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FORUM

Carrying Capacity as "Informed Judgment": The Values of Science and the Science of Values

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ABSTRACT / Contemporary park and wilderness carrying capacity frameworks rely on formulation of standards of quality, which are defined as minimum acceptable resource and social conditions. Formulation of standards of quality involves elements of both science and values, and both of these elements must be integrated into informed judgments on the part of park and wilderness managers. That is, managers must ultimately make value-based judgments about the maximum acceptable level of visitor-caused impacts to the resource base and the quality of the visitor experience. However, such judgments should be as informed as possible by scientific data on the relationships between visitor use and resulting impacts and the degree to which park and wilderness visitors and other interest groups judge such impacts to be acceptable. Such information represents the "values of science" to managing carrying capacity in parks and wilderness. A growing body of literature has begun to address the corresponding "science of values," and how this type of information might be integrated in park and wilderness management. Visitor-based research has employed normative theory and techniques to explore the acceptability of a range of resource and social impacts related to visitor use, and findings from these studies are being integrated into a body of knowledge and applied in management decision-making. Conceptual and methodological extensions of the normative approach are currently being explored in a variety of park and wilderness contexts, and new theoretical and empirical approaches are being adapted to address trade-offs inherent in carrying capacity. In these ways, the science of values is progressing to meet the opportunities and challenges of the values of science to park and wilderness management. The concept of carrying capacity, along with the theoretical and methodological approaches described in this paper, can be extended to a large number of natural resource and environmental issues.

Carrying Capacity of Parks and Wilderness

Resource and social impacts of recreation use constitute long-standing issues in the field of park and wilderness management, and these issues are often addressed within the context of carrying capacity. In its most generic form, carrying capacity refers to the amount and type of visitor use that can be accommodated within a park or wilderness without unacceptable resource and social impacts. Recent experience with carrying capacity suggests that it can be applied most effectively through formulation of indicators and standards of quality for biophysical conditions (resource carrying capacity) and for the visitor experience (social carrying capacity) (Graefe and others 1990, National Park Service 1997, Stankey and others 1985, Stankey and Manning 1986). Analysis of carrying capacity focuses primarily on defining the level of resource protection and the type of visitor experience to be provided and maintained. Indicators of quality are measurable, manageable variables that define the quality of park and wilderness resources and the quality of the visitor experience. Standards of quality define the minimum acceptable condition of indicator variables.

By formulating indicators and standards of quality, parks and wilderness can be managed within a defined carrying capacity. Indicator variables are monitored over time, and if standards of quality are violated (or are in danger of being violated), management action is required. This approach to carrying capacity is central to contemporary park and wilderness management frameworks, including limits of acceptable change (Stankey and others 1985), visitor impact management (Graefe and others 1990) and visitor experience and resource protection (National Park Service 1997).

Informed Judgment

The contemporary carrying capacity frameworks noted above rely (either explicitly or implicitly) on a foundation of informed judgment. That is, park and wilderness managers must ultimately render judgments about the level of impacts and related visitor use levels

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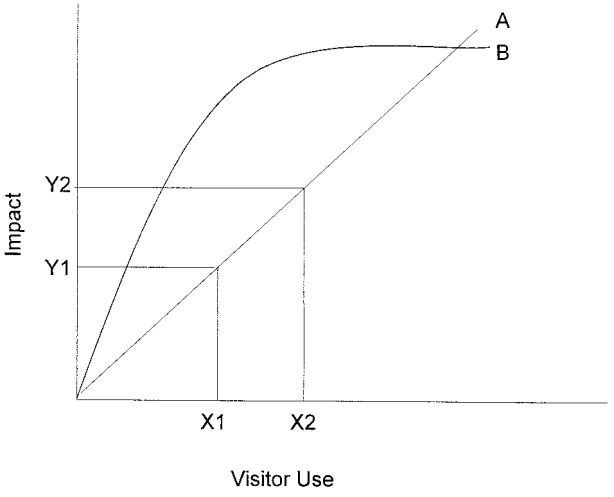

Figure 1. Hypothetical relationships between visitor use and impact to the recreation environment.

that are acceptable. A growing body of research illustrates that, while such relationships may be complex, increasing use levels of parks and wilderness may lead to increasing impacts to biophysical resources and the quality of the visitor experience (Hammitt and Cole 1998, Manning 1999). To what degree are such impacts and associated visitor use levels acceptable?

This issue can be illustrated graphically as shown in Figure 1. In this figure, hypothetical relationships between visitor use and impacts to the biophysical and social environments are shown. This figure suggests that such relationships can take varying forms (e.g., linear or curvilinear) but that increasing visitor use can and often does cause increasing impacts in the form of damage to fragile soils and vegetation and crowding and conflicting uses.[1] However, it is not clear from these relationships at what point carrying capacity has been reached. For example, for relationship A, X1 and X2 represent alternative levels of visitor use that result in corresponding levels of impact as defined by points Y1 and Y2, respectively. Which of these points—Y1 or Y2; or some other point along the vertical axis—represents the maximum amount of impact that is acceptable?

To emphasize and further clarify this issue, some studies have suggested distinguishing descriptive from evaluative and/or prescriptive components of carrying capacity (Shelby and Heberlein 1984, 1986). The descriptive component of carrying capacity focuses on factual, objective data such as the relationships in Figure 1. For example, what is the relationship between the amount of visitor use and perceived crowding? The evaluative and prescriptive components of carrying capacity determination concern the seemingly more subjective issues of how changes in the recreation environment are judged and, ultimately, how much impact or change in the recreation environment is acceptable. For example, the evaluative component of carrying capacity might address the question of how visitors judge increasing levels of use, while the prescriptive component of carrying capacity might address the question of what level of perceived crowding should be allowed.

From this discussion, it is apparent that carrying capacity analysis and management require a strong element of informed judgment. Park and wilderness managers must ultimately render judgments about acceptable levels of biophysical and social impacts, and associated use levels, but such judgments should be as informed as possible. Findings from scientific studies represent an important approach to informing such judgments.

The Values of Science

Science can inform management judgments about carrying capacity in at least two ways. First, research findings should serve as the basis of the descriptive component of carrying capacity. As noted above, the descriptive component of carrying capacity concerns the relationships between visitor use and the biophysical and social impacts of such use. A substantial body of scientific literature has been developed on both the resource and social components of carrying capacity, and recent meta-analyses have begun to integrate and synthesize this growing body of knowledge (e.g., Hammitt and Cole 1998, Manning 1999).

Second, research findings can also help inform the evaluative and prescriptive components of carrying capacity. These components of carrying capacity ultimately concern the maximum acceptable level of biophysical and social impacts. Again, a substantial body of scientific literature has been developed on the degree to which park and wilderness visitors are perceptive of such impacts and their subjective evaluations of these impacts. This research explores the park- and wilderness-related values of visitors and can be used with other types of information (e.g., legal and administrative mandates, agency policy, historic precedent, interest group politics, personnel and financial resources) to

[1]Research also suggests that other factors can influence the relationship between the amount of visitor use and impacts to the biophysical and social environments. These factors may include type of recreation activity, visitor behavior, spatial and temporal distribution of use, and resource sensitivity (Manning 1999, Hammitt and Cole 1998).

help inform management judgments about standards of quality and, ultimately, carrying capacity.

The Science of Values

Within the context of carrying capacity, scientific approaches to park and wilderness-related values have been applied primarily to formulation of standards of quality. Earlier in this paper, standards of quality were defined as minimum acceptable levels of indicator variables. Standards of quality ultimately reflect the values that visitors place on parks and wilderness. Research on visitor-based standards of quality has conventionally focused on normative theory and techniques. For example, what is the maximum acceptable number of groups that visitors feel can be encountered per day along a wilderness trail? More recent research has begun to extend the normative approach by emphasizing the potential consequences or trade-offs that may be inherent in normative research. For example, park and wilderness visitors may value both solitude and access, but these values may ultimately conflict. How do concerns about maintaining reasonable public access to wilderness areas affect normative judgments about the maximum acceptable number of groups that can be encountered per day along wilderness trails? The following subsections briefly describe and illustrate this evolving research on alternative park and wilderness values and their relationship to formulating standards of quality.

The Normative Approach

Developed in the disciplines of sociology and social psychology, the concept of norms has attracted considerable attention as a theoretical and empirical framework in park and wilderness research and management. In particular, normative theory has special application in helping to formulate standards of quality for park and wilderness experiences. As applied to outdoor recreation, norms are generally defined as standards that individuals and groups use for evaluating behavior and social and environmental conditions (Donnelly and others 1992, Shelby and Vaske 1991, Vaske and others 1986). If visitors have normative standards concerning relevant aspects of recreation experiences, then such norms can be measured and used as a basis for formulating standards of quality. In this way, parks and wilderness areas can be managed within a more empirically informed carrying capacity.

Application of the normative approach to formulating visitor-based standards of quality in park and wilderness management is most fully described in Shelby and Heberlein (1986), Vaske and others (1986), Shelby and others (1996), and Manning (1999). These applications have relied heavily on the work of Jackson (1965), who developed a methodology—return-potential curves or "norm curves"—to measure norms. Using these methods, the personal norms of individuals can be aggregated to test for the existence of social norms or the degree to which norms are shared across groups. Normative research in outdoor recreation has focused largely on the issue of crowding (e.g., Heberlein and others 1986; Manning and others 1996a,b, Patterson and Hammitt 1990, Shelby, 1981a, Vaske and others 1996, Whittaker and Shelby 1988, Williams and others 1991), but also has been expanded to include other potential indicators of quality, including ecological impacts at wilderness campsites (Shelby and others 1988), wildlife-management practices (Vaske and Donnelly 1988), and minimum stream flows (Shelby and Whittaker 1995). Research findings from published studies of recreation-related norms have recently been compiled in Manning (1999).

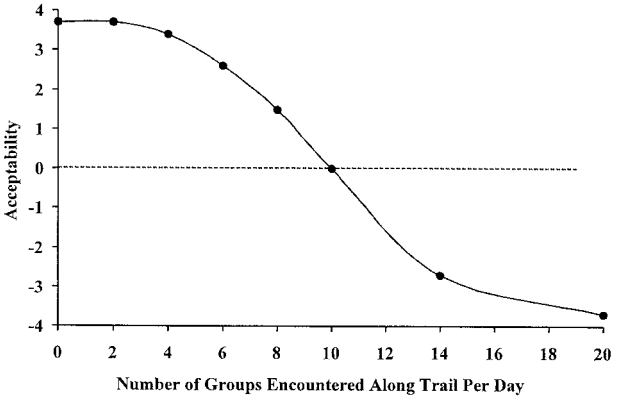

Figure 2. Hypothetical social norm curve.

A hypothetical social norm curve is shown in Figure 2 to illustrate the methodology described above. The norm curve traces the average acceptability ratings of a sample of recreationists for encountering a range of groups of other visitors per day along a trail. The highest point on the norm curve might be considered the optimal or preferred condition. The range of acceptable conditions might include all points on the norm curve above the zero point of the acceptability scale. The minimum acceptable condition might be defined by the point at which the norm curve crosses the zero point of the acceptability scale. The degree of consensus among the sample is indicated by the dispersion or variance of individual responses around the means that define the norm curve. This issue often is referred to as crystallization. Finally, the distance of the norm curve above and below the zero point of the acceptability scale defines norm intensity (also called salience) and is

a measure of the degree to which the impact under study is important to respondents.

Extending the Normative Approach

As research on normative standards has proceeded, several approaches to measuring norms have evolved. Traditionally, outdoor recreation-related norms have been measured using a numerical or narrative approach. For example, respondents might be asked to evaluate a range of encounters (0, 5, 10, 15, etc.) with other groups per day along trails. The personal normative data derived are aggregated and graphed (as illustrated in Figure 2) to construct a norm curve from which social norms might be identified. This numerical or narrative approach often is shortened to reduce respondent burden by simply asking respondents in an open-ended format to report the maximum acceptable number of encounters with other groups per day. These two approaches might be called the long and short versions of this measurement technique.

More recently, visual approaches to measuring crowding and other outdoor recreation-related norms have been developed. Two of these studies used photographs of wilderness campsites that illustrated a range of ecological impacts (Shelby and Harris 1985, Shelby and Shindler 1990). Two other studies used artistic renderings of alternative use levels and related impacts (Heywood 1993a, Martin and others 1989). More recently, computer software has been used to edit and produce photographs depicting a range of use levels and environmental impacts (Hof and others 1994, Manning and others 1995, 1996a,b). As with the numerical/narrative approach described previously, long and short versions of this measurement technique can be used. The long version asks respondents to evaluate each image in a series of photographs. The short version asks respondents to select the photograph that illustrates the highest impact or use level acceptable.

An issue implicit in all of these measurement approaches concerns the evaluative dimension used in these questions. When respondents have been asked to evaluate a range of use levels and related impacts, the response scale has included terminology specifying a variety of evaluative dimensions, including "acceptability," "preference," "pleasantness," "desirability," "satisfaction," and "tolerance." These alternative evaluative dimensions may have substantially different meanings to respondents and may result in significantly different personal and social norms.

A related issue concerns the normative nature of evaluative dimensions. Application of normative theory and techniques to outdoor recreation has noted several important elements of norms as they traditionally are defined (Heywood 1993a,b, 1996a,b, McDonald 1996, Noe 1992, Roggenbuck and others 1991, Shelby and Vaske 1991, Shelby and others 1996, Williams and others 1991). One of these elements suggests that norms have a strong obligatory nature; that is, norms define what should be. This suggests that norms might be measured by asking respondents about what recreation conditions or level of impacts they feel managers should maintain.

Recent studies of crowding-related norms for several national parks have allowed comparisons of findings among the norm measurement approaches described above (Manning and others 1997a,b, 1998, 1999c,d, 2000). These comparisons suggest that alternative measurement approaches can affect resulting norms in a statistically significant and substantive way (Manning and others 1999a). The most powerful effects concern the evaluative dimension used and more explicit introduction of the normative notion of the recreation conditions that managers should maintain.

Examples of these findings are shown in Table 1, which summarizes findings from several comparable studies. These findings suggest three important points. First, a range of personal and social norms can be estimated using a spectrum of evaluative dimensions that range from preference to absolute tolerance. Second, the management action evaluative dimension may be of special interest to park and wilderness managers because it more explicitly addresses trade-offs inherent in crowding-related issues (i.e., a desire to avoid crowding while also maintaining reasonable public access), and therefore may more closely approximate the traditional prescriptive nature of norms. For example, the management action question for the carriage roads of Acadia National Park, Maine, asked respondents "Which photograph shows the highest pattern of visitor use that the National Park Service should allow on this section of the carriage roads? In other words, at what point should visitors be restricted from using the carriage roads?" (Respondents were given options to report that visitor use should not be restricted at any point shown in the photographs or that visitor use should not be restricted at all. To the extent that respondents select these options, resulting crowding-related norms are underestimated.) It is important to note that management action-related norms are consistently and often substantially higher than preference and acceptability-based norms. The magnitude of these differences is often underestimated because up to one third of respondents in some studies reported that visitor use should not be restricted at any point shown in the photographs or that visitor use should not be

Table 1. Alternative evaluative dimensions of crowding norms

	Preference	Acceptability		Management action	Absolute tolerance
		Short form	Long form		
Carriage Roads, Acadia National Park (persons/viewscape)					
1995 (visitors)		10.7	12.7	17.8	25.2
1996 (visitors)	5.4	9.7		17.5	20.9
1996 (residents)	7.0	10.1		15.6	19.1
Hiking Trails, Grand Canyon National Park (1997) (persons/viewscape)					
Corridor trails	3.4	6.9	9.0	9.1	12.8
Rim trails	3.0	6.0	10.0	9.0	18.0
Threshold trails	1.1	3.6	5.0	5.1	7.9
Attractions, Yosemite National Park					
Trail to Yosemite Falls (1998) (persons/viewscape)	18	32	40	46	60
Base of Yosemite Falls (1998) (people at one time)	43	75	92	100	126
Trail to Vernal Fall (1998) (persons/viewscape)	11.2	20.6	26	29.7	38.6
Trail to Bridalveil Fall (1999) (persons/viewscape)	7	13	18	20	26
Base of Bridalveil Fall (1999) (people at one time)	8	15	20	19	25
Glacier Point (1999) (people at one time)	19	34	42	49	61
Trail to Mirror Lake (1999) (persons/viewscape)	10.4	18.5	24	26.0	33.9
Statue of Liberty National Monument (1998) (waiting time in minutes to get into the Statue of Liberty)			45	64	61
Alcatraz Island, Golden Gate National Recreation Area (1998) (people at one time in cell house)	25.1	36.0	44	43.9	
Arches National Park					
Delicate Arch (1997) (people at one time)	12	33	37	49	67
North Window (1997) (people at one time)	8	23	23	30	47
Devils Garden (1997) (persons/viewscape)	6	13	13	18	23

restricted at all. Finally, the range of crowding-related norms developed in the literature based in alternative evaluative dimensions may be useful to researchers and managers as it facilitates a more comprehensive understanding of the evaluative and prescriptive components of carrying capacity.

Beyond the Normative Approach

Data derived from the normative approach can be useful in helping researchers and managers quantify the values of park and wilderness visitors and formulate crowding-related and other standards of quality. However, such studies have also illustrated the complex nature of this research, as well as the strengths and weaknesses of normative theory and empirical techniques. In particular, conventional studies designed to estimate crowding-related and other norms may substantially underestimate such norms because these studies fail to explicitly (or even implicitly) introduce trade-offs between the desire to avoid crowding and other impacts of recreation and the desire to maintain reasonable public access to parks and wilderness.

Indifference curve analysis. Research on park and wilderness-related values might be strengthened through adaptation of alternative theoretical and empirical approaches, especially those that more explicitly address inherent trade-offs in park and wilderness management. For example, indifference curve analysis devel-

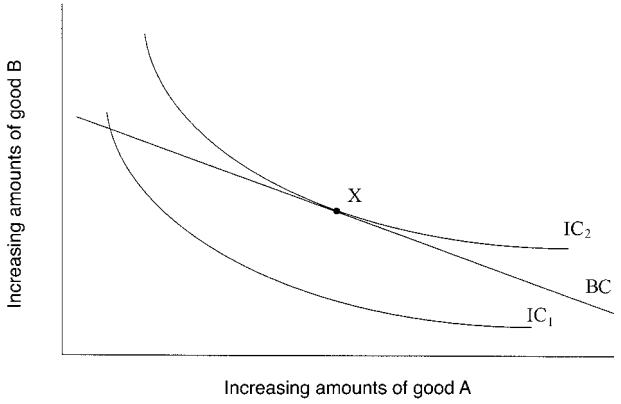

Figure 3. Theoretical indifference curves and budget constraint.

oped in the discipline of economics, provides a model representing the trade-off decisions an individual makes in allocating a fixed level of income between two consumer goods (Nicholson 1995). There are two primary components to the indifference curve model: the individual's indifference curves and his/her budget constraint. A single indifference curve represents all possible combinations of two goods (e.g., A and B) that provide the individual with the same level of utility (Pindyck and Rubinfeld 1995). The curves labeled IC_1 and IC_2 in Figure 3 are examples of indifference curves. Indifference curves further from the origin (i.e., indifference curves that include greater amounts of goods A and/or B) represent a higher level of utility or satisfaction than those closer to the origin. The budget constraint represents the possible combinations of goods A and B the individual can purchase, assuming the individual spends all of his/her income on the two goods (Pindyck and Rubinfeld 1995). For example, the budget constraint labeled BC in Figure 3 represents all possible combinations of the two consumer goods A and B, for a fixed income level.

According to indifference curve theory, the optimal combination of goods A and B for a given income is located where the budget constraint is tangent to one of the individual's indifference curves (Nicholson 1995). This represents the highest level of utility the individual can achieve from the consumption of goods A and B, given a fixed level of income. In Figure 3, the optimal condition is represented by point X. A more complete discussion of indifference curve theory is presented in Lawson and Manning (2000a,b, 2001b).

An initial application of indifference curve analysis to park and wilderness management was conducted within the context of carrying capacity at Arches National Park, Utah, USA, by substituting solitude at Delicate Arch and access to Delicate Arch for consumer goods (i.e., goods A and B in Figure 3). Specifically, the number of people at Delicate Arch was substituted for good B along the *y* axis, and the percent chance of receiving a hypothetical permit to hike to Delicate Arch was substituted for good A along the *x* axis.

Indifference curves were estimated following a procedure adapted from MacCrimmon and Toda (1969). In this procedure, respondents are presented with a series of pairs of solitude and access conditions. The first component of each pair of conditions is a fixed reference condition, against which respondents evaluate a unique alternative condition. Respondents are asked to indicate their preference within each pair of conditions they evaluate. For example, in the study at Arches National Park, respondents were asked to express their preference between a first set of conditions—having a 100% chance of receiving a permit to hike to Delicate Arch and seeing 108 people at Delicate Arch—and a second set of conditions—having a 50% percent chance of receiving a permit to hike to Delicate Arch and seeing 36 people at the arch. Study methods are described more fully in Lawson and Manning (2000a,b, 2001b).

Regression analysis was used to estimate an indifference curve for each respondent based on the data points derived from the respondents' evaluation of a series of pairs of access and crowding conditions at Delicate Arch. For each respondent, a hyperbolic, semi-log, or quadratic curve was fit to the data points. The functional form for each individual indifference curve was selected based on the goodness of fit (R^2) of the regression equation, and the explanatory significance of the access variable (chance of receiving a permit) on the number of people at Delicate Arch.

A simulation model of visitor use at Arches National Park was used to estimate points defining the budget constraint, representing the possible combinations of visitor use levels and accessibility at Delicate Arch. Computer simulation models have been successfully applied to a variety of parks and wilderness areas (e.g., Potter and Manning 1984, Wang and Manning 1999 Schechter and Lucas 1978). Additional information about the inputs used to develop the simulation model can be found in Lawson and Manning (2000a,b, 2001b).

The simulation model was run at three levels of daily visitor use. The first level of use represented the park's average daily use in the peak summer season, which was used as a proxy for a 100% chance of receiving a permit to hike to Delicate Arch. The second level of use was 50% of the Park's average peak daily use, which was used as a proxy for a 50% chance of receiving a permit

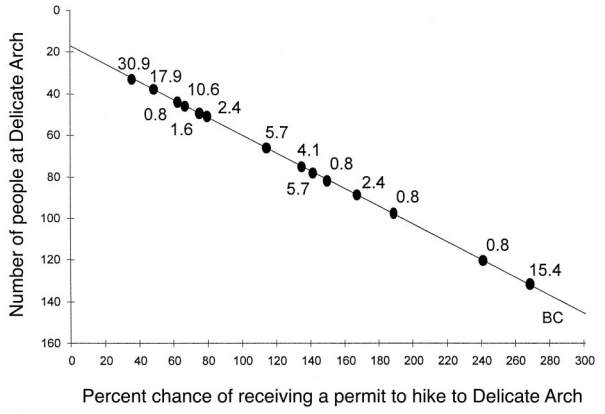

Figure 4. Findings from indifference curve analysis for Delicate Arch.

to hike to Delicate Arch. The third level of use was 25% of the park's average peak daily use, which was used as a proxy for a 25% chance of receiving a permit to hike to Delicate Arch.

For each use level, the model was run multiple times to account for variability in model parameters. The outputs from the simulation model runs were used to estimate the highest number of people any visitor would see at one time at Delicate Arch for each of the three accessibility conditions. A linear budget constraint was estimated from the three resulting data points.

Lastly, each individual's indifference curve was mathematically adjusted to find the point where the indifference curve is tangent to the budget constraint. The point of tangency between the adjusted indifference curve and the budget constraint reveals the respondent's preferred combination of visitor use and accessibility, given the possible conditions at Delicate Arch.

Study data were gathered from a survey of 124 visitors to Delicate Arch in September of 1999. The study used computer-generated photographs representing a range of the number of visitors at one time at Delicate Arch (Manning and others 1996b). The survey was administered on a lap top computer.

Study findings are shown in Figure 4, which presents the percent of respondents with each of the preferred combinations of access and visitor use at Delicate Arch. The budget constraint for Delicate Arch is represented by the line labeled BC. Each point noted along the budget constraint represents a preferred combination of access and crowding at Delicate Arch (the point of tangency between a respondent's indifference curve and the budget constraint) for at least one respondent. The number beside each point indicates the percentage of respondents with the corresponding preferred combination of access and crowding. Data analysis and study findings are described in more detail in Lawson and Manning (2000a,b, 2001b).

Study findings suggest that indifference curve analysis may provide a useful tool for park and wilderness managers to evaluate trade-offs inherent in carrying-capacity decisions. This research approach gathers data concerning crowding-related norms of visitors, but places such norms within a more realistic and applied management context regarding the trade-offs inherent in such normative judgments.

Stated choice analysis. Stated choice analysis represents another research approach to quantifying carrying capacity-related values and trade-offs inherent in park and wilderness management. Stated choice analysis models have been developed in the fields of psychometrics, econometrics, and consumer marketing to evaluate public preferences or attitudes (Green and Srinivasan 1978). There is a growing body of literature describing the application of stated choice analysis to outdoor recreation management issues in parks and related areas (Louviere and Timmermans 1990b, Louviere and Woodworth 1985, Schroeder and others 1990). In stated choice analysis, respondents are asked to make choices among alternative configurations of a multiattribute good (Louviere and Timmermans 1990a). Each alternative configuration is called a profile, and is defined by varying levels of selected attributes of the good (Mackenzie 1993). For example, respondents may be asked to choose between alternative recreation settings that vary in the number of other groups encountered, the quality of the natural environment, and the intensity of management regulations imposed on visitors. Respondents' choices among the alternatives are evaluated to estimate the relative importance of each attribute to the overall utility or satisfaction derived from the recreational setting. Further, stated choice analysis models are used to estimate public preferences or support for alternative combinations of the attribute levels (Dennis 1998). The theoretical framework underlying stated choice analysis is described more fully in Lawson and Manning (2001a, 2002).

A recent application of stated choice analysis was used to develop a decision-making model to inform judgments about the management of social, resource, and managerial attributes of the Denali National Park wilderness, within the context of carrying capacity (Lawson and Manning 2001a, 2002). Specifically, stated choice analysis was used to evaluate the choices Denali overnight wilderness visitors make when faced with hypothetical trade-offs among the conditions of selected

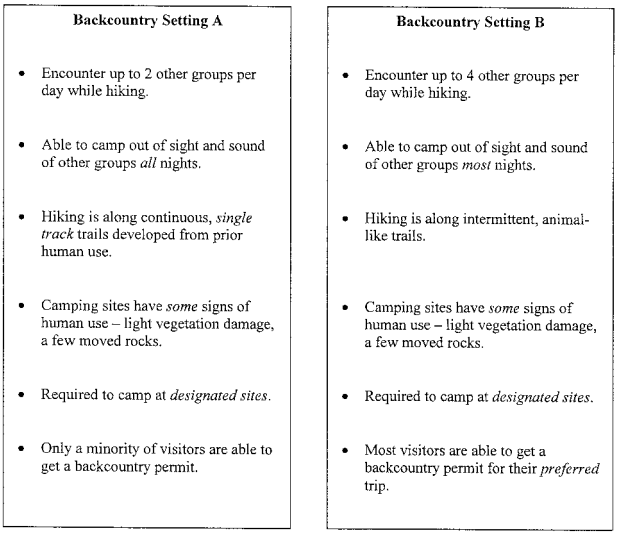

Figure 5. Example of Denali wilderness setting comparison.

social, resource, and managerial attributes of the wilderness portion of the park.

In the stated choice analysis study, a set of six Denali wilderness setting attributes were selected to define a series of hypothetical Denali wilderness settings. Attributes selected to reflect the social conditions of the Denali wilderness included the number of other groups encountered per day while hiking and the likelihood of being able to camp out of sight and sound of other groups. Two attributes related to the resource conditions of the Denali wilderness were selected: the presence and extent of trails and the amount of human impact at camping sites. The intensity of restrictions regarding where wilderness visitors are allowed to camp and the level of difficulty of obtaining a permit for an overnight wilderness trip were selected as attributes to reflect the management conditions of the Denali wilderness. An experimental design was used to combine the six attributes at varying levels into a set of paired comparison questions, each consisting of two hypothetical Denali wilderness settings. An example of a representative Denali wilderness setting comparison is presented in Figure 5. For a more detailed discussion of the methods used to design the stated choice survey see Lawson and Manning (2001a, 2002).

The stated choice analysis survey was administered from 24 July through 2 September 2000 to visitors returning from an overnight wilderness trip. Respondents to the survey were presented with a series of nine paired comparison questions, each containing two hypothetical Denali wilderness settings. In each question, the respondent was asked to read through each Denali wilderness setting description and indicate which they preferred. The response rate for the stated choice analysis survey was 81.2%, resulting in a total of 311 completed questionnaires (approximately 78 respondents for each of four versions of the questionnaire) and 2799 pairwise comparisons.

Table 2. Coefficient estimates for Denali wilderness setting attributes

Variable	Coefficient
Encounters with other groups per day while hiking	
0 other groups	0.439*
Up to 2 other groups	0.065
Up to 4 other groups	−0.504*
Able to camp out of sight and sound of other groups	
All nights	0.295*
Most nights	0.145*
A minority of nights	−0.440*
Hiking is along	
Intermittent, animal like trails	0.319*
Single track trails developed from human use	−0.028
Multiple track trails developed from human use	−0.291*
Camping sites have	
Little or no signs of human use	0.582*
Some signs of human use	0.207*
Extensive signs of human use	−0.790*
Regulation of camping	
Allowed to camp in any zone on any night	0.072*
Required to camp in specified zones	0.140*
Required to camp in designated sites	−0.212*
Chance visitors have of receiving a permit	
Most get a permit for their preferred trip	0.073*
Most get a permit for at least their second choice	0.143*
Only a minority get a permit	−0.216*

*Statistically significant at 0.05 level or better.

Responses to the stated choice analysis survey were analyzed using logistic regression analysis. The coefficients of the logistic regression analysis are presented in Table 2. Results of the data analysis provide information about the relative importance wilderness visitors place on the selected social, resource, and managerial attributes of the Denali wilderness. The magnitude of the regression coefficients presented in Table 2 reflects the relative importance of the corresponding level of the attribute to Denali overnight wilderness visitors. Specifically, the findings suggest that levels of attributes with relatively large positive or negative coefficient values (e.g., "Little or no sign of human use at campsites," "Extensive signs of human use at campsites") are of greater relative importance to visitors than levels of attributes with relatively small positive or negative coefficient values (e.g., "Most get a permit for their preferred trip," "Required to camp in designated sites"). Further, the study results suggest that when the levels of

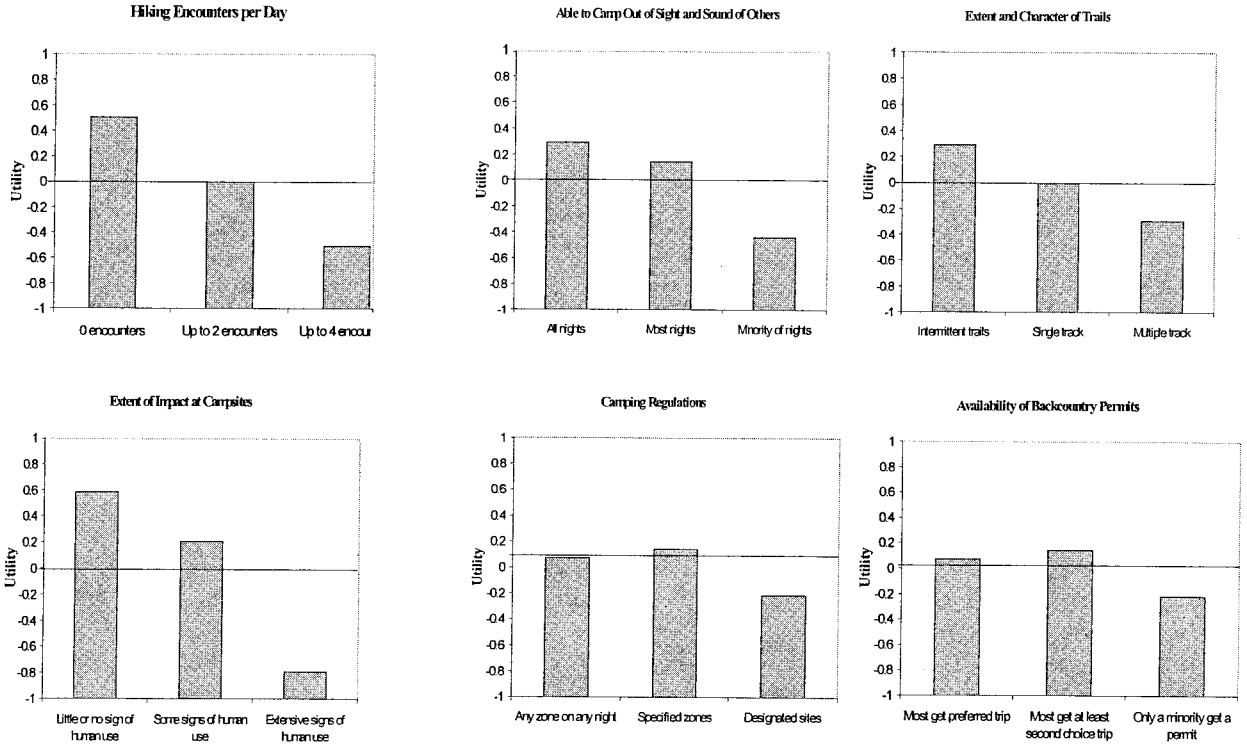

Figure 6. Graph of stated choice regression coefficients.

the Denali wilderness setting attributes deteriorate beyond certain thresholds, they provide less than average levels of utility or satisfaction, as shown in the graph of regression coefficients in Figure 6. For example, visitor utility or satisfaction falls from above average levels to below average levels as camping sites deteriorate from having "some signs of human use" to "extensive signs of human use," and this may represent a threshold.

These findings imply that a high quality wilderness experience can be maintained by keeping wilderness setting conditions from deteriorating beyond such threshold levels. The threshold levels identified in this study for each of the six Denali wilderness setting attributes could be used by park managers to help formulate standards of quality. For example, the study results suggest that fewer than two encounters with other groups per day while hiking provides a greater than average level of utility to Denali overnight visitors and that encounters with more than two other groups per day while hiking provides a less than average level of utility. Therefore, a potential standard of quality for this attribute might be set at "up to 2 encounters with other groups per day while hiking." Lastly, the regression equation can be used to estimate current users' support for a wide range of Denali wilderness management alternatives. A more in depth discussion of the data analysis and study findings is presented in Lawson and Manning (2001a, 2002).

Stated choice analysis provides a potential improvement over conventional normative research approaches to park and wilderness carrying capacity because resulting data are derived from a more holistic or contextual perspective. That is, visitors' normative judgments and the resulting statistical analysis explicitly consider the inherent trade-offs among the conditions of social, resource, and managerial attributes of the Denali wilderness. Further, this expanded approach to normative research yields information to help formulate standards of quality for multiple and related wilderness attributes simultaneously.

Conclusion

Carrying capacity is an important issue in park and wilderness management and is likely to increase in importance as the popularity of parks and wilderness continues to grow. Research on carrying capacity, along with management experience, has developed a number of planning and management frameworks and research approaches for addressing this issue. It is clear from the literature that management of carrying capacity involves matters of both science and values and that both

of these elements must be integrated into "informed judgments" on the part of park and wilderness managers. That is, managers must ultimately make value-based judgments about the maximum acceptable levels of visitor-caused impacts to the resource base and the quality of the visitor experience. However, such judgments should be informed to the extent possible by scientific data on the relationships between visitor use and resulting impacts and the degree to which park and wilderness visitors and other interest groups judge such impacts to be acceptable. Such information represents the values of science to managing carrying capacity in parks and wilderness.

A growing body of literature has begun to address the corresponding "science of values," and how this type of information might be integrated into park and wilderness management. Visitor-based research has employed normative theory and techniques to explore the acceptability of a range of biophysical and social impacts related to visitor use, and findings from these studies are being integrated into a body of knowledge and applied in management decision-making. Conceptual and methodological extensions of the normative approach are currently being explored in a variety of park and wilderness contexts, and new theoretical and empirical approaches, including indifference curve and stated choice analysis, are being adapted to address trade-offs inherent in carrying capacity management. In these ways, the science of values is progressing to meet the opportunities and challenges of the values of science to park and wilderness management.

While progress has been made in developing a more conceptually and empirically informed approach to the carrying capacity of parks and wilderness, this research should be interpreted and applied carefully, and more research is clearly warranted. For example, normative theory and techniques borrowed from the discipline of sociology have proven useful in carrying capacity analysis, but such data derived in the context of park and wilderness management may lack the full prescriptive power of norms as they have traditionally been defined. As noted earlier in this paper, crowding-related and other norms in outdoor recreation have generally not included explicit consideration of trade-offs that may be necessary to attain desired levels of solitude and other experiential and resource conditions. Additional conceptual and methodological approaches (such as indifference curve analysis and stated choice modeling, as described in this paper) may prove useful to supplement the normative approach. Moreover, the normative data described in this paper are often analyzed and presented using measures of central tendency such as means and medians. Researchers and managers should be careful not to mask important variation that might exist among different types of park and wilderness visitors.

A related issue concerns the inherent complexity and diversity of carrying capacity and its application to parks and wilderness. Current visitors have been the subject of most carrying capacity research, but other interest groups may be considered legitimate stakeholders as well, including local residents, displaced visitors, and the general public. Research should be expanded to include a wider spectrum of interest groups. Carrying capacity research has also traditionally been conducted on a site-by-site basis. However, viewing individual parks and wilderness areas as parts of larger regional or even national systems of outdoor recreation areas—and conducting research and management accordingly—may result in a more diverse system of park and wilderness opportunities that more fully serves the spectrum of public preferences. Such a systems approach may also help relieve some of the tension and confrontation often associated with the application of carrying capacity, as the preferences of multiple groups might be incorporated into larger scale research and management. It should also be noted that the types of data described in this paper are only one source of information on public values that might be incorporated into analyzing and applying carrying capacity to parks and wilderness areas. Other sources of information include legal and administrative mandates, agency policy, historic precedent, interest group politics, personnel and financial resources and—inescapably—management judgment, but judgment that is scientifically informed to the extent that is possible.

Finally, the concept of carrying capacity, along with the theoretical and methodological research approaches described in this paper, can logically be generalized to a large number and variety of natural resource and environmental issues that extend well beyond park and wilderness management. Contemporary natural resource and environmental management often focuses on defining and maintaining minimum acceptable standards of quality for a variety of environmental and societal attributes or indicators. For example, the authors are currently involved in a study to help refine a regional management plan for Lake Champlain. A component of this project is to develop a set of indicators and standards of quality for this important regional resource. The current plan has identified a number of goals for the lake, including protection of water quality, improvement of fish and wildlife habitat, enhanced public access and recreational use, and continued contributions of the lake to regional economic development. However, some of these goals may inher-

ently involve competing public values of the lake, and these values must ultimately be clarified and quantified. Normative research and stated choice modeling are being used to help identify the most important indicator variables and to provide an empirical basis for formulating associated standards of quality. The conceptual frameworks and research approaches described in this paper may be useful for exploring and quantifying competing public values of environmental resources, for formulating standards of quality for natural resource and environmental management, for capitalizing on the values of science in resolving these issues, and for assisting environmental managers and policymakers in ultimately reaching "informed judgments" regarding such matters.

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