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EDITORIAL

Not only is environmental monitoring critical for effective natural resource management, in many situations it is also required by law. To date, however, lack of expertise in the field of environmental monitoring has prevented many natural resource managers from implementing effective programs. It was in the interest of developing such expertise that over 200 natural resource professionals convened in Corvallis, Oregon, on 10–11 March 1992, for a workshop entitled 'Improving Natural Resource Management Through Monitoring'. The workshop, which was organized by Oregon State University's Department of Forest Science, addressed issues of concern to both developers and users of natural resource monitoring programs. The target audience, however, comprised those individuals responsible for implementing and maintaining such programs.

The workshops included one day of presentations on fundamental monitoring concepts and a second day of concurrent sessions that addressed monitoring practices related to the following: urban forestry; responses to forest management practices; water and stream quality; soils and long-term productivity; effects of climate changes on vegetation; and biodiversity and population. Areas of emphasis within each concurrent session included design and implementation of monitoring programs; information management, data analysis, and reporting of results within monitoring programs; and evaluation of monitoring programs.

Workshop speakers were selected on the basis of their expertise in various topics and their ability to communicate their knowledge to others. In addressing their specific topic, they drew largely upon their own experiences but were not constrained to limit their discussion to their own programs. Speakers were encouraged to describe the issues and challenges involved in designing, implementing, and maintaining cost-effective monitoring programs. Numerous papers were presented at the workshop. The series of papers included in this special proceedings volume will enlighten readers as to the need for monitoring programs, delineate the key elements of effective monitoring programs, and present approaches to interpreting monitoring results and to program evaluation.

Ben Stout, in the opening paper, cites 'the good, the bad, and the ugly' of monitoring programs and admonishes us to remember the importance of formulating questions and establishing program objectives up front. The 'ugly' is that initial enthusiasm for monitoring programs often wanes and the programs are abandoned. 'Bad' is when monitoring programs change protocols in midstream, leaving collections of incompatible data in their wake. 'Good' monitoring pro-

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grams, on the other hand, have clearcut objectives and a sampling design that captures large-, intermediate-, and small-scale variations. The collection protocols produce chronologically ordered data and permit rigorous statistical testing of key hypotheses. Such programs will garner long-term support from both scientific and political communities.

Monitoring programs can be diagnostic tools: They can facilitate assessment of the condition of natural resources so that managers know when an ecosystem is unimpaired and when it must be restored. The first step in designing a diagnostic monitoring system is to develop a conceptual model that identifies all ecosystem components and their interrelationships. To demonstrate this strategy, Gary Davis showcases the conceptual model developed for the Channel Islands National Park monitoring program.

Many of the statistical techniques used by natural resource managers assume independence of the observations in the sample. As Loveday Conquest reminds us, however, monitoring data are often spatially and/or temporally correlated. Although statistical methods for dealing with correlated data do exist, they are not widely familiar. Monitoring data possess certain characteristics which require special treatment. Conquest describes several techniques that will allow natural resource managers to compute required sample sizes for a given level of estimate precision and to compute confidence intervals based on ballpark estimates of correlation. She also describes a method of incorporating Bayesian techniques into hypothesis testing, to calculate the probability of a particular hypothesis being true given the observed evidence. Susan Stafford demystifies the often overwhelming task of managing long-term natural resource data and offers some practical advice on establishing and maintaining a data bank that facilitates both archiving and retrieval of long-term data sets.

Bill Shampine enumerates three necessary characteristics of monitoring data that permit effective quality assurance and control within a monitoring program: (1) The quality of the data must be known; (2) The data type and quality must be consistent and comparable; and (3) The data must be available and accessible. One of the most important requirements for implementing a monitoring program is to develop a plan that clearly identifies the level of data quality needed and describes in detail the actions that will ensure that this level is obtained.

Monitoring Urban Forests

Urban forests are increasingly being recognized not only for their aesthetic benefits but also for their carbon storage, air filtration, noise reduction, and wildlife habitat capacities. Several papers at the workshop dealt with urban forestry, a newly evolving science that relies heavily on monitoring procedures and data. Fred Baker presents a number of case studies to show that effective monitoring of urban forests involves more than inventorying trees. Programs should also gather information about the benefits these forests provide and about the beneficiaries. Although most

urban forest monitoring currently is done at the local level, Baker also discusses several state and national projects. In addition, he discusses ways in which quality control procedures, which are now used infrequently, could substantially improve the accuracy of monitoring data.

Greg McPherson identifies two important goals for urban forest monitoring programs – to increase public involvement in environmental stewardship and to help natural resource managers better define, detect, and predict urban forest health – and outlines a three-tiered approach to achieving these goals: canopy cover analysis, simplified detection monitoring (by trained volunteers) to better understand population dynamics, and intensive monitoring to characterize the urban forest's functions and stressors. In the final paper in this section, Paul Newman describes a technique, adapted from non-urban forestry, of using thematic mapper (TM) Landsat imagery to map the density of urban forests.

Monitoring Responses to Forest Management

Monitoring responses to forest management practices is essential if we are to understand the ramifications of new silvicultural systems. David Silsbee and David Peterson outline the steps involved in designing and implementing long-term forest management monitoring programs. David Shaw *et al.* present an interesting analysis of monitoring the growth and demise of retention forestry practices associated with 'New Forestry'. These authors collected quantitative data on the silvicultural and ecological effects of retention cuts in order to assess whether the silvicultural objectives were met, and they used the results of their analysis to help define guidelines for future retention cutting. David Marshall discusses the use of forest management monitoring from a more classical biometric growth-and-yield perspective.

Monitoring Water and Stream Quality

In 1991, Lee MacDonald and Alan Smart published their 'Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska'. In workshops conducted after the Guidelines were published, the authors learned several basic lessons about putting these monitoring guidelines into practice. They enumerate these lessons in the paper included here. Although most of the concepts may seem self-evident, they are widely applicable and should be explicitly incorporated into the planning and implementation of any stream monitoring program. Bob Wismar, focusing on the role long-term monitoring plays in the environmental assessment of stream ecosystems, describes a technique for detecting changes in stream ecosystem conditions over extended periods.

The Oregon Department of Forestry (ODF) was requested by the State to provide assistance in bringing the Tualatin River near Portland, Oregon, into compliance with pH and dissolved oxygen water quality standards. David Degenhardt and

Christian Fromuth report on ODF efforts that are currently underway and their success to date.

The Timber, Fish, and Wildlife (TFW) program in Washington State represents a consensus approach to implementing reforms in forest practice regulations involving industrial and private timberland owners, state agencies, environmental groups, and Native American tribes. The program includes a cooperative monitoring effort. Robert Bilby explains how close linkage between the TFW monitoring work and the procedure for implementing regulatory change has greatly improved the responsiveness of policy makers to new information. Results from the water temperature and forest chemical monitoring work are currently being incorporated into the forest practice regulations.

Other Topics

The remaining papers included in this proceedings volume address other topics of the 1992 monitoring conference. At the U.S. Department of Energy's Hanford site in southeastern Washington State, environmental monitoring has been ongoing for almost 50 years to assess the potential effects of exposure to radionuclides, ionizing radiation, and hazardous chemicals on humans, air, surface and ground waters, foodstuffs, fish, wildlife, soil, and vegetation. Robert Gray presents an overview of this extensive monitoring program, noting that the Hanford site now serves as a refuge for certain fish and wildlife species.

Also addressing population monitoring issues, Michael Palmer reminds us that one of the main objectives in monitoring is to be able to distinguish 'signals', or directional trends, from 'noise', or random elements. Ecological data, including population numbers, are often exceptionally noisy; even when no net long-term trend exists, numbers can fluctuate dramatically and lead us to wrong conclusions. Palmer illustrates this point by showing, through simulation studies, that rare species tend to remain rare and common species tend to remain common. He warns that the use of current rarity, abundance, or homogeneity of a species as selection criteria for ecosystem monitoring can cause the appearance of a trend when in fact none exists, and he cautions against the use of certain ecological variables for monitoring.

Papers by Jim La Bau and Dave Turner *et al.* both speak to the topic of monitoring climate changes and their effects on vegetation. La Bau presents an overview of the National Forest Health Detection Monitoring (FHM) Program, which was started in the eastern U.S. partly in response to findings from the National Acid Precipitation Assessment Program and is now expanding to a national program. La Bau describes the selection of forest health change indicators and linkages between the FHM Program and the EPA's Environmental Monitoring and Assessment Program (EMAP).

Satellite-based remote sensing (with data calibration and validation provided by ground-based surveys) offers great potential for frequent assessment of forest cover over large areas. Dave Turner and his colleagues suggest that forest cover surveying by remote sensing is especially promising in cases where forest inventory data are limited or where, due to climatic or human factors, rates of vegetation change are rapid. Turner *et al.* emphasize the fact that monitoring is the backbone of any successful adaptive forest management program. Factors to be monitored include growth and yield of regeneration; growth and mortality of the leave trees; use of snags by wildlife; monitoring windthrow patterns; and rate of stand development. Without a monitoring system, no quantitative basis exists for assessing whether the management objectives are being achieved or whether changes in the management practices are necessary.

Ross Johnson sums up the conference by asking three basic questions: (1) Can we improve natural resource management through monitoring? (2) Will the policy makers listen to new information based on monitoring programs? (3) Will the policy makers use monitoring results in formulating specific policies? Ultimately, the answer to all three questions is a resounding YES, but we must anticipate some bumpy roads *en route*.

It is clear from the papers in this volume that the creation of a strong monitoring program relies heavily on the three C's – champions, commitment, and consistency. A champion is necessary to maintain program visibility to both the public and policy makers. Commitment is necessary for long-term funding and allocation of resources. Fostering a strong link between research and management is essential for establishing this commitment. And finally, consistency within a monitoring program is crucial to ensure that data collected in the past can be compared to the data collected today. The existence of any one of these elements without the other two is not enough. With all three elements together, however, it is possible to develop a synergistic program that garners great support, produces good data, and leads to sound natural resource management policies. Natural resource monitoring is an idea whose time has come, especially given the current political climate in which natural resource issues must be resolved.

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