Defining and Managing Visitor Capacity in National Parks: A Program of Research in the U.S. National Park System

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Abstract

How much visitor use can be accommodated in national parks without unacceptable impacts to park resources and the quality of the visitor experience? Visitor capacity is a long-standing and increasingly urgent issue in national parks. Several management frameworks have been developed to help define and manage visitor capacity, and all of these frameworks rely on formulation of indicators and standards of quality for park resources and the visitor experience. Application of these frameworks can be informed by a program of research, including stakeholder surveys, normative theory and methods, visual research methods, analysis of tradeoffs in outdoor recreation, and computer-based simulation modeling. These methods have been applied in a program of research on visitor capacity in the U.S. National Park System.

Keywords: visitor capacity, carrying capacity, outdoor recreation, national parks

An Introduction to Visitor Capacity

Historical expansion of recreational use in national parks and related areas, along with the growing popularity of outdoor recreation more generally, has created a tradition of concern about appropriate use levels of parks. Most parks and related areas have been established for public use and appreciation. However, they must also be protected. The two-fold mission of the U.S. national parks stated in the National Park Service Organic Act of 1916 offers a classic expression of this inherent tension as it states that national parks are to be managed "to conserve the scenery and the natural historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 U.S.C. Section 1 (1916)). Most national park systems around the world have been patterned after

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this legislation (IUCN, 1994).

Recreational use can cause impacts to park resources in the form of soil compaction and erosion, trampling of vegetation, water pollution, and wildlife disturbance, and can also degrade the quality of the visitor experience through crowding, conflicting uses, and aesthetic implications of resource impacts (Hammitt & Cole, 1998; Manning, 2011). How much recreational use can be accommodated in national parks before there is unacceptable impact to park resources and the quality of the visitor experience? This issue is often addressed under the rubric of “carrying capacity” or more recently “visitor capacity”, has become an important component of the scientific and professional literature on parks and outdoor recreation in the United States and internationally, and has taken on added urgency in recent years (Arberger & Brandenburg, 2007; Buckley, 2004; Legare & Haider, 2008; Manning, 2007).

The first rigorous scientific application of visitor capacity to parks and related areas came in the early 1960s with a conceptual monograph (Wagar, 1964) and a preliminary empirical treatment (Lucas, 1964). Perhaps the major contribution of Wagar’s conceptual analysis was the expansion of visitor capacity from its dominant emphasis on environmental concerns to a dual focus including social or experiential considerations: “The study reported here was initiated with the view that the carrying capacity of recreation lands could be determined primarily in terms of ecology and the deterioration of areas. However, it soon became obvious that the resource-oriented point of view must be augmented by consideration of human values (Wagar, 1964, preface).”

Wagar’s point was that as more people visit a park or related outdoor recreation area, not only are the environmental resources of the area affected, but also the quality of the recreation experience. Thus, visitor capacity was expanded to include consideration of the social environment as well as the ecological environment. The effects of increasing use on recreation quality were illustrated by Wagar by means of hypothetical relationships between increasing use level and visitor satisfaction.

A preliminary attempt to estimate the visitor carrying capacity of the Boundary Waters Canoe Area, Minnesota, followed shortly, and researchers found that perceptions of crowding varied by different user groups (Lucas, 1964). Paddling canoeists were found to be more sensitive to crowding than motor canoeists, who were in turn, more sensitive to crowding than other motor boaters. A range of visitor capacities was estimated depending upon these different relationships.
Visitor capacity has attracted intensive focus as a research and management issue in parks and outdoor recreation. A number of authoritative bibliographies, books, and review papers have been published on visitor capacity and closely related issues over the past several decades (Stankey & Lime, 1973; Graefe, Vaske, & Kuss, 1984; Shelby & Heberlein, 1986; Stankey & Manning, 1986; Kuss, Graefe, & Vaske, 1990; Haas, 2000; Manning, 2007), and these publications include hundreds of citations.

**Frameworks for Defining and Managing Visitor Capacity**

Based on the growing scientific and professional literature described above, a number of contemporary visitor capacity management frameworks have been developed and applied. Prominent examples include Limits of Acceptable Change (LAC) (Stankey, Cole, Lucas, Peterson, Frissell, & Washburne, 1985), Visitor Impact Management (VIM) (Graefe, Kuss, & Vaske, 1990), and Visitor Experience and Resource Protection (VERP) (National Park Service, 1997; Manning, 2001). All of these frameworks rely on formulation of management objectives and associated indicators and standards of quality for park resources and the visitor experience. Management objectives are descriptive statements of the desired level of resource protection and the desired type and quality of the visitor experience. Indicators of quality are measurable, manageable variables that are used to help define management objectives, and standards of quality specify the minimum acceptable condition of indicator variables (Manning, 2007). Once indicators and standards of quality have been formulated, indicators are monitored and management actions taken to ensure that standards of quality are maintained.

**Research to Support Defining and Managing Visitor Capacity**

Defining and managing visitor capacity inevitably requires some professional judgment by park managers. However, such judgment should be as “informed” as possible (Manning & Lawson, 2002). Research can help inform this process through identification of potential indicators and standards of quality, development of monitoring programs, and testing the potential effectiveness of management actions.

Several research approaches have been developed and applied to support application of visitor capacity. This paper describes this program of research. Emphasis is placed on research conducted in the U.S. National Park System. This section of the paper describes five basic research approaches and their application in a diverse array of national parks. This program of research was conducted in the context of the U.S. National Park Service's
VERP framework noted above.

**Stakeholder Surveys**

Survey research is a traditional social science method and, in the context of visitor capacity, can be especially useful in identifying potential indicators of quality for park resources and the visitor experience. As defined above, indicators of quality are measurable, manageable variables that are used to help define management objectives. A conventional characteristic of indicator variables is that they should be important to park visitors and other stakeholders in determining the quality of the visitor experience (Manning, 2007). Thus, surveys of park visitors and other stakeholders can be especially useful in identifying indicators of quality. Survey research can generally be characterized as either qualitative or quantitative.

Qualitative surveys are open-ended, in-depth discussions with respondents; they are generally characterized by a series of questions that encourage respondents to think about and discuss their opinions or experiences (Tashakkori & Teddlie, 1998; Patton, 2002). Surveys are guided by a structured series of questions, but interviewers are permitted to ask other clarifying or exploratory questions. This survey method is termed qualitative because study findings are designed to describe the range of opinions or experiences in a population as opposed to estimating their quantitative distribution throughout that population. Qualitative surveys are often conducted using purposive rather than representative sampling to help ensure that as full a range of responses as possible is derived. Purposive sampling might be designed on the basis of type of respondent or diversity of activities or sites within a park. Interviews are usually recorded, transcribed and coded to identify important themes and, ultimately, indicators of quality (Patton, 2002; Miles & Huberman, 1994; Coffey & Atkinson, 1996).

As an example of the qualitative approach, interviews were conducted with visitors and other stakeholders at Arches National Park, Utah (Manning, 2001). The purpose of the interviews was to help identify indicators of the quality of the visitor experience, including the ways in which the condition of park resources affected the visitor experience. A semi-structured interview script was developed that asked a series of probing, open-ended questions about what respondents felt were the most important qualities or characteristics of the visitor experience at the park. Interviews were conducted in the park with 112 visitors at seven sites. In addition, ten focus group sessions were also conducted with a total of eighty-three participants. Participants included park staff, visitors who participated
in the park's interpretive programs, and residents of the local community.

Responses were initially coded into ninety-one categories and then grouped into several major themes or subject matter classes. Themes that emerged as good indicators of quality included crowding at attraction sites and along trails, visitors walking off trails and damaging soils and vegetation, and vehicle traffic on park roads.

Quantitative surveys are generally characterized by a series of close-ended questions with defined response scales. This survey method is termed quantitative because it is designed to measure the distribution of responses throughout a population. Quantitative surveys are conducted using representative sampling methods incorporating an element of randomness. Study findings are coded, analyzed, and reported using mathematical and statistical procedures.

As an example, the program of research at Arches National Park described above conducted a second visitor survey that incorporated a battery of close-ended questions addressing fourteen potential indicator variables (Manning, 2001). These potential indicators were developed from the initial qualitative survey, literature review, and the judgment of park staff. The survey was administered to representative samples of visitors at seven sites within the park. Respondents were asked to rate the importance of each potential indicator on a five-point scale that ranged from one ("very unimportant") to five ("very important"). For park visitors as a whole, the most important indicators of quality were vandalism, litter, inappropriate behavior of visitors (including walking off trails), damage to soils and vegetation, visitor-caused noise, and crowding at attraction sites and along trails. However, there were some differences among study sites. For example, visitors to developed areas in the park rated the indicator of visitors walking off trails as more important than did visitors to the backcountry.

Qualitative and quantitative survey approaches can be employed in a complementary way. As with the example at Arches National Park, qualitative interviews can be used to help identify the range of potential indicators, and follow-up quantitative surveys can help determine the relative importance of those indicators across representative samples of park visitors or other relevant publics.

Normative Theory and Methods

Perhaps the most challenging component of the management frameworks outlined above is formulating standards of quality. How much impact to park resources and the quality of the visitor experience is acceptable? What are the minimum acceptable
environmental and experiential conditions in national parks? Formulation of standards of quality can be guided by normative theory and related empirical methods. Norms are a theoretical construct that have a long tradition and are widely used in the discipline of sociology and the social sciences more broadly. As the word suggests, norms represent what is considered “normal” or generally accepted within a cultural context. In a more technical sense, norms are cultural rules that guide behavior. Moreover, such behavior is a function of a sense of obligation to abide by the norm and a belief that sanctions (rewards or punishments) may be forthcoming, depending on whether or not norms are followed (Grasmick, Blackwell, & Barsik, 1993; Heywood, 2002; Vaske & Whittaker, 2004). It is this sense of obligation and associated sanctions that make norms different from, and potentially more powerful than, attitudes. Attitudes are positive or negative evaluations of behavior, while norms define what behavior should be. Sanctions associated with norms can range from informal and internally imposed (e.g., feeling good or guilty) to formal and externally imposed (e.g., public recognition or being publicly ostracized). When norms apply to behaviors that are important to society and for which there is wide agreement, they can ultimately be codified into administrative rules and regulations, public policy, or even law.

Normative theory has developed along three basic lines (Vaske & Whittaker, 2004). One branch of normative theory addresses the variables that activate norms or bring them into focus (Cialdini, Kaligren, & Reno, 1991; Cialdini, Reno, & Kaligren, 1990). A second branch of theory deals with how completely attitudes and norms ultimately direct behavior (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). A third branch of normative theory and methods – structural characteristics models – has special application to park management and formulation of standards of quality in particular. This work has been based largely on development of the return potential model (Jackson, 1965). In the context of park management this model works by asking survey respondents (e.g., park visitors, residents of surrounding communities, the general public) to evaluate the acceptability of a range of recreation-related impacts to park resources or the quality of the visitor experience. Resulting data are generally graphed so that impacts are displayed on the horizontal axis and evaluations are displayed on the vertical axis. The resulting line connecting the evaluation scores is often called an impact acceptability curve or simply a norm curve. A hypothetical norm curve is shown in Figure 1. In this case, a sample of park visitors might have been asked to rate the acceptability (using a nine-point response scale) of encountering a range of other groups per day while hiking along a park trail.
Norms can be measured for both individuals (personal norms) and groups (social norms). As the terms suggest, personal norms are measures of the standards or evaluations of individuals, while social norms represent shared standards or the evaluations of a group. Social norms are measured by aggregating the evaluation data for members of a group. The resulting line (as illustrated in Figure 1) is often called a social norm curve.

![Hypothetical Social Norm Curve](image)

**Figure 1. Hypothetical Social Norm Curve**

Structural characteristics models of norms can be especially useful in helping to formulate standards of quality for national parks. If park visitors or other interest groups have shared norms for the condition of park resources and/or the visitor experience, then such norms can be studied and used as a basis for formulating standards of quality. This approach to normative theory and methods has been increasingly applied to parks and protected areas (Shelby & Heberlein, 1986; Vaske, Graefe, Shelby, & Heberlein, 1986; Whittaker & Shelby, 1988; Shelby, Vaske, & Harris, 1988; Patterson & Hammitt, 1990; Williams, Roggenbuck, & Bange, 1991; Vaske, Donnelly, & Petruzzi, 1996; Manning, Lime, Freimund, & Pitt, 1996; Manning, Lime, & Hof, 1996; Manning, 1997; Manning, Jacobi, Valliere, & Wang, 1998; Jacobi & Manning, 1999; Manning, 2007).

Application of normative theory and methods to parks involves extension of normative theory and methods as originally conceived (Roggenbuck, Williams, & Bange, 1991; Shelby & Vaske, 1991; Vaske & Whittaker, 2004). Many of these applications address resource and social conditions, not behavior. Moreover, unlike behavior, resource and
social conditions do not appear to be subject to sanctions, nor do they entail an explicit notion of obligation on the part of individuals. However, visitor-caused impacts to park resources and the quality of the recreation experience are a direct consequence of visitor behavior. Moreover, the decision to manage such impacts in relation to socially acceptable levels represents institutional behavior of management agencies such as the U.S. National Park Service. These agencies have an obligation to manage parks and related areas to meet the needs of society, and these agencies are ultimately subject to sanctions (e.g., public disapproval, legal challenge) if they are perceived to fail to live up to this obligation.

As outlined earlier, the hypothetical social norm curve illustrated in Figure 1 is derived from a series of questions that might ask respondents to judge the acceptability of meeting a range of other groups along a trail in a day. The social norm curve is constructed from the mean (or median) acceptability ratings for the sample as a whole and can simply connect these points with a series of straight lines or, as represented in the illustration, can be a regression line, which serves to interpolate between points and “smooth” the curve. A “real” social norm curve is shown in Figure 2. In this example, a representative sample of wilderness hikers in Zion National Park, Utah, were asked to rate the acceptability (on a nine-point response scale) of encountering between zero and sixteen groups of hikers per day along park trails (Manning, Freimund, & Marion, 2004). Average (mean) acceptability ratings were used to construct the resulting social norm curve.

![Figure 2. Social Norm Curve for Groups Encountered per Day for Wilderness Hikers in Zion National Park, Utah](image_url)
Social norm curves have several potentially important features or characteristics that can contribute to their interpretation and usefulness, as illustrated in Figure 1. First, all points along the curve above the neutral point on the acceptability scale – the point on the vertical axis where aggregate evaluation ratings fall out of the acceptable range and into the unacceptable range – define the range of acceptable conditions. All of the conditions represented in this range are judged to meet some aggregate level of acceptability. The optimum or preferred condition is defined by the highest point on the norm curve. This is the condition that received the highest rating of acceptability from the sample as a whole. The minimum acceptable condition is defined as the point at which the norm curve crosses the neutral point on the acceptability scale. This is the point at which aggregate ratings of the condition of the indicator variable fall out of the acceptable range and into the unacceptable range. Norm intensity or norm salience – the strength of respondents' feelings about the importance of a potential indicator – is suggested by the amplitude of the curve or the distance of the norm curve above and below the neutral point of the evaluation scale. The greater this distance, the more strongly respondents feel about the indicator or the condition being measured. High measures of norm intensity or salience suggest that a variable may be a good indicator because respondents feel it is important in defining the quality of park resources or the recreation experience. Crystallization of the norm concerns the amount of agreement or consensus about the norm (Krymkowski, Manning, & Valliere, 2009). The less variance or dispersion of data about the points defining the social norm curve, the more consensus there is about social norms.

Norms can also be measured using a shorter, open-ended question format by asking respondents to report the maximum level of impact that is acceptable or preferable. For example, a representative sample of backpackers in Yosemite National Park, California, was asked to report the maximum number of groups per day they preferred to encounter along park trails (Newman, Manning, & Dennis, 2005). The resulting frequency distribution of responses is shown in Table 1 and Figure 3. A plurality of respondents reported that they preferred to encounter no more than five groups per day, and the vast majority of respondents agreed that it was preferable to encounter no more than ten groups per day. This open-ended question format is designed to be less burdensome to respondents, but it also yields less information.
Table 1. Frequency Distribution of Preferred Number of Encounters per Day on Trails in the Wilderness Portion of Yosemite National Park, California

<table>
<thead>
<tr>
<th>Number of trail encounters</th>
<th>Frequency</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 or less</td>
<td>265</td>
<td>36.9</td>
</tr>
<tr>
<td>6-10</td>
<td>192</td>
<td>63.6</td>
</tr>
<tr>
<td>11-15</td>
<td>76</td>
<td>74.2</td>
</tr>
<tr>
<td>16-20</td>
<td>73</td>
<td>84.4</td>
</tr>
<tr>
<td>21-25</td>
<td>37</td>
<td>89.6</td>
</tr>
<tr>
<td>26-30</td>
<td>25</td>
<td>93.1</td>
</tr>
<tr>
<td>&gt;30</td>
<td>8</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Figure 3. Frequency Distribution of Preferred Number of Encounters per Day on the Trails in the Wilderness Portion of Yosemite National Park, California

**Visual Research Methods**

Normative research as described above relies on an effective means of communication between researchers and respondents. For example, researchers may wish to present a range of visitor-caused impacts (e.g., increasing levels of use, increasing levels of trail impacts) to respondents for their evaluation, or respondents may simply be asked to report the minimum social and environmental conditions they find acceptable in parks and related areas. In many cases, this communication can be conducted in conventional numerical and/or narrative formats. For example, in parks where visitor-use levels are low, it may be reasonable to ask respondents to report the maximum number of
other hiking groups per day it would be acceptable to see along trails. However, where use levels are relatively high, or when the impacts of visitor use are more complex and can be verbally described only in technical terms (e.g., level of trail erosion), visual approaches may be useful.

Visual simulations constructed by using computer-based photo editing programs offer a potentially important research approach that can be applied to measuring standards of quality for parks and related areas, and they offer several potential advantages to narrative/numerical descriptions of certain park and outdoor recreation conditions (Manning & Freimund, 2004). For example, visually based studies can provide pertinent information to respondents that would be difficult or awkward to communicate through conventional narrative/numerical approaches. For instance, in visual studies of crowding, all respondents see not only the same number of visitors encountered, but also potentially important characteristics of those encountered, including recreation activity engaged in, mode of travel, and group size. This is potentially important because perceived crowding has been found to be mediated by such variables (Manning, 1986; Manning, 1999; Manning, Valiere, Minteer, Wang, & Jacobi, 2000). In more conventional narrative/numerical approaches, respondents may have to make assumptions about such characteristics and these assumptions are likely to vary among respondents. Visual research methods also focus directly and exclusively on the variables under study. For example, in visual studies of crowding, the number and type of visitors encountered is the only “treatment” allowed to vary, with all other variables held constant. Visual research methods can be especially useful in studying standards of quality for indicator variables that are difficult or awkward to describe in narrative/numerical terms. For example, visual images of trail and campsite impacts may represent a more powerful and elegant means of communication with respondents than detailed and technical narrative descriptions. Finally, visual images can be edited to present conditions that are difficult to find in the field or that do not currently exist. For example, visual studies of crowding and resource impacts have incorporated images of conditions that do not now exist but will occur in the future as a function of continuing use trends.

Visual simulations have been used increasingly in normative research on standards of quality. For example, in a study at Grand Canyon National Park, Arizona, hikers were asked to rate the acceptability of a series of six computer-edited photographs illustrating a range of use levels on the park’s famous Bright Angel Trail (manifested by persons-per-viewscape or PPV) (Manning, Lawson, Newman, Laven, & Valiere, 2002). Study
photographs are shown in Figure 4. The social norm curve derived from resulting data found that most visitors prefer very low use levels and that aggregate ratings of acceptability fell out of the acceptable range (i.e., crossed the neutral or “0” point on the response scale) at about 8.2 PPV (Figure 5).

Figure 4. Representative Photographs of a Range of Visitor Use Levels on the Bright Angel Trail, Grand Canyon National Park, Arizona

![Representative Photographs of a Range of Visitor Use Levels on the Bright Angel Trail, Grand Canyon National Park, Arizona](image)

Figure 5. Social Norm Curve for the Number of Hikers on the Bright Angel Trail, Grand Canyon National Park, Arizona
Visual simulations have also been used to quantify the effect of recreation conflict on visitor capacity. For example, in a study of a multiple use trail system at Acadia National Park, Maine, a series of computer-edited photographs illustrated a range of use levels and alternative proportions of the two principal user groups – hikers and bicyclists (Manning et al. 2000). Respondents included representative samples of both hikers and bicyclists who were asked to rate the acceptability of each of the study photographs. A series of social norm curves were derived from resulting data as shown in Figure 6. These four social norm curves suggest the ways in which visitor capacity of this multiple use trail system varies depending upon the recreation activities accommodated.

Figure 6. Alternative social norm curves for use level on the Carriage Roads of Acadia National Park, Maine.
As noted earlier, visual research methods have also been applied to selected resource-related impacts of outdoor recreation (Manning et al., 2004; Martin, McCool, & Lucas, 1989; Shelby & Shindler, 1992). For example, ecological research suggests that one of the principal impacts of recreation in wilderness is degradation of campsites through destruction of groundcover vegetation, soil compaction and erosion, injury to trees, and construction of multiple fire rings (Hammit & Cole, 1998; Leung & Marion, 2000). To measure visitor-based standards of quality for these impacts, a series of five computer-edited photographs was prepared illustrating a range of impacts to campsites in the wilderness portion of Yosemite National Park, California. Study photographs are shown in
Figure 7. The photographs were constructed on the basis of data from the park’s long-term Wilderness Impact Monitoring System (Boyers, Cincher, & van Wagendonk, 1999). As part of a larger survey, a representative sample of wilderness visitors was asked to indicate which photograph was most like the campsite conditions they preferred to find, and a frequency distribution of preferred campsite conditions is shown in Figure 8. A strong plurality of respondents (40.8%) preferred to see no more impact than that represented in study photograph 7(a), and a large majority of respondents (67.8%) preferred to see no more impact than that represented in study photograph 7(b). These data provide an empirical basis for helping to formulate standards of quality for resource conditions (at least their aesthetic dimensions) at this park.

![Graph showing frequency distribution of preferred campsite impacts.]

Figure 8. Frequency Distribution of the Preferred Level of Campsite Impacts in the Wilderness of Yosemite National Park, California

**Tradeoffs in Park and Outdoor Recreation Management**

Tradeoffs are an inherent and challenging element of park and outdoor recreation management. Indeed, tradeoffs are at the heart of the concept of visitor capacity: How much and in what ways can we use national parks and related areas while protecting their ecological integrity and social value?
This generic question gives rise to a number of more specific manifestations. Park and outdoor recreation experiences are conventionally thought of as having three basic components: resource conditions (e.g., the amount of human impact at camping sites); social conditions (e.g., the number of other groups camped within sight and sound); and management conditions (e.g., the number of camping permits allowed) (Hendee & Dawson, 2002; Manning, 2011). Visitors to national parks and related areas are often thought to prefer a relatively pristine, natural environment, relatively few encounters with other groups, and a high degree of freedom from management control. While this is the ideal, attempts on the part of park managers to provide ideal conditions along one dimension of the park experience typically involve having to make concessions along one or both of the other dimensions of the park experience. As a result, decisions about how to manage parks involve inherent tradeoffs among the conditions of resource, social, and managerial attributes of the park experience. For example, the number of permits issued for recreational use of a national park could be increased to allow more public access, but this might result in more resource impacts and encounters among groups within the park. Conversely, limiting the number of recreational-use permits issued might reduce resource impacts and encounters among groups but would allow fewer people to use and enjoy the park.

Stated choice modeling has been developed as a survey and related statistical technique to explore tradeoffs among multiple attributes of a good or service and is often applied in several types of consumer research (Green & Srinivasan, 1978). In stated choice modeling, respondents are asked to make choices among alternative configurations of a multi-attribute good (Louviere & Timmermans, 1990). Each alternative configuration is called a profile and is defined by varying levels of selected attributes of the good (or varying standards of quality for relevant indicator variables in the terminology of visitor capacity) (Mackenzie, 1993). For example, in the context of parks and outdoor recreation, respondents might be asked to choose between alternative park settings that vary in the quality of the natural environment, the number of other groups encountered, and the intensity of management regulations imposed on visitors. Respondents' choices among the alternatives are evaluated to estimate the relative importance of each indicator to the overall utility derived from the park setting. Further, stated choice analysis models are used to estimate public preferences or support for alternative combinations of the standards of quality (Dennis, 1998).

Stated choice modeling was applied to study wilderness use in Denali National Park,
Alaska (Lawson & Manning, 2001c; Lawson & Manning, 2002a; Lawson & Manning, 2002b; Lawson & Manning, 2002c). Based on review of the wilderness recreation literature and consultation with park staff, six wilderness indicators were selected to define the resource, social, and management conditions in the wilderness portion of the park. Each of these indicators was further defined by a range of three standards of quality. Indicators and standards used in the study are shown in Table 2. Given three standards for each of the six study indicators, a full factorial design would produce a total of \(3^6\) (729) hypothetical Denali wilderness settings. This number of alternatives is far too large for survey respondents to reasonably consider. Therefore, an orthogonal fractional factorial design was constructed containing nine pairwise comparisons (Seiden, 1954). An example of a representative Denali wilderness setting comparison is presented in Figure 9. Questionnaires were administered to a representative sample of overnight visitors to the wilderness portion of Denali. In each of the nine choice questions included in each version of the questionnaire respondents were asked to read each of the two wilderness-setting descriptions (A and B) and indicate which they preferred.

Table 2. Indicators and Standards of Quality Used in Wilderness Study at Denali National Park, Alaska.

<table>
<thead>
<tr>
<th>Resource conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent and character of hiking trails:</td>
</tr>
<tr>
<td>- Hiking is along intermittent, animal like trails</td>
</tr>
<tr>
<td>- Hiking is along continuous single track trails developed from prior human use</td>
</tr>
<tr>
<td>- Hiking is along continuous trails with multiple tracks developed from prior human use</td>
</tr>
<tr>
<td>Signs of human use at camping sites:</td>
</tr>
<tr>
<td>- Camping sites have little or no signs of human use</td>
</tr>
<tr>
<td>- Camping sites have some signs of human use-light vegetation damage, a few moved rocks</td>
</tr>
<tr>
<td>- Camping sites have extensive signs of human use-bare soil, many rocks moved for wind protection and cooking</td>
</tr>
<tr>
<td>Social conditions:</td>
</tr>
<tr>
<td>- Number of other groups encountered per day while hiking:</td>
</tr>
<tr>
<td>- Encounter 0 other groups per day while hiking</td>
</tr>
<tr>
<td>- Encounter 2 other groups per day while hiking</td>
</tr>
<tr>
<td>- Encounter 4 other groups per day while hiking</td>
</tr>
<tr>
<td>Opportunity to camp out of sight and sound of other groups:</td>
</tr>
<tr>
<td>- Able to camp out of sight and sound of other groups all nights</td>
</tr>
<tr>
<td>- Able to camp out of sight and sound of other groups most nights</td>
</tr>
<tr>
<td>- Able to camp out of sight and sound of other groups a minority of nights</td>
</tr>
<tr>
<td>Management conditions:</td>
</tr>
<tr>
<td>Regulation of camping:</td>
</tr>
<tr>
<td>- Allowed to camp in any zone on any night</td>
</tr>
<tr>
<td>- Required to camp in specified zones</td>
</tr>
<tr>
<td>- Required to camp in designated sites</td>
</tr>
<tr>
<td>Chance of receiving an overnight backcountry permit:</td>
</tr>
<tr>
<td>- Most visitors are able to get a permit for their preferred trip</td>
</tr>
<tr>
<td>- Most visitors are able to get a permit for at least their second choice trip</td>
</tr>
<tr>
<td>- Only a minority of visitors are able to get a backcountry permit</td>
</tr>
</tbody>
</table>
Wilderness Setting A

- Encounter up to 2 other groups per day while hiking.
- Able to camp out of sight and sound of other groups all nights.
- Hiking is along continuous, single track trails developed from prior human use.
- Camping sites have some signs of human use – light vegetation damage, a few moved rocks.
- Required to camp at designated sites.
- Only a minority of visitors are able to get a backcountry permit.

Wilderness Setting B

- Encounter up to 4 other groups per day while hiking.
- Able to camp out of sight and sound of other groups most nights.
- Hiking is along intermittent, animal-like trails.
- Camping sites have some signs of human use – light vegetation damage, a few moved rocks.
- Required to camp at designated sites.
- Most visitors are able to get a backcountry permit for their preferred trip.

Figure 9. Example Wilderness Setting Paired Comparison Question for Denali National Park, Alaska

Responses to the stated choice questions were analyzed using logistic regression analysis to estimate a linear utility-difference model (Hosmer & Lemeshow, 2000; Opaluch, Swallow, Weaver, Wessells, & Wichlins, 1993). The coefficients of the model, together with their standard errors, Wald Chi-Square values, and P values are presented in Table 3. All coefficients are significantly different than zero at the < .001% level, except the coefficients on "up to 2 other groups" and "intermittent animal-like trails." The overall fit of the model is supported by the results of the Hosmer and Lemeshow goodness of fit test ($X^2 = 3.49, p = 0.838$).

The magnitude of significant coefficients reflects the relative importance of the corresponding standard of quality of the indicator to Denali overnight wilderness visitors. The values of the coefficients in Table 3 imply that signs of human use at campsites influence Denali overnight wilderness visitors' utility or satisfaction more than any other wilderness-setting indicator considered in this study. Specifically, campsite conditions characterized as having "extensive signs of human use" are evaluated less favorably by Denali overnight wilderness visitors than any other standard of the six wilderness-setting indicators studied. Additionally, campsite conditions characterized by "little or no signs of human use" are preferred more than any standard of any other wilderness-setting indicator
included in the study.

Table 3. Coefficient Estimates for Wilderness-setting Indicators of Quality at Denali National Park, Alaska.

<table>
<thead>
<tr>
<th>Indicators/Standards</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encounters with other groups per day while hiking:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 other groups</td>
<td>0.440*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 2 other groups</td>
<td>0.065</td>
<td>0.043</td>
<td>2.246</td>
<td>0.134</td>
</tr>
<tr>
<td>Up to 4 other groups</td>
<td>-0.504</td>
<td>0.044</td>
<td>132.826</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Able to camp out of sight and sound of other groups:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All nights</td>
<td>0.295*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most nights</td>
<td>0.145</td>
<td>0.044</td>
<td>11.148</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>A minority of nights</td>
<td>-0.440</td>
<td>0.046</td>
<td>94.814</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hiking is along:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermittent, animal like trails</td>
<td>0.319*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single track trails developed from human use</td>
<td>-0.028</td>
<td>0.044</td>
<td>0.403</td>
<td>0.526</td>
</tr>
<tr>
<td>Multiple track trails developed from human use</td>
<td>-0.291</td>
<td>0.043</td>
<td>46.340</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Camping sites have:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little or no signs of human use</td>
<td>0.582*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some signs of human use</td>
<td>0.207</td>
<td>0.044</td>
<td>22.151</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Extensive signs of human use</td>
<td>-0.790</td>
<td>0.049</td>
<td>264.972</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Regulation of camping:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowed to camp in any zone on any night</td>
<td>0.072</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required to camp in specified zones</td>
<td>0.140</td>
<td>0.048</td>
<td>8.620</td>
<td>0.003</td>
</tr>
<tr>
<td>Required to camp in designated sites</td>
<td>-0.212</td>
<td>0.045</td>
<td>21.946</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chance visitors have of receiving a permit:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most get a permit for their preferred trip</td>
<td>0.073*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most get a permit for at least their second choice</td>
<td>0.143</td>
<td>0.044</td>
<td>10.424</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Only a minority get a permit</td>
<td>-0.216</td>
<td>0.043</td>
<td>24.656</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Coefficients for the excluded standard of the indicator were not estimated by the statistical model. They were calculated as the negative sum of the coefficients on the other two standards of the corresponding indicator.

The magnitude of the coefficient estimates in Table 3 suggest that solitude-related indicators represent a second tier of importance to Denali wilderness visitors. That is, while the number of encounters with other groups per day while hiking and opportunities to camp out of sight and sound of other groups are less important wilderness-setting indicators than campsites impacts, they demonstrate a relatively large influence on Denali overnight wilderness visitors' utility. The extent and character of trails, regulations concerning where visitors are allowed to camp in the Denali wilderness, and the availability of backcountry permits are less important to Denali overnight wilderness visitors relative to campsites impacts and solitude-related indicators of the Denali wilderness.

Analysis of tradeoffs among competing goods using stated choice modeling and other research approaches such as indifference curve analysis can help inform management of
visitor capacity (Lawson & Manning, 2000; Lawson & Manning, 2001a; Lawson & Manning, 2001b; Lawson & Manning, 2002d; Manning, Lawson, & Valiere, 2009). Examples of such applications include insights into the relative importance of potentially competing indicators of quality in national parks and the public acceptability of potentially intrusive management actions designed to control the resource and/or social impacts of visitor use.

**Computer-based Simulation Modeling**

Simulation modeling is the imitation of the operation of a real-world process or system over time (Banks & Carson, 1984; Law & Kelton, 1991; Pidd, 1992; Wang & Manning, 1999). Simulation modeling enables the study of, and experimentation with, the internal workings of a complex system (e.g., a dispersed recreation setting, such as a national park). This approach is especially suited to tasks that are too complex for direct observation, manipulation, or even mathematical analysis.

The first generation of computer simulation modeling applications to parks and outdoor recreation, which came to be known as the *Wilderness Travel Simulation Model* (WTSM), was introduced in the 1970s and continued through the mid-1980s (Borkan & Underhill, 1989; Manning & Potter, 1984; McCool, Lime, & Anderson, 1977; Potter & Manning, 1984; Schechter & Lucas, 1978; Smith & Headly, 1975; Smith & Krutilla, 1976; Underhill, Xaba, & Borkan, 1986; van Wagendonk & Cole, 2005). The WTSM was designed to provide estimates of the number of encounters between recreation groups in a park or wilderness area, including their type (e.g., meeting, overtaking, encounters among different types of user groups), and location. Despite the early success of the WTSM, it fell into disuse largely due to the cost and technical difficulty of running computer simulations (Cole, 2002).

Recent advances in computing technology have made computer simulation modeling more accessible and affordable (Pidd, 1992). With improved computer simulation capabilities, a second generation of applications of computer simulation modeling to park and outdoor recreation management has emerged (Wang & Manning, 1999; Cole, 2005; Gimblett & Skov-Peterson, 2008). This new generation of simulation modeling has been applied in several national parks and related areas to track visitor-use patterns and to assist managers in monitoring and managing visitor capacity and related issues (Daniel & Gimblett, 2000; Gimblett, Richards, & Itami, 2000; Manning et al., 1998; Wang & Manning, 1999; Wang, Manning, Lawson, & Valiere, 2001; Cole, 2005; Gimblett & Skov-Peterson, 2008).
Simulation modeling has many potential applications in park and outdoor recreation planning and management. For example, simulation models of visitor use can provide detailed estimates of the amount and type of visitor use in a park, modeling its spatial and temporal distribution. In parks where visitor use is often dispersed over relatively large areas, and where visitor use can be difficult to observe directly, this type of information can be helpful in planning and managing such use (Cole, Cahill, & Hof, 2005). However, in the context of visitor capacity, simulation modeling can be especially helpful in three ways: monitoring indicator variables, estimating maximum visitor-use levels without violating standards of quality, and testing the effectiveness of management actions designed to maintain standards of quality.

Monitoring indicator variables can be time consuming and costly. Moreover, some indicators, such as trail and campsite encounters, can be inherently difficult to observe. For these reasons, simulation models offer a potentially attractive alternative to on-the-ground monitoring. Once a simulation model is developed, it can be used to estimate the condition of indicator variables.

For example, a simulation model of visitor use of the carriage roads in Acadia National Park, Maine, was developed to help monitor the indicator variable of persons-per-viewscape (PPV) (the number of people at any one time on a typical hundred-meter section of the carriage road system) (Manning et al., 1998; Wang & Manning, 1999; Jacoby & Manning, 1999; Manning & Wang, 2005). The model was constructed using diary reports by visitors of their travel routes and times along the carriage roads, and counts of the number of visitors entering each of the eleven major access points into the carriage road system. These and related data were processed using the commercially available, general purpose, simulation software, Extend. The model was designed to estimate PPV levels along the carriage roads and can be run at any total daily-use level of the carriage road system. The park’s monitoring program measures total daily use of the carriage roads through an electronic trail counter and uses the simulation model to estimate PPV levels (the crowding-related indicator variable) to ensure that crowding-related standards of quality are not violated. (Research to support formulation of crowding-related standards of quality at this area was described earlier in the section on visual research methods.)

Visitor capacity frameworks such as VERP might be described as "reactive" in nature, at least in terms of monitoring and the management implications of resulting data. That is, management actions are taken only when monitoring data suggest that standards
of quality for indicator variables have been violated or are in danger of being violated. Visitor capacity frameworks could be applied more "proactively" by estimating the level of visitor use that will ultimately cause standards of quality to be violated. Simulation modeling of visitor use can be used to make such estimates.

For example, a simulation model of visitor use at Arches National Park, Utah, was developed as part of a research program to help support application of the VERP framework (Lawson, Manning, Valliere, & Wang, 2003; Wang et al., 2001). Initial phases of this research program were used to help formulate a suite of crowding-related indicators and standards of quality throughout the park. For example, at Delicate Arch, an iconic feature of the park, a crowding-related standard of thirty people-at-one-time (PAOT) was set based on findings from a study of visitor-based crowding norms. To account for occasional random surges in visitation, the standard was stated so that PAOT at Delicate Arch should not exceed thirty more than 10% of the time (National Park Service, 1995).

A variety of methods were used to gather data needed to develop the simulation model, including an automobile traffic counter placed at the park entrance and surveys of park visitors which traced their routes of travel through the park. The simulation model was designed to estimate PAOT at Delicate Arch based on the number of cars entering the park. Based on multiple runs, the model estimated that a maximum of 750 vehicles can enter the park each day without violating the crowding-related standard of quality of 30 PAOT at Delicate Arch more than 10% of the time, and this estimate can serve as a visitor capacity.

Simulation modeling can also be used to test the potential effectiveness of management actions designed to maintain standards of quality. For example, the simulation model of visitor use at Arches National Park described above was used to test the potential effect of implementing a mandatory shuttle bus system for hikers to Delicate Arch (Lawson & Manning, 2002d). Public transit systems can be used to control the number and timing of visits to park attraction sites to help ensure that crowding-related standards of quality are maintained.

To test the potential effectiveness of a shuttle bus system, the simulation model was modified to deliver visitors to the Delicate Arch trailhead at regularly scheduled time intervals. Separate model runs were conducted to simulate alternative shuttle bus schedules designed to arrive at the Delicate Arch trailhead every fifteen, thirty, and sixty minutes. For each shuttle bus system simulated, the number of visitors riding the shuttle
bus and hiking to the arch was varied to estimate the maximum number of visitors that could be allowed to hike to Delicate Arch without exceeding the crowding-related standard of quality (no more than thirty PAOT more than 10% of the time) for the arch.

Results of simulation runs conducted to test the effect of implementing a mandatory shuttle bus system to Delicate Arch are reported in Table 4. The data in the third and fourth columns suggest that the daily visitor capacity of the arch could be increased by 29% to 68% if visitors were required to ride shuttle buses to Delicate Arch. For example, the model estimates that a shuttle bus system designed to deliver visitors to Delicate Arch every sixty minutes would increase the daily visitor capacity of the Arch from 315 hikers to 407 hikers. Further, the results suggest that smaller, more frequent shuttle buses would increase the daily visitor capacity of Delicate Arch to an even greater extent. These increases in visitor capacity are due to a more even distribution of visitors over the day.

Table 4. Estimates of Daily Visitor Capacity of Delicate Arch with Mandatory Shuttle System

<table>
<thead>
<tr>
<th>Arrival Interval (min)</th>
<th>Passengers</th>
<th>Estimated daily carrying capacity</th>
<th>Percent increase in carrying capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>37</td>
<td>407</td>
<td>29</td>
</tr>
<tr>
<td>30</td>
<td>21</td>
<td>462</td>
<td>47</td>
</tr>
<tr>
<td>15</td>
<td>12</td>
<td>528</td>
<td>68</td>
</tr>
</tbody>
</table>

**Conclusion**

Visitor capacity is a long-standing, fundamental, and increasingly urgent issue in national parks. How much and what types of recreation can be accommodated in national parks without unacceptable impacts to park resources and the quality of the visitor experience? A growing body of scientific and professional literature has provided the conceptual foundation for a management framework that can guide definition and management of visitor capacity. This framework relies on formulation of management objectives and associated indicators and standards of quality, monitoring indicator variables, and application of management actions designed to maintain standards of quality.

A number of research approaches have been adapted to help inform and support application of visitor capacity. Qualitative and quantitative surveys of visitors and other stakeholders can be used to help identify indicators of quality. Normative theory and
methods can be applied to guide formulation of standards of quality for indicator variables, and visual research methods can be used to add clarity and validity to this process. Stated choice modeling can be used to analyze public preferences for tradeoffs inherent in managing visitor capacity. And simulation modeling can be used to help monitor indicators of quality, estimate visitor capacity, and test the effectiveness of alternative management practices. The studies outlined in this paper illustrate the ways in which these research approaches can and are being used to support management of visitor capacity in the U.S. National Park System.

Armed with a growing body of scientific and professional literature, a related conceptual foundation, an associated management framework, a growing set of supporting research approaches, and a number of hopeful case studies, we are ready to engage the visitor capacity of national parks more aggressively. Of course, this will be challenging and sometimes even contentious. But failure to do so will be even more painful in the long run. Do we want to manage national parks – the crown jewels of our natural and cultural heritage – by design or by default? If we choose not to manage the visitor capacity of national parks, we are implicitly deciding that their current conditions are acceptable and that trends in use and related impacts are not worrisome. We should find comfort and courage in the democratic and civic character of the substance and process outlined in this paper. Management of parks and protected areas should be based on societal values and related norms, not on privilege bestowed by power or even scientific knowledge. Engaging the public in decisions about managing national parks builds trust, ownership, and the “social capital” that engenders public enthusiasm and support (Minteer & Manning, 2003; LaChappelle & McCool, 2005; Manning & Ginger, 2007).

Despite advances in theory and related empirical methods, some measure of management judgment will remain inescapable in defining and managing the visitor capacity of national parks. However, when this judgment is rendered in the context of a rational conceptual foundation and associated management framework, and when it is supported by informed research and related public engagement, it will lead to a program of management that protects both national parks and the public good.

References


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界定與管理國家公園之遊客容量：
美國國家公園系統之研究計畫

Robert E. Manning*

摘要

國家公園可以接待多少遊客而無對於公園資源與遊客體驗品質不可接受之衝擊？遊客容量在於國家公園係為一個屹立不搖與急迫性與日俱增之議題，若干管理架構業已發展藉以協助界定與管理遊客容量。前述架構均同侷限於公園資源與遊客體驗品質指標與標準之方程式。前述架構之應用可以藉由研究計畫使其資訊完備，涵蓋：利益關係人調查、規範理論與方法、視覺研究方法、戶外遊憩權衡分析與電腦模型。前述方法業已應用於美國國家公園系統遊客容量研究之計畫。

【關鍵字】：遊客容量、承載量、戶外遊憩、國家公園

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