The Role of Science in Wilderness Planning—A State-of-Knowledge Review

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Abstract—Wilderness planning has evolved since the Wilderness Act of 1964 in an atmosphere of intense debate and public scrutiny. Wilderness planning and the role science has played in developing the planning process has been influenced by many complex legal mandates, by thorny social issues, and by emerging planning paradigms. Wilderness planning has at times been inspired by scientific contributions to various elements of the emerging processes. However, seldom has it benefited from a sustained focus of scientific inquiry which would lead to progress through testing or improving the planning process or individual planning elements. Twelve ways that science could play an appropriate role in wilderness planning are described and strategies are suggested to help focus future scientific efforts.

Since the passage of the Wilderness Act of 1964 (U.S. Public Law 88-577) the United States has embraced the concept of identifying, protecting, and managing vast amounts of land in the National Wilderness Preservation System. Presently there are some 104 million acres protected in over 530 wilderness areas, or about 4.6% of the United States. Most of the political battles fought to protect and preserve these pristine landscapes have been lengthy and intensely debated, and the resulting legislation often includes compromises that pose problems for future management. It was early apparent that designation alone is not sufficient to protect and perpetuate the human and ecological values for which these areas have been designated. In fact, the Wilderness Act of 1964 defines wilderness as, "an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions…" (Section 2. (c)). An ongoing program of management is necessary to deal with the human influences from both outside and within and their accompanying undesirable impacts. Along with the recognition that management was necessary, even in wilderness, came realization of the need to develop plans that would direct management toward long-range goals. In fact, it can be argued that the drive for passage of the Wilderness Act was spurred by the very lack of management and long-term planning afforded the original wild, wilderness and primitive areas designated under the L-20 regulations and the U-regulations of the Forest Service (Hendee and others 1990). Thus, the need for wilderness planning has been an integral part of wilderness management since the inception of the National Wilderness Preservation System.

This paper examines the role of science in wilderness planning, concentrating on the 1980s and 1990s. It will show that wilderness planning and the role of science in wilderness planning have been influenced by many complex legal mandates, by thorny social issues, by emerging planning paradigms and by the coevolution of several planning processes. Finally, a clarification of what role science could and should play in wilderness planning is presented.

Legislative History Affecting Wilderness Planning

Early wilderness plans exhibit several common characteristics. They were typically developed as stand-alone plans for the land area defined by the legally established wilderness boundaries. Although they focused primarily on managing recreational users and their associated impacts, often they were compartmentalized, reflecting natural resource disciplines, and addressed such things as grazing, water quality, fire management, vegetation or fish and wildlife. A manager or a concerned citizen could quite simply look to one document, the wilderness plan, to find a description of the resources, impending issues, on-the-ground-problems and proposed solutions and management direction for a particular wilderness. This did not last for long. Spurred by new and complex legal mandates, changes within the managing agencies, a focus on carrying capacity and the emerging demand for public participation, wilderness planning became increasingly complex and contentious.

Several new legal mandates (and the resultant implementation of policy and regulations) called for the concept of carrying capacity to be implemented by the federal agencies that manage wilderness (National Park Service, US Forest Service, Bureau of Land Management, and the US Fish and Wildlife Service). Cole and Stankey (1997) explain that in 1979, regulations implementing the 1976 National Forest Management Act (NFMA) specified that each national forest wilderness would "provide for limiting and distributing visitor use of specific portions in accord with periodic estimates of the maximum levels of use that allow natural processes to operate freely and that do not impair the values for which wildernesses were created" (Federal Register 1979). Similarly, since 1978, the General Authorities Act (U.S. Public Law 95-625) has required the National Park Service to develop "visitor carrying capacities" for each unit of the park system. This act requires all park units to have a general management plan and calls for "identification of implementation commitments for visitor carrying capacities for all areas of the unit."

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At the same time, implementation of the National Environmental Policy Act of 1969 (NEPA, Public Law 91-190) prescribed a process to develop environmental impact statements (EIS) for all major federal actions, and this has applied to wilderness plans since the 1980s. NEPA requires that environmental impacts be considered through an analysis of a proposed action and its alternatives, and that the public be allowed to comment on the actions under consideration. Although the EIS process was logical in conception, the legal challenges that often followed have resulted in a rather lengthy process that invites intense scrutiny by citizens and special interest groups. In effect, this has forced many wilderness planning processes to become subordinate to the EIS process required by NEPA, often to the detriment of good planning.

Changes within the managing agencies also affected the structure and approach to developing wilderness plans. In implementing the NFMA, the Forest Service established a policy that there would be only one, single forest plan for each national forest. Thus, all wilderness planning would either be subsumed in the forest plan or be relegated to merely making an amendment to the forest plan. This often further disappointed the public which was already disenchanted by the controversial forest planning process. Complicating matters was the fact that each of the four federal agencies that manage wilderness had quite different regulations and requirements for developing plans.

Furthermore, increasing disenchantment with resource management and government in general in the 1970s prompted new demands that a wider spectrum of citizens be given access to the decision-making process. This sentiment was reflected in the legislation of the period, especially the National Environmental Policy Act (NEPA) of 1969, the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), the National Forest Management Act (NFMA) of 1976 and the Federal Land Policy Management Act (FLPMA) of 1976, which outlined increased roles for public participation (Fazio and Gilbert 1986). How the public was invited to participate in the planning process, to what extent and when varied widely among federal agencies and even among wilderness planning efforts within each agency. While government entities often touted the benefits of citizen participation, many agencies were negligent in their efforts to include the public in decision making, or worse yet, offered only token avenues for participation. This inability or unwillingness to listen or respond to public comment resulted in a lack of trust and a sense of tokenism between the citizenry and government entities (McCoy and others 1995).

In summary, the course of wilderness planning has been rather chaotic, spurred more by outside pressures in a dynamic and changing society than by a systematic development of an optimal process. Consequently, science has played only a limited role in wilderness planning. Wilderness planning has sometimes been inspired by science, but rarely has scientific research focused directly on the planning process. Nevertheless, it is instructive to examine the underlying themes addressed by science, some defining characteristics of the context in which wilderness planning takes place today and the dominant planning frameworks that have emerged. These will provide insights into the future role of science in wilderness planning.

Underlying Suppositions That Affected Wilderness Planning

Burgeoning Recreational Use

Several underlying suppositions have influenced the evolution of wilderness planning and the role played by science. The first assumption to emerge was that the great surge in outdoor recreational use following the end of World War II would continue to grow, causing increasing impacts and related management problems in national forest and park wildlands. This assumption was fueled by America's population growth, which was characterized by an increasingly mobile society with more leisure time and discretionary income, improved access and improved equipment and marketing. Managers feared that this surge in use and the accompanying ecological and social impacts would jeopardize the essential wilderness qualities of naturalness and solitude that wilderness designation was mandated to perpetuate.

Recreation Carrying Capacity

The assumption of continued growth in use led managers and researchers to embrace the carrying capacity concept, which was one of the dominant concepts in natural resource management. Borrowed from range management and wildlife management, carrying capacity was defined as the maximum level of use an area can sustain within constraints imposed by natural factors of environmental resistance such as food, shelter or water. Beyond this natural limit, no major increases in the dependent population can occur (Stankey and others 1990). Recreation carrying capacity was simplistically considered the amount of use an area could tolerate without causing unacceptable damage to its resource and social conditions. Although never supported by empirical research, recreation carrying capacity was interpreted by managers and politicians to mean that a concrete number of users which an area could support could be empirically determined—exceeding this number would cause unacceptable impacts. Managers first enthusiastically embraced setting recreation carrying capacities on Western whitewater rivers where dramatic increases in boating use were causing noticeable instances of congestion and resource damage. This concept was so appealing that, with the impetus of the legal mandates mentioned above, most wilderness plans either explicitly or implicitly have focused on establishing recreational carrying capacities over the past 30 years. Recreation carrying capacity also became the central focus of most of the research that addressed wilderness management and planning during this period. Stankey and others (1990) state that an analysis of references dealing with carrying capacity revealed that from 1970 to 1990, over 2,000 papers had been published. Perhaps the most striking characteristic of this body of research is that no commonly accepted procedures emerged for applying the carrying capacity concept in the field (Graefe and others 1984). Scientific research provided some important insights which would greatly influence the direction wilderness planning would take in the 1990s.

First, a substantial body of research focused on the social and psychological experience recreationists seek in wilderness, their perceptions of crowding and their judgments about the appropriateness of various management practices. It was concluded that different people seek different experiences in wilderness, and their judgement of quality varies with the experience being sought and the degree of environmental change deemed appropriate. In regards to carrying capacity, it was recognized that both the ecological capacity (defined by physical and biological dimensions) and the social capacity (defined by social psychological perceptions) had to be addressed. Recreational use could impact not only an area's physical-biological resources, such as vegetation and soils, but also the character of the recreational experience (Stankey and others 1990).

The second scientific insight was that the amount of use is only one of many variables that influence the quality of recreational experiences and ecological conditions. Many studies pointed out that the intensity of use is a poor indicator of total impact. Such things as the season of use, party size, length of stay, method of travel and behavior of the recreationists were often more important in explaining impact than the amount of use alone (Cole 1987; Hammitt and Cole 1987). Scientists initially concentrated on applying careful observation and research to determine the inherent value of the resource to sustain recreation use. Their failure to identify intrinsic limiting factors led to the realization that carrying capacity could only be determined through making value judgments that weighted resource and social impacts, along with human needs and values within the legal constraints of the Wilderness Act and enabling legislation.

Rational Comprehensive Planning Model

Another supposition was that natural resource management was predicated on the scientific precepts of rational, objective, unbiased observation and experimentation. Rationality, science and objectivity are regarded as the cornerstones of modern, scientific natural resource management. The role of science and research was elevated as an integral part of land use planning and decision making. Therefore, the wilderness management agencies adopted what they perceived to be rational and comprehensive planning models. These models relied heavily on the scientific approach to help identify issues, conduct inventory, analyze demands and needs, identify alternatives, evaluate alternatives, and subsequently monitor management practices. History shows that this approach did not lead to plans that were widely accepted, understood or trusted by the public. Rather, the public viewed planning as controlled by technocrats, engineers, economists and computer modelers, who produced plans the public neither understood nor trusted (Krumpe and McCool 1997). It may be an unfortunate historical footnote that the problem with these rational comprehensive plans is perhaps more attributable to the agencies' failure to help the public understand their inner workings than to some inherent flaw in the findings. Nevertheless, managers discovered that establishing recreation carrying capacity was not a technical problem, but rather a socio-political problem that involved making value judgments about what type and character of use were appropriate and how much impact to resource and social conditions would be tolerated. George Stankey (1997) sums this up:

> What became apparent early on was the need to recognize the significant, even predominant, political component of establishing limits on the use of public resources and the associated development of management strategies to implement those limits. Ultimately, the underlying questions of limitation, regulation, and management involved *choices*: about values (such as recreation use versus environmental protection), about the distribution of those values (such as, who gains versus who pays, such as between private and commercial users), and about the means through which the distribution of those benefits and costs were achieved (such as use limits, campsite closures).

Politicized Nature of Planning

A fourth realization was that wilderness planning takes place in a political marketplace, in which consensus and negotiation are every bit as important as scientific data and logic (Krumpe and Stokes 1993). Planners and managers began to recognize that dual conditions are required for effective planning. First, a technically sound planning process is required for explicitness and to facilitate the search for reasonable alternatives by systematically working through a logical sequence. This is a necessary, but not sufficient condition for effective planning. Managers now know that they also need a consensus among those affected by the plan about the proposed course of action. In the politicized settings in which wilderness planning takes place, the values in conflict are often well articulated, expressed and pursued by the various contending groups. The arena of conflict may shift over time, but it still encompasses the agency and its perceived mission. Indeed, one or several groups may in reality hold the power of implementation rather than the planning agency. This power, held in the political realm, is in practice "the power of veto" (Krumpe and McCool 1997).

Planners and wilderness managers often become frustrated when politics gets in the way of rational planning. They become frustrated when decisions are motivated more by political considerations than by purely biological or philosophical considerations of fairness, equity or other idealized values they hope would guide the management of publicly held natural resources. The public, on the other hand, experiences equal frustration at the significant effort going into planning that often results in no change, or in plans that do not address the needs of a particular interest. As a result, both managers and the public have become disillusioned that science does not, or often cannot, give them the facts they need to answer the thorny questions raised in wilderness planning. In fact, it has become a common delaying tactic in recent years for one group or another to simply question the legitimacy of (and thus dismiss) any science that runs counter to their values or expectations.

The value-laden nature of steps in the planning process has limited the role of science in wilderness planning in several ways. First, science has limited capacity to address disagreement over goals that are value-based. Almost always there is some disagreement over primary goals for individual wilderness areas—in other words, how wild should the wilderness be? The Wilderness Act of 1964 is a product of compromise hammered out over eight years of political wrangling; much of the act's language (such as "outstanding opportunities for primitive and unconfined experiences") is still subject to different and conflicting interpretations by a variety of interest groups when discussing management of individual wilderness areas. Planners must address the following types of questions: What unique values or distinctive features and characteristics of the wilderness area should be perpetuated? Does the area contain outstanding ecological, scientific, recreational, educational, historic or conservation values, highlighted in legislation, that warrant special attention? Does the area provide critical habitat for threatened or endangered species? Do land uses or contiguous areas represent situations requiring special management attention? Are there existing or potential nonconforming uses in the area that will require special attention? How does the wilderness ecosystem and recreation opportunities fit in the regional context of natural resource management? What are the legislative acts, related legal guidelines and organizational policy that constrain management direction? These questions are important when identifying long-term goals, or desired future conditions, which is an essential first step in the planning process. Although science can be of assistance, these questions go beyond a mere inventory of features and existing conditions.

Limitations of Science to Provide Answers

A final supposition that arguably caused more harm than good was that science could directly provide the answers to solve the wilderness planning dilemma. To the contrary, over the past decade, managers and planners have come to realize that fundamentally planning occurs in an environment of uncertainty rather than rules or certainty. Among scientists there is legitimate disagreement over cause-effect relationships in wilderness. For example, there is often widespread disagreement over whether stocking game fish, or even recreational harvesting of fish, has a detrimental effect on the naturalness of wilderness conditions (Duff 1995; Murray 1994). Similar disagreement exists over goals and over cause-and-effect relationships concerning the use of pack stock, technical climbing (for example, using rock bolts and fixed anchors), airplane and powerboat access and their effects on biophysical attributes and conditions, and the effect of campers on wildlife species. Similarly, little is known about the cause-effect relationship in the spread of many exotic plant and animal species. For instance, spotted knapweed was initially thought to be spread in wilderness by pack stock but this is now questionable, given its ubiquitous infestation throughout the West, even in parts of wilderness areas which are inaccessible. Planners soon learned that addressing questions that were value-laden and for which there was no clear answer demanded more public participation and social learning. In these cases, resolution of the problem is more a function of negotiation than data collection and analyses.

Finally, science has been less than successful in giving managers answers to questions about monitoring and evaluating the implementation of wilderness management plans. There is little "science" that documents what indicators work well to detect change in many physical and social characteristics of wilderness conditions. For example, there is scant research to tell us what indicator is best to use to monitor trampling impacts caused by recreation pack stock. Should we measure soil compaction? Increased or decreased soil surface roughness? Depth of hoof prints? Soil moisture? Area of trampling? Plant damage? Seedling damage? Shift in species composition? Changes in plant vigor? Likewise, indicators of social conditions are often ambiguous, at best. Specific questionnaire items from social science studies are commonly taken out of context and used as social indicators, to deal with such things as, "overall satisfaction," "perceived crowding," "encounter levels" and "solitude."

Emergence of Dominant Planning Frameworks

The preceding discussion has painted a rather negative picture of the role of science in wilderness planning. For two decades managers clung to the notion that scientific and technically astute investigation could provide the necessary answers to produce better wilderness plans. As they learned that there are important limitations to the application of science to wilderness planning problems they began to look for alternative approaches. What emerged, beginning in 1978, were five dominant wilderness planning frameworks. These are commonly referred to by their acronyms: ROS (recreation opportunity spectrum), LAC (limits of acceptable change), VIM (visitor impact management), VAMP (visitor activities management) and eventually in 1993, VERP (visitor experience and resource protection). For a comprehensive review and comparison, the reader is referred to Nilsen and Tayler (1997).

The seminal framework was the ROS, which reflected advances in recreation research that posited that people seek to engage in recreation activities in preferred physical, social and managerial settings to realize desired psychological experiences and benefits (Clark and Stankey 1979; Driver and Brown 1978). It proposed that landscapes could be inventoried and classified into distinct categories, each capable of providing a different type of recreation opportunity. These ranged from the most primitive to the most developed or urban outdoor recreation opportunities and were initially labeled primitive, semi-primitive non-motorized, semi-primitive motorized, roaded natural, rural and urban. The contribution to wilderness planning was the concept that the wilderness (or primitive) experience was based on maintaining suitable biophysical settings of naturalness (that is, essentially unmodified natural environments of large size and remoteness), social setting conditions of solitude (very low concentration of users, absence of evidence of other users) and a managerial setting that provides freedom from intrusive regulation. The ROS explicitly recognized that recreation experiences are related to the settings in which they occur and that settings are a function of environmental, social and managerial factors which mangers should address in the wilderness planning process (Manning 1986).

The limits of acceptable change (LAC) planning process was developed specifically to address wilderness recreation planning (Stankey and others 1985) and as an alternative model for making decisions about carrying capacity, by making explicit the value judgments about appropriate types and levels of use and their management. It explicitly recognized that all recreational use of wilderness causes some impacts, but a limit should be placed on the amount of change to be tolerated (Stankey 1997). At the core of the nine-step process were the selection of indicators of change, the development of standards, the assessment of current conditions through inventory and monitoring and the formulation and implementation of management prescriptions to bring conditions into compliance with standards. The LAC process recognized the predominant political component of establishing limits on the use of public resources.

From its first application in the Bob Marshal Wilderness, the transactive planning model was adopted as the framework that would guide public involvement, collaboration and consensus building. This model, based on the work of John Friedmann (1973a; 1973b), argued that dialogue among stakeholders was a necessary component of planning and that the scientific experts and public stakeholders should interact on equal footing to produce the plan (Stokes 1990). LAC is a specific planning process, separate from the transactive or collaborative processes utilized in many of its applications. By 1992, the LAC process had become the most widely applied wilderness planning process in America, reportedly used by 92% of fifty western national forests that contain 116 wilderness areas (McCoy and others 1995). A full discussion of the development, application and evolution of the LAC process can be found in two proceedings published in 1986 and 1997 (Lucas 1986; McCool and Cole 1997).

Two somewhat similar planning processes were developed in conjunction with the National Park Service, VIM (visitor impact management) in 1990 and VERP (visitor experience and resource protection) in 1993 (Graefe and others 1990; Hof and Lime 1997). Both were developed to address the mandate to determine carrying capacity in national parks in both front country (accessible by road and offering visitor amenities) and backcountry (accessible by trail and offering only primitive camping) comparable to wilderness. VIM addresses three basic issues relating to impact: problem conditions, potential causal factors and potential management strategies. VERP is a new framework that deals with carrying capacity in terms of the quality of the resources and the quality of the visitor experience. It produces a prescription for desired future resource and social conditions, defining what levels of use are appropriate, where, when and why (Nilsen and Tayler 1997).

Created by Parks Canada, the Management Process for Visitor Activities (VAMP) was developed in 1985 and incorporates the principles of ROS to assess visitor opportunities, analyzing both opportunities and impacts. Its emphasis is on identifying heritage themes, resource capability and suitability, appropriate visitor activities and alternative visitor activity concepts for these settings.

Common Strengths and Weaknesses of the Planning Frameworks

VERP, VIM, VAMP and LAC are conceptually more similar than different, in that they all propose to address questions of carrying capacity, appropriate visitor use and biophysical and social impacts caused by recreation use. While each framework calls for its own steps and procedures, they all address both environmental and social (experiential) conditions and call for development of future management direction, such as goals, objectives or desired future conditions (Hof and Lime 1997). All recognize that a combination of biological, social and managerial conditions defines what kind of recreation experience a place can offer. All involve a hierarchy of decisions: inventory, strategic zoning, implementation and monitoring strategies. All focus on management of human-induced change and call for utilization of natural science and social science data. All include provisions for public involvement to greater or lesser degrees. All identify factors, indicators and standards which are measurable attributes of resource and social conditions (implicitly borrowed from management-by-objectives planning), and all call for ongoing monitoring and evaluation.

These planning frameworks have made many advances in attempting to address recreation carrying capacity in a more holistic fashion, by maintaining desired future conditions rather than just limiting numbers of visitors. Nevertheless, some common shortcomings of wilderness planning have been fairly pervasive and should be pointed out. These will serve as a springboard for discussion of what the role for science should be in the future and what some of the next steps should be. The following are nine weaknesses exhibited by many wilderness plans over the years.

- A primary, almost exclusive focus on recreation. Recreation use is obviously an introduced variable in the wilderness setting that is known to produce undesirable impacts. However, many other things that can detract from pristine natural qualities are often overlooked. Outside vectors, such as anthropogenic air pollution, mechanical noise pollution, loss of flora and fauna species, loss of primary predators, accumulation of fuels and change in species composition from fire suppression, changes in water quality and flow regimes from rivers and streams that flow into wilderness and impacts from only partial protection of habitats, are examples of many impacts that could potentially cause greater long-term change in pristine natural conditions than most recreation impacts.
- Failure to address biophysical components of the ecosystem in any but a most cursory manner.
- The quest for over 20 years to empirically determine a concrete carrying capacity, in terms of the appropriate number of visitors.
- Failure to articulate specific desired future conditions or long-term goals in any but the most general of terms.
- Being issue-driven rather than goal-driven. Although plans must address issues that are important to the public, focusing on issues tends to be negative and pits user groups against one another. This misdirects too much attention to the most current or inflammatory issue rather than the issues that may have the most impact on the health of the wilderness ecosystem .
- Inadequate inventory data of all kinds. Both managers and the public become frustrated when they discover how little data have been collected prior to starting the plan, how limited in scope it is, how unreliable it often is, and how expensive and time consuming it will be to collect additional data to address pressing management questions.
- The lack of support and involvement from higher levels of management in the planning process.

- Failure to follow through and systematically complete things that were articulated in the plan.
- Last-minute changes by upper level administrators who were not involved in the planning process or knowledgeable about the compromises and tradeoffs that were considered and agreed upon.

What Is the Role for Science? _____

The preceding discussion has enumerated the many problems and shortcomings of wilderness planning. A central argument is that although science has perhaps inspired various elements of wilderness planning, it has seldom specifically focused on testing or improving the process or the individual elements before adopting a new approach. This does not need to be the case in the future. The following presentation discusses how science could contribute to better wilderness planning by addressing specific elements and process variables.

Inventory and Description

Managers often have only limited inventory data, often of questionable quality or reliability. The best science and newest techniques and protocols should be used to conduct better inventories, surveys and samples in wilderness. For instance, collecting DNA from animal hair or droppings can reveal not only which species are present, but can also identify individual animals within the species. This is much less invasive than the typical radiotelemetry techniques, which require capture, handling, collaring and recapture of the animals.

Problem Detection

Science should play a key role in identifying the presence and direction of change in wilderness conditions. Arguably, scientists are better equipped than the public to detect subtle changes in biophysical and social conditions to assess the rate of change and even determine probable consequences to other elements of the wilderness resource. This could greatly supplement the common practice of placing too much reliance on the issues generated by public input.

Research on Cause and Effect

Scientists have done a lot to identify impacts, categorize them and measure them after they have taken place (Cole and Landres 1996). However, very little research has been done to discover how the impacts actually occur. For instance, we commonly measure damaged trees associated with campsites. But we do not know what behaviors or conditions augment or suppress this damage, at what rate it occurs, by which types of users, by how many users or in what season it primarily occurs. The same could be said for cutting trail switchbacks, defacing cultural artifacts, trampling stream banks and even littering.

Understanding the Limitations of Data

Members of the public, managers and planners often do not know how to interpret scientific data and reports. In particular, they often are not knowledgeable about the adequacy of sampling and the limitations of various research methods, and they do not understand how to interpret margins of error, confidence limits or levels of statistical significance. Scientists could do wilderness planning a great benefit by teaching people more about how to interpret data and how to understand the limitations of the data.

Development of Monitoring Protocols

Monitoring data are only as good as the methods used to collect them. Scientists could contribute in two ways. First, they need to explain the methods, sampling schemes and collection protocols that were followed to collect any data that they provide to planners or managers. Second, they need to conduct research specifically aimed at testing and improving protocols for monitoring biophysical and social conditions in wilderness. Furthermore, whenever possible, scientists should develop and test the most simple and straightforward means of data collection possible because experience has shown that when sophisticated equipment and complicated analyses are required, the probability is high that the method will not be maintained in the field by management personnel.

Development of Long-Term Databases

Managers seldom have the ability to collect and maintain databases over the long term. Turnover in personnel, shifts in funding and staffing levels, availability of trained personnel, lack of understanding of how to manipulate, query or analyze the database and lack of understanding of the need for rigor in following data collection protocols are some of the reasons why managers are ill-suited to maintain long-term databases. Rich rewards could accrue from developing long-term databases in the world's most pristine natural environments—the wildernesses of America.

Search for Key Ecosystem Indicators

Scientists need to continue to search for sensitive species or ecosystem characteristics that should be monitored to detect changes in natural conditions. Specifically, indicators that are sensitive to human use, change early in response to initial impacts or foretell more serious damage should be identified and tested.

Search for Robust Social Indicators

Similarly, social scientists need to focus on identifying human factors that are sensitive to the loss or deterioration of the wilderness experience or loss of wilderness conditions. For example, to what extent is visitor displacement a problem in park and wilderness settings, and what social or physical impacts are responsible for displacement? Refining measurement instruments and collection techniques for social indicators would also be beneficial to wilderness planners.

Assist in Monitoring the Effectiveness of Various Management Practices

A major outcome of the wilderness planning frameworks is the prescription of management strategies to maintain desired wilderness conditions. All too often, management practices are implemented with little knowledge about how effective the practices are. Likewise, managers seldom determine whether or how conditions are actually improving once the practices are implemented. Applying the scientific method would greatly assist in measuring the effectiveness of various management practices.

The preceding recommendations have focused primarily on the role science should play in wilderness planning by contributing to better monitoring practices. Science should also contribute to better wilderness planning by studying various aspects of the planning process itself. Three recommendations follow.

Evaluation of the Effectiveness of Different Planning Processes

A huge body of knowledge exists about evaluation research and, more particularly, social program evaluation. These research methods can be applied to park and wilderness management processes—for example, see Ham (1986) or Ashor and others (1986). Planners and managers are constantly seeking and trying new ways to conduct various parts of the planning process. These trials should be viewed as field experiments, and scientific methods should be utilized to evaluate their effectiveness.

Case Study Research on Different Wilderness Planning Applications

Research on actual planning processes is difficult because scientists cannot control the manipulation of variables during the process. Alternate qualitative research methods and case study research approaches should be applied to understand such things as the rich interplay of participants, the effectiveness of various public involvement techniques, how tradeoffs are evaluated and how compromises and consensus decisions are made.

Move From Anecdotal Descriptions to Comparative Analyses and Hypotheses Testing

Much of the literature about wilderness planning has appeared in conference proceedings and consists primarily of anecdotal descriptions and discussions. This has been of limited help to other planners. Although it is difficult to do, scientists could contribute much to wilderness planning by conducting more comparative analyses of plans that used the same (or different) planning processes. A clearer understanding should be sought of what conditions and circumstances contribute to successful (and unsuccessful) planning programs. This could lead to field experimentation applying different techniques and testing hypotheses. The result would be a better understanding of the various strengths and shortcomings of planning processes.

Next Steps for Science in Wilderness Planning

The past three decades have witnessed an amazing growth in wilderness designations in the United States and a corresponding increase in the time and effort devoted to producing wilderness plans. Buffeted by societal changes, demands for citizen participation and complex new legal mandates for natural resource management, wilderness planning has at times been inspired by science. But seldom has it benefited from a sustained focus of scientific inquiry. If science in general is going to continue to make positive contributions to wilderness planning, several strategies are necessary.

First, there should be greater collaboration across disciplines. Wilderness areas span complex ecosystems, with diverse and highly concerned constituencies. It is counterintuitive to assume that one or more scientists trained in a single discipline could make as large a contribution as a team of scientists who work together to collaborate across different disciplines. For example, scientists investigating the impacts of deteriorating air quality would likely reach greater insights if they examined the interrelated impacts on visitors, soil, water, fish reproduction, macroinvertebrates, lichens and moss, insects and wildlife. Likewise, closer collaboration between scientists and managers would be mutually beneficial. Managers have an intimate understanding of many things that would be beneficial to scientists in the field, such as trail conditions, stream levels, remote sites, game trails, historic conditions and so forth. Scientists who have spent days and weeks in the backcountry often gain insights that escape managers, who must focus their attention on travel corridor upkeep, campsite restoration and other daily management problems.

Another beneficial strategy would be to implement carefully planned research demonstration projects and pilot management projects with heavy scientific involvement. This idea is not new. Concepts underlying the ROS and LAC process were demonstrated in the Maroon-Bell Snowmass Wilderness in Colorado in the early 1980s (Stokes 1991). Demonstration projects that featured collaboration across scientific disciplines could test new ideas and promote deeper understanding.

Another old idea whose time has come is the development of large, shared databases that include input from scientists, from both social and natural science disciplines, from parks and wilderness areas and from all four federal management agencies. This has already begun through the Aldo Leopold Wilderness Research Institute. However, with the advent of improved Internet access (and soon the super high-speed Internet2) the entire database could be made instantly accessible to any scientist or manager. What needs to be developed is thoroughly user-friendly, front-end software to facilitate interactive live searches and exploration of the data over the Internet.

Finally, we need to work together to ensure the seamless integration of science, planning and management with an informed and involved public. Scientists should assume a pivotal role because they have the unique opportunity of playing the dual role of investigator and educator, collecting and interpreting data that is relevant and useful to planners, managers and citizens alike. As we move into the new millennium, scientists will have the unique opportunity and ability to help educate professionals and laymen to use, appreciate and apply scientific information to enhance future wilderness planning processes.

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