Monitoring and Management of Recreation in Protected Areas: the Contributions and Limitations of Science

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Abstract: Scientists assist protected area managers by developing information and knowledge that can be used to better monitor and manage recreation use and its impacts. Most recreation management decisions have both a descriptive and an evaluative component. There is widespread consensus that science is well suited to discovering, synthesizing and applying descriptive information. This paper provides an overview of some of the most significant contributions of science to visitor monitoring and management. It covers the related scientific purposes of explanation, causation, prediction and assessment. As scientific enquiry moves from description to evaluation, from facts to values, from providing statements of "what is" to providing statements of "what ought to be", it ventures into more contested territory. While some advocate a substantial role for science in the establishment of normative standards about what ought to be, others believe science should be very cautious in this arena. Recreation examples, largely drawn from wilderness management in the United States, are provided.

Introduction

For close to a century, park and protected area administrators have struggled to monitor and appropriately manage recreation use. One challenge to effective management has been a chronic lack of staff, funding and resources. Politicians either do not understand that designation of a protected area does not result, in and of itself, in protection or they do not care enough to allocate sufficient resources to ensure that protection occurs. In my agency for example, the United States' Forest Service, less than 1% of the agency's funds are spent on wilderness management, despite the fact that 18% of Forest Service lands have been designated as wilderness. Less than 0.5% of Forest Service research funds are spent on wilderness management science.

A second barrier to effective monitoring and management is insufficient information and knowledge. Scientists have joined with protected area managers to confront this barrier. Depending on one's point of view, progress in this arena can be considered substantial or disappointing. Much has been learned over the decades but some of the most fundamental issues seem even more intractable than they did 30 or 40 years ago. It is my contention that much of the disappointment with progress derives from unrealistic expectations regarding the abilities of science. In this paper I review some of the most substantial contributions of science to improved monitoring and management of recreation use. I also comment on the limitations of science and the dangers of privileging scientific knowledge and the worldview of scientists to the detriment of other valid sources of knowledge and other legitimate stakeholders. I will attempt to draw equally from work in the social and the biophysical sciences. Many of my specific examples involve research related to visitor management in wilderness areas in the United States because that is the situation I am most familiar with. However, conclusions should be generally applicable across a broad array of recreation and protected areas.

Science and Recreation Management

Much has been written about science and the often contentious debate about the appropriate role for science in land and natural resource management. Ultimately science is a process for building understanding (Dietz and Stern 1998), particularly from knowledge gained through empiricism, rationality and logic, quantification, reductionism and specialization (Hall 2004). There is widespread consensus that science is a powerful tool for description.

Descriptive Science

The scientific method is an effective means of describing phenomena such that their most salient qualities are better understood. Scientists can also develop knowledge about phenomena that occur at spatial and/or temporal scales outside human sensory and perceptual capabilities (Hall 2004). Such descriptive information is critical to recreation managers, serving purposes ranging from identifying threats, adverse impacts and benefits, situations that might be considered problems and the most critical variables that should be monitored.

For example, substantial research has been conducted on the biophysical impacts of trampling. Initial descriptive research documented readily observable impacts – loss of vegetation cover, removal of soil organic horizons and compaction of mineral soil (e.g. Bayfield 1973, Liddle 1975) (Figure 1). Subsequent research has improved our understanding of less readily observable impacts, such as reductions in the functional diversity of microbial populations (Zabinski and Gannon 1997). Recently, critical interactions between vegetation and soil have been explored. For example, Alessa and Earnhart (2000) report that plants in compacted soils may be less able to utilize available nutrients because they grow fewer lateral roots and root hairs and because cytoplasmic streaming within root hairs is reduced.

As Figure 1 suggests, models of trampling effects contain many reinforcing (positive) feedback mechanisms. The insights that can be derived from this fundamental descriptive understanding of how this system operates are critically important to effective management. Due to the reinforcing feedback loops, recreation impacts can be long-lasting even where recreational disturbance has been eliminated. Consequently, restoration of disturbed recreation sites often requires implementing interventions that are capable of severing critical positive feedback loops.

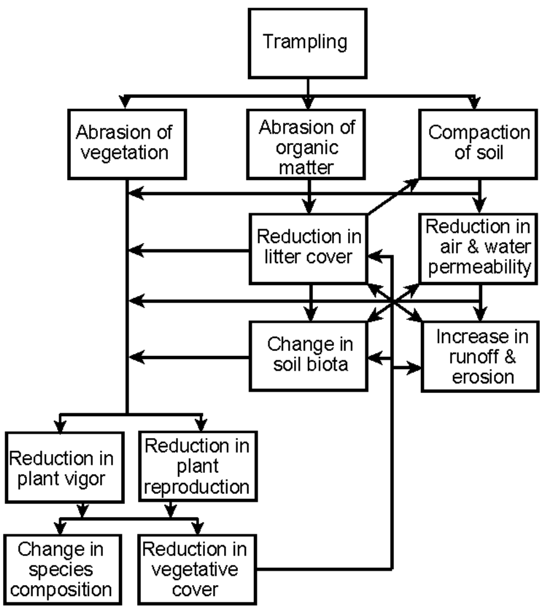

Figure 1. A conceptual model of the primary biophysical impacts caused by trampling (adapted from Liddle 1975).

Similarly, substantial fundamental descriptive information about recreation visitors has been developed. Initial research was focused on developing methods for counting recreationists and observing their activities and behaviours. Subsequent research delved into understanding phenomena that are less observable, such as visitors' motivations, attitudes, preferences and evaluations, as well as the linkages between these phenomena (Manning 1999). Special attention has been devoted to understanding the effect of amount of use on the quality of visitors' experiences. This system can be modelled in detail (Figure 2), providing managers with considerable insight. As use levels increase, perceived crowding increases and visitor experiences are adversely affected; however, the magnitude of adverse effect is often surprisingly small (Stewart and Cole 2001). Put simply, experiencing substantial crowding seldom makes a good trip bad.

Recently, visitor research has begun to move beyond relying solely on evaluations of what visitors experience (or of experience quality or satisfaction) as the metric of management success. Greater emphasis is being placed on understanding the effects of setting attributes, particularly those managers can control, on what visitors actually experience (e.g. Borrie and Roggenbuck 2001). A greater reliance on qualitative methods (e.g. Arnould and Price 1993) is one characteristic of this research thrust.

Relationships, Explanation and Causation

The model in Figure 2 describes functional relationships between different variables. Perceived crowding is a function of contacts and a number of variables that affect the influence of a given number of contacts on perceptions of crowding. Number of contacts, in turn, are a function of amount of use and

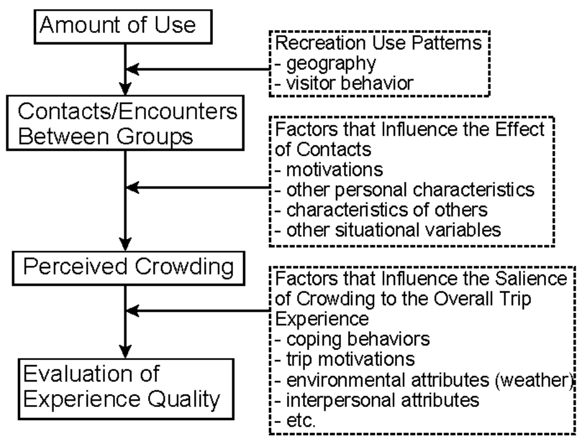

Figure 2. A conceptual model of the effects of amount of use on crowding and visitors' evaluations of experience quality (adapted in part from Manning 1999).

variables that influence the relationship between amount of use and number of contacts. Description of the functional relationships between attributes that managers can control and the outcomes that managers seek is among the most important contributions of science.

To manage visitor use such that biophysical impacts are minimized, managers must attempt to minimize both the area of impact and the intensity of impact per unit area. The primary factors that influence intensity of impact (Figure 3) are (1) frequency of use, (2) type and behaviour of use, (3) season of use, and (4) environmental conditions. The area of impact is primarily a result of the spatial distribution of use.

Given the interest in estimating an area's carrying capacity, considerable attention has been focused on the relationship between frequency or amount of use and the intensity of resultant impacts. Numerous studies, using varied methodologies, conducted in varied ecosystems and on varied types of recreation sites, and measuring different response variables, have all come to the same general conclusion. Across the most relevant range of use frequencies, this relationship is curvilinear and asymptotic (Figure 4). Relatively infrequent and small amounts of use can cause substantial impacts. At low use frequencies, small differences in use frequency can result in substantial differences in amount of impact. At high use frequencies, even large differences in use frequency typically result in minor differences in impact (Hammitt and Cole 1998). At extremely low use frequencies there may be another inflection point in the curve, suggesting that the relationship is best approximated with a logistic function (Cole and Monz 2004a). But it is generally not practical to manage for such low frequencies of use.

Cole and Monz (2004b) found, for a forest with low shrub groundcover, that vegetation cover was almost entirely eliminated by just 4 nights per year of camping on previously undisturbed sites. Use frequency could be increased many fold with relatively little further increase in impact. The same situation pertains to hiking impacts. In this same forest, 75 hikers per year eliminated all but about 20% of the vegetation, while 500 hikers per year eliminated virtually all the vegetation (Cole and Monz 2002). The importance of environmental conditions as a significant determinant of impact intensity is also apparent in these studies. In an alpine turf ecosystem, dominated by grasses and just 2 km from the forest, 1000 hikers per year caused about one-third of the vegetation impact caused by 75 hikers in the forest (Cole and Monz 2002). In this more resistant vegetation type, the relationship between frequency of use and intensity of impact is still asymptotic, as it is in the forest. However, the effect of a given use frequency is less profound.

Similar research illustrates how variation in type of recreation use and visitor behaviour influences intensity of impact. For example, the impacts of horses on trails have been found to be much more substantial than the impacts of similar use frequencies by hikers, llamas or bicycles (Wilson and Seney 1994, DeLuca et al. 1998). The relationship between visitor behaviour and impact intensity is more anecdotally documented. Many impacts of concern are entirely the result of either vandalistic or unnecessarily destructive behaviours. The relationship between time of use and impact is particularly apparent for impacts on wildlife populations. There are numerous reports of impacts on wildlife being particularly severe at certain times, such as during nesting, birthing or feeding times (Knight and Gutzwiller 1995).

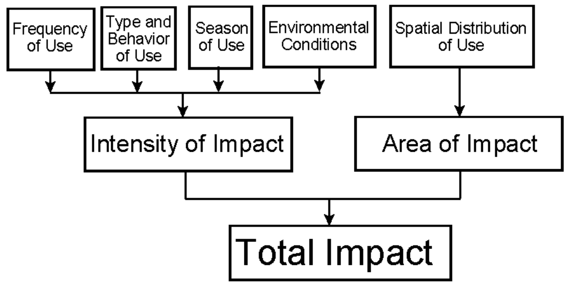

Figure 3. A conceptual model of the primary factors that influence the magnitude of biophysical impact from recreation use.

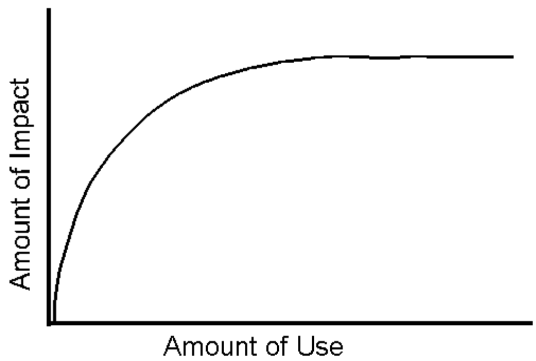

Figure 4. The relationship between frequency of use and intensity of impact is asymptotic.

The models in Figures 2 and 3, and associated research describing relationships between variables that managers can control (e.g. amount of use) and the outcomes that managers desire (appropriate or quality experiences, acceptable levels of impact), are critically important to recreation management. They illustrate the complexity of the management situation. For example, the numerous intervening factors between amount/frequency of use and desired outcome, in Figures 2 and 3, illustrate why the simple notion of establishing a carrying capacity (use limit) is both difficult and, by itself, of limited utility.

More fundamentally, this knowledge is at the core of selecting the management strategies and actions that are most likely to be effective. The model complexity also suggests that a successful management program will likely have to manipulate many variables – amount, type, season and location of use, as well as the expectations, behaviours, knowledge and attitudes of visitors. Knowledge about the nature of the relationship between frequency of use and intensity of impact has caused management to emphasize concentration of use more than dispersal of use (e.g. Marion and Farrell 2002). It provides the foundation for recommendations about appropriate low-impact recreational practices. Two of the fundamental principles of low-impact behaviour are to concentrate use and impact in popular places and to spread out and disperse use in infrequently used places (Hampton and Cole 2003).

Science is often capable of moving beyond simply describing relationships between variables to providing explanations for observed phenomena or to establishing cause-and effect relationships. Figures 2 and 3 are attempts to explain why evaluations of trip quality and levels of biophysical impact vary. They also imply causality; they utilize unidirectional arrows. The intent is to suggest that if managers manipulate the causal variables, the effects should change in predictable and desirable ways.

In many cases, however, our understanding of these relationships comes largely from correlational studies. Correlational studies are often a good first step at identifying probable causal relationships. Ideally they generate hypotheses regarding causality and then these hypotheses can be experimentally tested under controlled situations. For example, the initial insights regarding the use-impact relationship on campsites came from correlational studies. Impact levels on low-, moderate, and high-use sites were compared (e.g. Frissell and Duncan 1965). However, it is possible that observed differences in impact were the result of uncontrolled variables – how long these sites had been used or environmental differences – rather than the variable presumed to be causal. Multiple correlational studies, conducted under varying circumstances but arriving at the same conclusion, decreased the likelihood that reported relationships were spurious rather than causal. However, this possibility was most conclusively eliminated when differing levels of use were applied to experimental campsites (Cole and Monz 2004a,b).

Reliance on correlational studies and resultant uncertainty about causality is particularly problematic in recreational visitor research. The prevalence of experimentation in the parent discipline of psychology suggests that this limitation could be overcome. However, many important relationships are fundamentally difficult to study experimentally.

Even the ability to explain relationships can be problematic with some of the research designs that are most common in recreation visitor research. For example, numerous studies have used cross-sectional designs to understand the relationships between amount of use, crowding and assessments of trip quality (often operationalized as trip satisfaction). Metrics for these three variables are compared among different individuals in a population of visitors. Typically, reported relationships are weak; correlations are very low (Manning 1999). It is well established, however, that differences between individuals (in experience, motivations and the salience of crowding) have a huge influence on relationships between these variables. In these cross-sectional designs, this between-subjects variance is noise that obscures any relationship that might exist between the variables of interest. Stewart and Cole (2001) used a within-subjects research design to examine these relationships. Multiple assessments of each visitor made it possible to examine relationships within rather than between visitors. From this analysis a highly consistent and predictable relationship emerged. Encounters and crowding consistently caused small decreases in visitor evaluations of trip quality.

Progress in increasing explanatory insights can also be increased by designing tests capable of differentiating among competing explanations for observed phenomena or relationships. Hall (2004) provides an example regarding interest in the relationship between crowding and satisfaction and the unexpected finding that visitors in crowded wilderness are often satisfied with their experience. One explanation for this finding is that visitors who expect and desire an uncrowded experience have been displaced elsewhere, leaving only those who are likely to be satisfied even if conditions are crowded. An equally plausible explanation is that experiencing crowded conditions is simply not that bad, given all the other benefits and positive experiences that accrue during the visit. Research designed *a priori* to compare these alternative explanations could be much more successful than the more common approach – attempting in the analysis phase to tease apart a multitude of largely uncontrolled variables.

Prediction

The ability of good science to predict the likely consequences of alternative scenarios is another way that science can contribute to management. Much of the motivation for conducting trampling experiments (e.g. Cole and Monz 2002, 2004a,b) was to predict the levels of off-trail trampling and informal camping which different plant communities could sustain before they were substantially impacted. In places where predicted use exceeds these thresholds, managers should consider constructing trails rather than permitting off-trail travel and confining camping to established campsites rather than allowing visitors to camp wherever they want.

Similarly, managers would like to be able to predict how the actions they take and do not take will affect the number, type, distribution, behaviours and experiences of visitors. Unfortunately, the precision of predictions is limited by the multitude of variables that must be accounted for, substantial interaction among variables and how difficult it is to operationalize many of these variables. Heavy reliance on visitor self-reports is particularly problematic, since there is substantial evidence that such reports have low reliability (Cole and Daniels 2004).

For example, there has been considerable interest in identifying attributes that have a profound influence on the quality of experiences. Such attributes are strong candidates as indicator variables that could be monitored to ensure that quality experiences are protected. The most common approach to identifying such variables, however, is to simply ask visitors how much they think an attribute would influence their experience. In one such study, conducted in four wilderness areas in the United States, the second most influential attribute on peoples' experience (out of 19) was the number of trees around a campsite damaged by people (Roggenbuck et al. 1993). The difficulty comes in reconciling this finding with the findings of other studies that few visitors notice even substantial tree damage at campsites (Knudsen and Curry 1981) and that extent of tree damage has little relationship to either visitor evaluations of site conditions (Farrell et al. 2001) or their campsite choices (White et al. 2001). Do we believe what people say or what they do? Should we conclude that tree damage has a substantial effect on experience quality because people tell us, hypothetically, that it would? Or should we conclude that their behaviour indicates that tree damage has little influence on experience quality? Perhaps it is the "idea" of tree damage that is bothersome, not the reality of it? Should managers give higher priority to things visitors dislike in concept (like tree damage perhaps) or things visitors clearly respond adversely to behaviourally? Or more to the point of this portion of the paper, how should we predict that visitors would behave in response to management programs that result in higher or lower levels of tree damage? It is hard to know with much certainty.

Certain types of information about visitors is much more amenable to prediction, however. For example, Ploner and Brandenburg (2004) show how linear regression models and regression trees can be used to predict visitation from information on day of the week and the weather. Computer simulation models of visitor use and flow provide more powerful and flexible tools that increase the predictive capacity of visitor management (e.g. Itami et al. 2004). The predictive ability of simulation models helps managers monitor and manage more efficiently and effectively. They are capable of predicting what is going on in specific places and at specific times in the interior of a large park, using simple counts of visitors entering the area. Many protected areas attempt to monitor and control the number of encounters that occur between different groups of visitors. Although hard to monitor directly, predicted encounter levels are one of the standard outputs of simulation models.

Models can also predict the maximum use levels that can be sustained without violating an established standard. For example, at Delicate Arch, a visitor attraction in Arches National Park, Utah, a standard has been established limiting persons-at-one-time to 30. This standard is to be exceeded no more than 10 percent of the time. Lawson et al. (2002) used a simulation model to predict the maximum number of people who could hike to Delicate Arch per day without exceeding the standard (315 hikers between 5:00 a.m. and 4:00 p.m. They were also able to extend their model to predict that the standard for Delicate Arch was likely to be violated if more than 750 vehicles per day entered Arches National Park. Clearly, monitoring the number of cars entering the park (information that is already collected) is much more efficient than monitoring people at one time at Delicate Arch (entailing a hike of several km). Moreover, the model makes it possible to estimate the maximum use level that can be accommodated without having to go through a period of trial and error. Some monitoring will be necessary to calibrate and validate model predictions.

Paradise Meadows in Mount Rainier National Park, Washington, are fragile subalpine meadows that are among the primary frontcountry attractions for day hikers at the park. They are accessed by a complex web of paved and gravel trails. Visitors are required to remain on trails to avoid vegetation damage. In developing a public transportation system for the park, planners must make decisions about how frequently buses of varied capacity should arrive at the meadows with hikers. One approach to decision-making that is being considered is to link predictive biological models and visitor flow models. Experimental trampling research (conducted in vegetation similar to much of Paradise Meadows) indicates that just 25 people per year would disturb vegetation sufficiently to create noticeable bare ground (Cole and Bayfield 1993). Trampling resulting from high use levels primarily occurs at bottlenecks in the meadow trail system, such as stairways on steep trail sections. Research in walkway design suggests that people will be jostled off the trail when the density at such places is so high that there is less than about 40 ft^2 of walkway per hiker. A travel simulation model for the network of trails at Paradise Meadows is currently being developed. It will be able to predict use levels at the varied entry points to the trail system that should not be exceeded to ensure that the density standard is not violated. The public transportation system can then be designed to deliver a number of visitors that will not exceed these maximum use levels.

Monitoring and Assessment

As noted before, fundamental descriptive studies of visitors and their impacts provide the foundation for decisions about the most important variables to monitor. In addition, the methods developed by scientists conducting these descriptive studies provide reliable protocols for much recreation monitoring. Using their analytical and research design skills, scientists can adapt these protocols to maximize efficiency. For example, varied techniques are available for collecting different types of information on visitors and their recreational visits (Watson et al. 2000). New innovations are constantly being developed that improve and complement existing technologies (Cessford and Muhar 2004). Work on sampling designs is increasing efficiencies as well as contributing to better interpretation of results, particularly in regards to characterizing precision at various spatial scales (English et al. 2004).

For biophysical impacts, efficient and effective protocols have been developed for campsites and trails, where concern is primarily with impacts to vegetation, soil or the recreational facility itself (Cole 1989, Marion and Leung 2001). The ability to monitor impacts on mobile phenomena such as wildlife is much more problematic because it is seldom possible to isolate the effects of recreation use.

The systematic nature of scientific enquiry also makes it a powerful tool for assessing the effectiveness of established management programs. Once desired outcomes are clearly stated, good science can efficiently and effectively describe the extent to which these outcomes have been achieved.

Science and Normative Evaluation

Land management decisions, including decisions about appropriate visitor management and carrying capacity, have both a descriptive and an evaluative component (Shelby and Heberlein 1986, Manning 2002). Value-based decisions (the evaluative component) must be made about the public interest and appropriate normative standards. These standards establish management objectives and are the means for judging the success of a protected area's management program. Some recreation researchers have argued that science has much to contribute to discovering appropriate normative standards for visitor experiences and levels of resource impact – that normative data "are exactly the type of information that managers need to develop evaluative standards" (Shelby et al. 1996, p. 116).

Others disagree--arguing that description, not evaluation, is the proper domain for science (Hall 2004) – that the process of developing standards should rely on sources of knowledge beyond the limited but powerful domain of scientific knowledge (Williams and Matheny 1995, McCool and Stankey 2004). As scientific enquiry moves from description to evaluation, from facts to values, from statements of what is to statements of what ought to be, it ventures into arenas where many believe it should not go or at least should be careful about going. Freyfogle and Newton (2002, p. 864), for example, state that the fundamental "aim of science is to describe nature and how it functions, rather than to pass normative judgment upon it". They also note the substantial confusion that is created when single terms are used "in two ways – as both the descriptive *is* (or *will be)* and the normative *ought.*" (p. 870). Similarly, More (2002) reminds us that, since the 18th century when David Hume first drew the distinction between facts and values, it has been a general established point of logic that "you cannot derive "ought" statements (values) from "is" statements (facts)." (p. 115).

Within recreation, this issue has surfaced in a debate about the prescriptive utility of normative information derived from visitor surveys – the most common method used to develop standards that are "based in science" (Shelby et al. 1996, Manning 2002). In the "normative research approach", people (usually current on-site visitors) are sampled and asked for their opinion about acceptable conditions (about what standards ought to be). Typically these data from individuals are aggregated to define a social norm, usually the mean response. The mean neutral response for sampled individuals (on a scale from acceptable to unacceptable) is often considered to be the minimum acceptable condition – an empirically derived standard (Manning 1999). But how equivalent is this empirical standard (a description of *what is*) to a normative standard (a prescription of *what ought to be*)?

The normative approach has much in common with standard opinion polling, a method that is commonly used to gain input (or at least assess public sentiment) on policy issues. Freyfogle and Newton (2002, p. 866) note that the opinion poll lies at one extreme of available methods for gaining public input in the standard setting process. It is characterized by seeking evaluations from "isolated individuals without study or deliberation", by presuming "that people know enough to make determinations" and by allowing people to select whatever standards they want in making a decision. Freyfogle and Newton (2002, p. 866) contrast the opinion-poll approach with what they consider to be its opposite, the courtroom process. In this process, jurors are carefully selected so that they are not highly biased. They are provided with information "in a setting that encourages reflection". Decisions are made collectively using standards (laws) that are "established in advance and proffered when the time comes by the judge."

There are many methods for gaining public input regarding the public interest that lie between these two extremes. Each method varies in terms of who gets to decide, the type of knowledge considered, the spatial scale employed, the emphasis on information provided, the emphasis on learning and consideration of trade-offs, the explicitness of standards that are applied, the degree of interaction between stakeholders and the collectiveness of final decisions. Some rely more on scientific knowledge than others. Which process is best for defining the public interest – for defining normative standards? Should the normative, opinion-polling approach be preferred because the data gathered are empirical? There is no simple answer and this issue is currently being debated in academic journals (Manning 2003, Stewart and Cole 2003). But what is clear is that the standards that are ultimately selected are dependent on the method that is used to define the public interest. Consequently, the biases inherent to any method of gathering public input – or particularly to any scientific study – should be explicated as clearly as possible.

The power of science as a descriptive tool fosters a desire to base as many decisions as possible on science. Williams and Matheny (1995) note that the "search for correct public policies is seen as similar to the search for scientific knowledge…this search assumes there is a single answer to public policy problems, that this answer can be found within a single language, and that this language is one of scientific expertise"(p. 39). This can cause us to prefer a scientific answer to the wrong question to an answer to the right question that draws more heavily from some other source of knowledge.

Conclusions

Management of recreation in protected areas is primarily concerned with ensuring that appropriate experiences are provided and that acceptable levels of impact are not exceeded. Given agreement about clearly specified desired end states (what is appropriate and acceptable), science provides powerful tools for monitoring recreation use and impacts, for identifying management actions likely to be effective in achieving desired end states, for predicting the consequences of alternative actions and how current visitors are likely to be affected by those actions and for assessing the efficacy of management actions. These tasks play to the strengths of science – description, explanation, prediction and assessment (Hall 2004). As the preceding review suggests, progress on this portion of the recreation management process has been substantial.

Lack of progress in recreation management largely stems from paralysis during the step of specifying desired end states--standards for acceptable impact levels and for appropriate experiences or appropriate settings in which experiences occur. Managers face difficult decisions when choosing between the competing values of a diverse public. They have turned to science for help but the power of science at this step is much more limited. Science usually cannot provide good answers to the most important value-based questions. Consequently, scientists who venture into this arena, attempting to describe the values of the public, need to be overtly attentive to the potential biases in their descriptions (stakeholders included and excluded; information provided or withheld, etc.). As Freyfogle and Newton (2002, p. 865) note "Although we are confident in claiming that science…is purely descriptive…we do recognize …limits on the power of humans to engage in value-free description."

The relationship between management and science is a reciprocal one. Although the emphasis of this paper has been on science helping management, management decisions also help science. Science can be much more efficient and effective once controversial value judgments regarding standards are in place (Dietz and Stern 1998). Ultimately, recreation scientists may need the decisions of recreation managers (to give their research focus and meaning) as much as recreation managers need the empirical data of recreation scientists to help them develop desired end states.

Acknowledgements

Some of the ideas and examples about appropriate roles for science were inspired by reading Hall (2004).

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