testing our understanding of natural systems and the consequences of management actions.

The more complex a system is, the less we know about it. Wilderness ecosystems are very complex, and we have even less knowledge about synergistic and cumulative impacts from the many threats to natural conditions within wilderness, such as air and water pollutants, exotic species, livestock grazing and activities on adjacent lands. Given these uncertainties, monitoring offers the best, and maybe only, means for detecting change in the condition of ecological attributes, and testing how well our management is protecting and preserving wilderness ecological systems. Managers, resource specialists and others often have a gut

feeling for changes in resource conditions; monitoring provides a reality check for these feelings.

In addition, many management actions are experiments performed on the land, often at large spatial and long temporal scales. These experiments are usually uncontrolled in the sense that we have no means for identifying whether the management action produced the desired outcome, and if not, why not. A rigorous monitoring program provides data to test our knowledge about the consequences, both planned and unplanned, of management actions to protect and preserve wilderness character. By carefully developing monitoring efforts and making them an integral part of management programs, monitoring data can directly improve the information base available for decision making. In essence, monitoring is simply a tool for learning from past successes and failures. Recognizing our ignorance about ecological systems, the impacts from many different threats and the consequences of management actions should only increase our commitment to monitoring. In wilderness, where our ignorance is profound and the stakes so high, we must learn as much, and as fast as we can.

### **What to Monitor?**

It is impossible to provide an exhaustive list of ecological components or attributes to monitor because each agency, every region and every wilderness has a unique set of concerns and constraints which necessarily drive the inventorying and monitoring process.

Wilderness managers will never have complete information because of insufficient time, money and personnel. Managers must therefore determine the minimum set of information that is both necessary and sufficient for making decisions; this set of information needs then

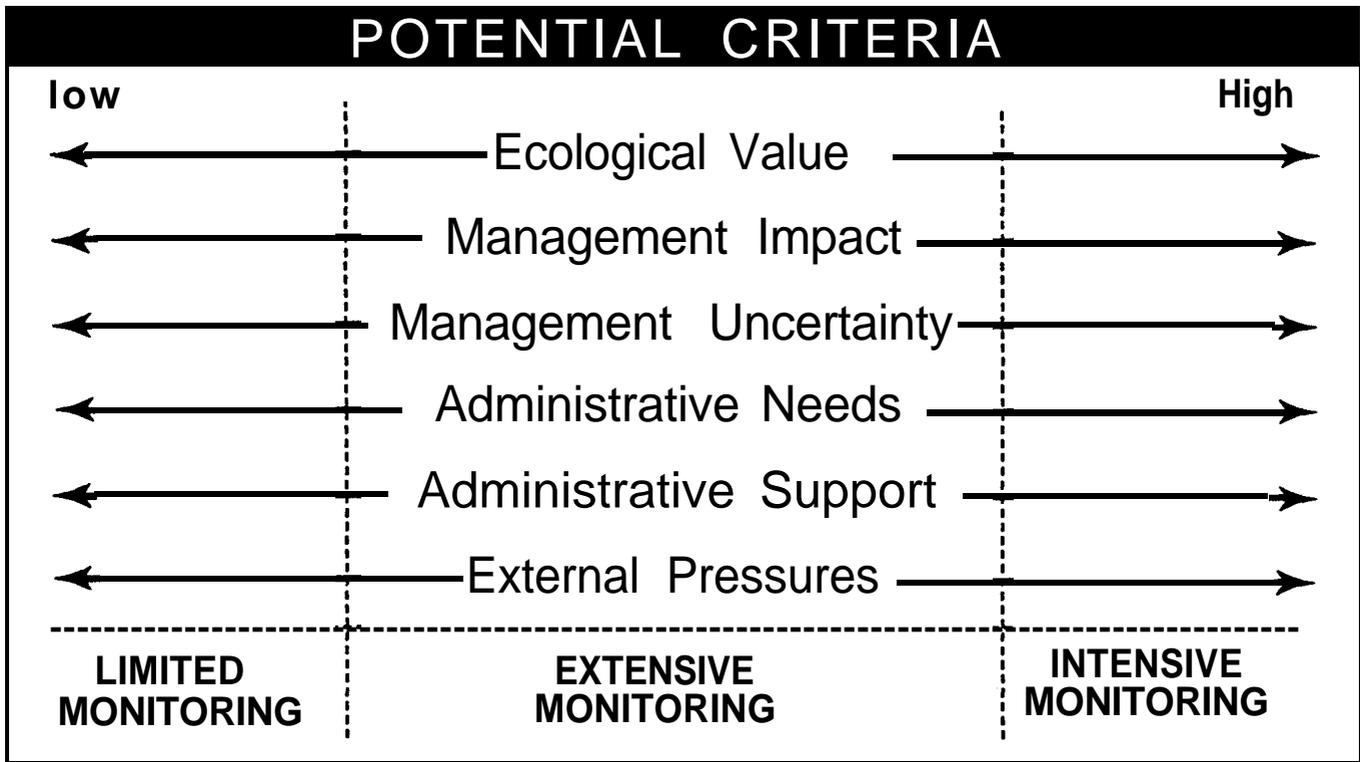


FIGURE 1. Potential criteria for prioritizing attributes of interest in inventory and monitoring programs, and resulting intensity of these programs. "Ecological Value" is based on the rarity and importance to the community or ecosystem. "Management impact" is the probability that management actions will affect ecological attributes of interest. "Management Uncertainty" is the level of uncertainty of management actions producing desired outcomes or effects. "Administrative Needs" are the information needs of legislators and administrators. "Administrative Support" is the level of interest, funding, personnel and commitment to inventory and monitoring. "External Pressures" are the outside pressures, political, social and economic, that influence all management activities and hence inventory and monitoring programs. These criteria, in combination, determine which attributes will be inventoried and monitored, and the level or intensity of monitoring. "Intensive" monitoring incorporates rigorous statistical design and high sampling frequency on selected ecological attributes to provide data of the best possible quality. "Extensive" monitoring provides course-level data on many different attributes.

drives the monitoring program. Several different criteria could be used in determining what these information needs are. Every wilderness needs to develop its own prioritization criteria, but criteria likely to be of general importance include ecological value, management impact, management uncertainty, administrative needs, administrative support and external pressures (Figure 1).

Wilderness managers use these criteria in combination to determine which ecological attributes are monitored, and intensity of the monitoring effort. Where value, impacts, uncertainty, need, support

and pressures are moderate to high, the time, effort and cost of "intensive" monitoring is warranted. This type of monitoring seeks to provide detailed information on specific attributes: the goal is depth rather than breadth. Threatened and endangered species, for example, require intensive monitoring of distribution and demographic attributes. Where there is little or no value, no known impacts, no uncertainty, no administrative need or support and no outside pressure, little or no monitoring is needed. In the large grey area between these two extremes, "extensive" monitoring is justified.

This type of monitoring seeks to provide general information on many different attributes: the goal is breadth rather than depth. Most monitoring efforts would likely begin with coarse, extensive monitoring. If concerns or negative trends emerge from these coarse data, then finer-level, more detailed intensive monitoring is needed to fully investigate these concerns.

How these criteria are combined and used must be determined by the managers of individual wildernesses. There are no rules or guidelines to help prioritize among these criteria, to show, for example,

when and where external pressures outweigh ecological value, or what happens when value, impacts, uncertainty and need are high, but support is low. Clearly, there will be much subjectivity in the process of developing and applying prioritization criteria; this is acceptable as long as all sources of subjectivity and reasons for decisions are explicitly documented so their merits can be openly discussed.

### Emerging Issues

*Standardization across all wildernesses.* Standardization of monitoring is praised by some, condemned by others. Standardization allows legislators and administrators to be informed on conditions and trends across the National Wilderness Preservation System, and allows wilderness managers from across the country to communicate in common, comparable terms regardless of agency. Perhaps some minimum set of wilderness attributes could be consistently monitored across all wildernesses, satisfying legislative and administrative needs, while still providing individual wildernesses some valuable information. Funding and administrative support for this standard, minimum set would logically come from national or regional offices since these offices derive the primary benefit from this comparable information. Despite potential benefits of standardization, there must be sufficient flexibility to allow wilderness-specific issues and ecological variation to drive monitoring programs. Moreover, standardization must not detract from local wilderness efforts. At the local level time, funding and personnel are too limited to be saddled with increased paperwork and bureaucratic chores that will not directly improve individual wildernesses.

*Monitoring ecosystems,*  
Ecosystems are extraordinarily complex, and we have limited

knowledge about monitoring ecosystem patterns and processes. The mandate of the Wilderness Act is to protect and preserve natural conditions. But how is "natural" operationally defined, how do we assess baseline conditions and variability of processes, and how are these monitored to assess threat impacts and management effectiveness? The use of ecosystem-level indicators for monitoring is alluring, especially if these indicators are relatively easy and cheap to monitor. A wilderness manager, for example, may need information about forest health, and use population estimates of one or a few species as a surrogate for direct information on forest health. However, do we derive all the information we need about forest health by knowing the density and distribution of a single species? How reliable will decisions be about forest health based on a single species? At present, too many questions remain on the cost-effectiveness and reliability of using ecosystem-level indicators. All indicators must be chosen carefully because they will become the units of reality by which management effectiveness is judged.

New management concepts and tools. As concepts of ecosystem science mature, and legislators recognize and mandate the importance of managing for intact ecosystems, wilderness managers will increasingly find themselves needing to understand and manage ecosystems. In such times of rapid change, we need to question whether traditional management concepts and tools provide the information wilderness managers need today.

For example, a new lexicon related to analyzing ecosystems and landscapes is emerging, with terms such as landscape, boundary dynamics, permeability, corridors, patch size and shape, fractal

dimension, contagion, hierarchy, disturbance regime, chaotic, stochastic, simulation modeling, GIS, LANDSAT Thematic Mapper and many others. Uncritical acceptance of new terms and concepts, however, can waste as much time and effort is dogmatically following old concepts. Discriminating judgment is needed with regard to all concepts, both traditional and new. This judgment must be based on a clearly articulated vision of what wilderness management is and where it is headed, and on as much ecological knowledge as is available. Only discriminating judgment will allow us to separate insights and progress from limitations and deadends.

*Foresight and surprise.* We are trained to use the clarity of hindsight to improve on what we have done in the past. But will this serve for new management challenges such as cumulative, synergistic threats and impacts to wilderness conditions? Protecting and preserving wilderness conditions require an understanding of ecological systems we don't have. Surprise is to be expected. Hindsight will continue to serve us well, but foresight may be more important. In one sense, structuring monitoring programs as a fundamental part of management is the ultimate foresight, putting in place a process for generating the information needed for detecting change. Then, closer ties between managers and researchers would ensure sound design of monitoring programs that develop new ecological knowledge and provide information that improves management of wilderness ecosystems. 📄

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