**Abstract**

Recreational carrying capacity addresses the issue of how much and what types of recreation can be accommodated in parks and related areas without unacceptable impacts. Contemporary approaches to carrying capacity rely on formulation, monitoring, and management of indicators and standards of quality. Recreational carrying capacity of Lake Umbagog National Wildlife Refuge, located in northern New Hampshire and Maine, was analyzed using visitor surveys that employed normative theory and methods and visual simulations of a range of recreation-related conditions. Study findings suggest that indicators of quality for the visitor experience include the number of boats seen on Lake Umbagog and associated rivers, the size of boating groups, the minimum acceptable chance of seeing selected types of wildlife, and the minimum acceptable chance of catching selected types of fish. Study findings also suggest a range of standards of quality for these indicators. Recreational carrying capacity of Lake Umbagog National Wildlife Refuge can be managed by using study findings to guide formulation of indicators and standards of quality, monitoring indicator variables, and taking management actions to ensure that standards of quality are maintained.

**Keywords:** carrying capacity; Lake Umbagog; normative research

Received: May 5, 2010; Accepted: August 27, 2010; Published Online Early: August 2010; Published: November 2010


Copyright: All material appearing in the *Journal of Fish and Wildlife Management* is in the public domain and may be reproduced or copied without permission. Citation of the source, as given above, is requested.

The findings and conclusions in this article are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

* Corresponding author: robert.manning@uvm.edu

**Introduction**

How much recreational use can be accommodated in parks, wildlife refuges, and related protected areas? This long-standing and increasingly urgent question is often addressed under the rubric of carrying capacity (Manning 2007). The underlying concept of carrying capacity has a rich history in the natural resource professions. In particular, it has been applied in wildlife and range management where it refers to the number of animals that can be maintained in a given habitat (Dasmann 1964). Carrying capacity has obvious parallels and intuitive appeal in the field of outdoor recreation. However, the first rigorous applications of carrying capacity to management of parks and related areas did not occur until the 1960s.

These initial scientific applications suggested that the concept was more complex in this new management context. At first, as might be expected, the focus was placed on the impacts that recreational use can have on natural resources, including trampling of vegetation, soil compaction and erosion, water pollution, and wildlife disturbance (Hammitt and Cole 1998; Leung and Marion 2000). However, it soon became apparent that there was another critical dimension of carrying capacity dealing with the quality of the visitor experience. Wagar (1964), for example, in his early and important monograph on the application of carrying capacity to outdoor recreation, reported that his study “was initiated with the view that 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’s point was that as more people visit a park or related area, not only can the natural resources of the area be affected but the visitor experience can also be affected. For example, increasing recreational use can lead to perceived crowding, conflict among visitors, and aesthetic degradation caused by natural resource impacts (Manning 2010). Thus, as applied to parks and protected areas, carrying capacity has two primary components: resource and social.

A growing body of research has identified a range of resource and social impacts caused by outdoor recreation (Hammitt and Cole 1998; Manning 2010). However, the operative question posed by the issue of carrying capacity is how much impact and associated use should be allowed (Manning 2007). To help answer this question, several carrying capacity frameworks have been developed based on a management-by-objectives approach. Prominent examples of these frameworks include limits of acceptable change (Stankey et al. 1985) and visitor experience and resource protection (Manning 2001). These frameworks rely on formulation of management objectives and associated indicators and standards of quality.

Management objectives are broad, narrative statements that define the degree of resource protection and the type of visitor experience to be provided. Indicators of quality are measurable, manageable variables that reflect the essence or meaning of management objectives; they are quantifiable proxies or measures of management objectives. Indicators of quality may include elements of both the natural and social environments. Standards of quality define the minimum acceptable condition of indicator variables. Once management objectives and associated indicators and standards of quality have been formulated, indicators of quality are monitored and management actions are taken when and where needed to maintain standards of quality.

Research on standards of quality has relied on normative theory and methods developed in sociology and extended to parks and outdoor recreation (Manning 1999; Vaske and Whitaker 2004; Manning 2007). Norms in parks and outdoor recreation are generally defined as standards that individuals and groups use for evaluating environmental and social conditions (Shelby and Vaske 1991; Vaske et al. 1986). If visitors have normative standards concerning relevant aspects of resource conditions and recreation experiences, then such norms can be studied and used as a basis for formulating standards of quality.

Application of norms to standards of quality has followed the work of Jackson (1965), who developed a methodology to measure norms (Vaske and Whitaker 2004; Manning 2007). Using these methods, the personal norms of individuals are aggregated to derive social norms. These social norms are often displayed graphically in the form of social norm curves. Normative research in outdoor recreation has focused largely on the issue of crowding, but it also has been expanded to include other potential indicators of quality, including ecological impacts of outdoor recreation (Manning et al. 2004; Manning 2007).

Traditionally, norms have been measured through a numerical approach. For example, respondents are asked to evaluate the acceptability of alternative use levels, such as a range of groups encountered per day along trails. Resulting data are aggregated to determine social norms. More recently, visual approaches to measuring norms have been developed (Manning et al. 1996; Manning and Freimund 2004). In this technique, computer software is used to develop a set of visual simulations of a range of recreation use levels and associated resource and social impacts.

The approach to carrying capacity described above has been used in an increasing number and variety of parks and protected areas with special emphasis on the national park system (Manning 2007). In this article, this approach to carrying capacity is extended to Lake Umbagog National Wildlife Refuge (Lake Umbagog NWR), located in Coos County, New Hampshire, and Oxford County, Maine, by identifying a suite of indicators and standards of quality for the visitor experience. Lake Umbagog NWR is located in northern New Hampshire and Maine and contains significant natural and recreational resources, including 2,833-ha Lake Umbagog, portions of three rivers flowing in and out of the lake, large areas of wetlands, and upland areas surrounding the lake. It is estimated that the refuge accommodates approximately 50,000 recreation visits annually (U.S. Fish and Wildlife Service 2008).

Methods

Two surveys of visitors to Lake Umbagog NWR were conducted to support formulation of management objectives and associated indicators and standards of quality for the visitor experience at Lake Umbagog NWR. A phase 1 survey was conducted in summer 2006 to identify potential indicators of quality of the visitor experience. The survey used both open- and close-ended questions. An open-ended question asked respondents what they enjoyed most about their visit to the refuge. Responses were coded verbatim and then combined into several broad categories. A follow-up, close-ended question presented respondents with a list of 22 potential issues at Lake Umbagog NWR related to the quality of the visitor experience and respondents were asked to rate the degree to which these issues were thought to be a problem, by using a three-point response scale: “not a problem”, “small problem,” and “big problem.” Respondents also were asked to report the recreation activities in which they engaged. Baseline characteristics of visitors and use patterns also were collected. Sampling was conducted at the four primary access points to the refuge. Interviewers were stationed at these access points on 10 randomly selected days in July and August and asked all visitors to participate in the survey. The sampling days were spread over the days of the week with sampling occurring during daylight
hours. Within each sampling period, a trained surveyor approached each group exiting the site and asked them to participate in the survey. Visitors completed the on-site questionnaire in the presence of the surveyor, who answered any questions that arose and collected the questionnaires upon completion. In total, 256 visitors were approached, and this yielded 197 completed questionnaires representing a 77% response rate. The high response rate minimizes the possibility of nonresponse bias (Vaske 2008; Dillman et al. 2009). The sample size of approximately 200 yields a margin of error of 7% or less at the 95% level of confidence (Lohr 1999).

A phase 2 survey was conducted in 2007 to identify potential standards of quality for indicator variables identified in the phase 1 survey. These indicators were number of boats seen at one time on the lake, number of boats seen at one time on rivers, number of boats seen at one time in fishing coves, size of boating groups, minimum acceptable chance of seeing selected types of wildlife, and minimum acceptable chance of catching selected types of fish. The same survey and sampling methods as described above were used. In total, 254 visitors were approached, and this yielded 193 completed questionnaires representing a 76% response rate. Once again, the high response rate minimizes the possibility of nonresponse bias. Data from the phase 2 survey were used to derive a series of norm curves (described below). The level of agreement (or “crystallization”) about the points that describe these norm curves can be measured using Van der Eyk’s A (Van der Eyk 2001; Krymkowski et al. 2009). The A statistic is always between −1 and +1, with −1 indicating complete disagreement, +1 complete agreement, and 0 uniformly distributed responses across all values of the response scale. Baseline characteristics of visitors and use patterns also were collected.

Three series of visual simulations were used to measure standards of quality for the number of boats seen in three contexts: on the lake, on rivers, and in fishing coves. For the lake, six study photographs (mounted on 61 cm × 91 cm poster boards) were used showing a range of 0 to 20 boats, each with an even distribution of motorboats and nonmotorboats (Figure S1, http://dx.doi.org/10.3996/052010-JFWM-011.S1). Respondents were asked to rate the “acceptability” of each photograph on a 9-point scale bounded by −4 (“very unacceptable”) and 4 (“very acceptable”), with a neutral point of 0. Respondents also were asked to report the study photograph that showed the number of boats they 1) would prefer to see (“preference”), 2) would find so unacceptable they would no longer visit Lake Umbagog NWR (“displacement”), 3) felt should be allowed to use the lake before visitors were restricted from using the area (“management action”), and 4) thought looked most like the number of boats they typically saw on the lake on the day they were surveyed (“typically seen”). A series of six photographs (mounted on 61 cm × 91 cm poster boards) also were used to present a range of boats on refuge rivers (Figure S2, http://dx.doi.org/10.3996/052010-JFWM-011.S1). The number of boats ranged from 0 to 15, each with and even (or near even) distribution of motorboats and nonmotorboats. Respondents were asked the same series of questions as described above. A series of six study photographs (mounted on 61 cm × 91 cm poster boards) also were used to present a range of fishing boats in a generic cove on Lake Umbagog (Figure S3, http://dx.doi.org/10.3996/052010-JFWM-011.S1). The number of boats ranged from 0 to 20. Respondents were asked the same series of questions as described above.

Standards of quality for group size of boaters (number of boats in a group of visitors) were measured by asking respondents to rate the acceptability (using the 9-point response scale described above) of groups that ranged from 1 to 10 boats. Standards of quality for seeing wildlife were measured by asking respondents in an open-ended series of questions to report the minimum acceptable percentage of visitors who should be able to see each of several types of wildlife while visiting Lake Umbagog NWR. Standards of quality for catching fish were measured in a similar way: respondents were asked to report the minimum acceptable percentage of visitor who should be able to catch several species of fish.

**Results**

Baseline characteristics of visitors and use patterns were quite similar across the two surveys (Supplemental Material, Table S1, http://dx.doi.org/10.3996/052010-JFWM-011.S2). In the phase 1 survey, the majority of visitors (92.1%) were from the New England states, most (60.9%) were male, and the average group size was 3.6 people. Most visitors (67.2%) had been to Lake Umbagog NWR before, and repeat visitors have been visiting the area for an average of 11 y and have visited an average of six times in the past 12 mo. On average, visitors spend nearly 5 h/d in Lake Umbagog NWR, and approximately one-third of visitors camp at either the state park campground at the southern end of Lake Umbagog or at one of the remote campsites on the lake shore. The most popular recreation activities were viewing wildlife (85.8%); paddling (63.5%); swimming (52.8%); photography (52.3%); camping (49.7%); motorboating (41.1%); and fishing for bass (47.2%), trout and salmon (26.4%), and other fish (27.4%).

Four categories of variables were mentioned by more than 10% of visitors for what they enjoyed most about their visit: seeing wildlife and catching fish (22.4%); enjoying a specific recreation activity (e.g., boating, fishing; 20.9%); enjoying the peaceful, uncrowded character of the area (15.8%); and enjoying the natural beauty of the area (12.6%). The follow-up, close-ended question found that the three most problematic issues all related to motor boats—their number, noise, and speed on the lake and on rivers.

Visitor responses to the series of normative questions are shown in Figures 1–4 and Tables 1 and 2. The values for “acceptability” in Table 1 are the point at which the social norm curves cross the neutral point of the acceptability scale (i.e., the point at which the aggregate ratings of acceptability fall out of the acceptable range and into the unacceptable range). Levels of agreement...
for boating-related standards of quality (as measured by Van der Eyk’s A) are moderate to high, and most respondents reported that they saw fewer boats than the maximum number acceptable suggesting that recreational carrying capacity has not been exceeded.

**Discussion**

Study findings provide empirical guidance to help formulate a suite of indicators and standards of quality for analyzing and managing recreational carrying capacity at Lake Umbagog NWR. The popularity of wildlife viewing and fishing as recreational activities, along with open-ended comments of visitors noting that seeing wildlife and catching fish were the most enjoyable aspects of visiting Lake Umbagog NWR, suggests that opportunities to see wildlife and catch fish are potentially good indicators of quality for this area. Moreover, the number of boats on the lake and on rivers and associated issues of speed and noise of motorboats were reported by visitors as the most problematic issues, suggesting that the number of boats and size of boating groups using Lake Umbagog also may be important indicators of quality.

A range of standards of quality were identified for these indicator variables. Using visual simulations of a...
range of boats in three contexts (on the lake, on rivers, and in fishing coves), respondents reported a series of standards of quality that ranged from the number of boats they preferred to see to the number of boats that would cause them to stop visiting the area (Table 1). A standard of quality in the low end of these ranges would provide a very high-quality visitor experience but may ultimately limit the number of visitors who can use the area. A standard of quality in the high end of the ranges would allow substantial public access, but the quality of the visitor experience may be relatively low. The “management action”-based standard has some special appeal in that it explicitly asks respondents to consider the inherent trade-offs between quality and access. The question asked respondents: “Which photograph shows the highest level of use you think should be allowed on the lake? In other words, at what point should visitors be restricted from using the lake?”

However, other points along the range of potential standards of quality also might be selected, depending upon management objectives for the area and other considerations. For example, the relatively remote location of Lake Umbagog NWR may suggest that management emphasize opportunities for solitude and intimate contact with nature, thus selecting standards of quality that will provide a very high quality of experience for these values. Decisions about standards of quality also might consider the objective of providing a diversity

Figure 3. Social norm curve for number of fishing boats seen at one time in a generic cove of Lake Umbagog. Photographs illustrating a range of fishing boats in fishing coves on Lake Umbagog are shown in Figure S3 (http://dx.doi.org/10.3996/052010-JFWM-011.S1). The social norm curve traces the mean acceptability rating for each of the study photographs.

Figure 4. Social norm curve for boating group size on Lake Umbagog and associated rivers. The social norm curve traces the mean acceptability rating for each of the boat group sizes.
of visitor experiences at Lake Umbagog NWR or even throughout wildlife-oriented recreation areas in the broad geographic area. This spatial zoning approach may be effective in meeting potentially wide-ranging demands for outdoor recreation among the public by providing a spectrum of recreation opportunities from which people can choose. This approach is in keeping with the Recreation Opportunity Spectrum framework designed to encourage diverse recreation opportunities (Clark and Stankey 1979) and the goal of providing for the needs of a diverse public (Manning 2010). Formulation of standards of quality also should consider opportunities and constraints posed by natural resource considerations, such as the sensitivity of wildlife species and other environmental resources.

The contemporary carrying capacity frameworks described at the beginning of this article require that indicators of quality be monitored and management actions taken when needed to help ensure that standards of quality are maintained. The indicators of quality identified in this study could be monitored in several ways. Periodic visitor surveys could be conducted asking respondents to report the types of wildlife seen and catch rates for selected species of fish. The study photographs illustrating a range of boats on the lake, on rivers, and in fishing coves also could be used by simply asking visitors to report the photograph that looks most like what they experienced on the day of the survey. This approach was used in the phase 2 survey, and resulting data suggest that current use levels are relatively low compared with standards of quality, as reported here. Alternatively, refuge staff could monitor the number of boats directly through observation or photography.

A diverse array of management actions might be used to help ensure that standards of quality are maintained. The professional literature in outdoor recreation suggests four basic strategies for managing outdoor recreation: increase the supply of opportunities, reduce the demand, reduce the impact of use, and increase the durability of the resource (Manning 2010). A wide variety of tactics or specific management practices are available within each of these strategies. Examples include visitor information and education programs, providing hardened facilities such as trails and campsites, and establishing a visitor permit system. Managing the percentage chance of seeing wildlife and catching fish may be especially challenging given the mobility of wildlife, changing environmental conditions, and variation in visitor use levels and behavior (Anderson et al. 2010). However, advances in research on the relationships between visitor use levels and behavior and the presence of wildlife may enhance the ability of managers to make informed decisions.

Table 1. Summary table for standards of quality for boating on Lake Umbagog.

<table>
<thead>
<tr>
<th>No. of boats seen at one time on Lake Umbagog</th>
<th>Mean</th>
<th>Median</th>
<th>Agreementa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptability</td>
<td>13.1</td>
<td>0.9–0.85</td>
<td></td>
</tr>
<tr>
<td>Preference</td>
<td>5.7</td>
<td>4.0</td>
<td>0.45</td>
</tr>
<tr>
<td>Displacement</td>
<td>16.8</td>
<td>20.0</td>
<td>0.68</td>
</tr>
<tr>
<td>Management action</td>
<td>11.5</td>
<td>12.0</td>
<td>0.41</td>
</tr>
<tr>
<td>Typically seen</td>
<td>8.0</td>
<td>8.0</td>
<td>0.51</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of boats seen at one time on refuge rivers</th>
<th>Mean</th>
<th>Median</th>
<th>Agreementa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptability</td>
<td>8.2</td>
<td>0.07–0.89</td>
<td></td>
</tr>
<tr>
<td>Preference</td>
<td>4.1</td>
<td>3.0</td>
<td>0.50</td>
</tr>
<tr>
<td>Displacement</td>
<td>11.0</td>
<td>10.5</td>
<td>0.38</td>
</tr>
<tr>
<td>Management action</td>
<td>7.3</td>
<td>6.0</td>
<td>0.60</td>
</tr>
<tr>
<td>Typically seen</td>
<td>4.3</td>
<td>3.0</td>
<td>0.64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of fishing boats seen at one time in a generic cove of Lake Umbagog</th>
<th>Mean</th>
<th>Median</th>
<th>Agreementa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptability</td>
<td>14.7</td>
<td>0.11–0.86</td>
<td></td>
</tr>
<tr>
<td>Preference</td>
<td>6.6</td>
<td>8.0</td>
<td>0.38</td>
</tr>
<tr>
<td>Displacement</td>
<td>15.7</td>
<td>16.0</td>
<td>0.56</td>
</tr>
<tr>
<td>Management action</td>
<td>10.8</td>
<td>8.0</td>
<td>0.45</td>
</tr>
<tr>
<td>Typically seen</td>
<td>5.6</td>
<td>4.0</td>
<td>0.58</td>
</tr>
</tbody>
</table>

a Van der Eyk’s A statistic.

Table 2. Summary table for minimum acceptable percentage chance of seeing wildlife and catching fish at Lake Umbagog National Wildlife Refuge.

<table>
<thead>
<tr>
<th>Minimum % chance</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>See loon</td>
<td>61.7</td>
<td>70.0</td>
</tr>
<tr>
<td>See eagle</td>
<td>51.5</td>
<td>50.0</td>
</tr>
<tr>
<td>See osprey</td>
<td>50.6</td>
<td>50.0</td>
</tr>
<tr>
<td>See waterfowl</td>
<td>67.8</td>
<td>75.0</td>
</tr>
<tr>
<td>See moose</td>
<td>43.8</td>
<td>30.0</td>
</tr>
<tr>
<td>Catch bass</td>
<td>61.9</td>
<td>50.0</td>
</tr>
<tr>
<td>Catch trout and salmon</td>
<td>43.2</td>
<td>30.0</td>
</tr>
<tr>
<td>Catch other fish</td>
<td>56.2</td>
<td>50.0</td>
</tr>
</tbody>
</table>
Recreational Carrying Capacity of Lake Umbagog

to address this issue (Klein et al. 1994; Monz et al. 2004). Managers also might increase chances of encountering wildlife by educating visitors about optimum locations and times for wildlife viewing and fishing.

Recreational carrying capacity is a challenging but increasingly important issue in management of parks and protected areas. The information developed in this study offers an empirical basis for analyzing and managing recreational carrying capacity at Lake Umbagog NWR and other units of the NWR System. Specifically, it identifies indicators and standards of quality for the visitor experience. Once indicators and standards of quality have been formulated, indicator variables should be monitored and management actions taken to ensure that standards of quality are maintained. In this way, recreational carrying capacity can be defined and managed.

Until more studies like this are conducted, it is difficult to generalize study findings to other, related areas. Other studies of water-oriented outdoor recreation in the same geographic region, for example, have found that the ability of visitors to camp out of sight and sound of others is an important indicator of quality (Daigle et al. 2003; Daigle 2004). However, this was not important to visitors to Lake Umbagog NWR, perhaps because camping is allowed only at designated campsites. This article addresses the social component of carrying capacity, but this is an important dimension of managing NWRs because they receive more than 35 million visitors each year and wildlife-dependent recreation in these areas is recognized as a legitimate and appropriate use of the NWR System (Carver and Caudill 2007). Moreover, there may be strong connections between the resource and social components of carrying capacity, including societal judgments about the minimum acceptable environmental conditions in NWRs.

Supplemental Material

Please note: The Journal of Fish and Wildlife Management is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author.

**Figure S1.** Study photographs showing a range of boats seen at one time on Lake Umbagog. Photographs (28 cm × 19 cm) were mounted on poster boards for the survey, ensuring the number of boats was plainly evident.

**Figure S2.** Study photographs showing a range of boats seen at one time on refuge rivers. Photographs (28 cm × 19 cm) were mounted on poster boards for the survey, ensuring the number of boats was plainly evident.

**Figure S3.** Study photographs showing a range of fishing boats seen at one time in a generic cove of Lake Umbagog. Photographs were mounted on poster boards (45 cm × 14 cm) for the survey, ensuring the number of boats was plainly evident.

All figures found at DOI: 10.3996/052010-JFWM-011.S1 (222 KB PDF).

**Table S1.** Phase 1 and phase 2 data archive.

Found at DOI: 10.3996/052010-JFWM-011.S2 (238 KB XLS).

Acknowledgments

Appreciation for assistance in conducting this study is expressed to Lake Umbagog National Wildlife Refuge staff Paul Casey and Laurie Wunder and to Carol Foss of New Hampshire Audubon. The Subject Editor and two anonymous reviewers provided helpful comments on this article.

References


