Research to Support Management of Visitor Carrying Capacity of Boston Harbor Islands

ROBERT MANN1, YU-FEI LIAO1, AND MEGHNA BUDER2

Abstract: Visitor carrying capacity has been a long-standing issue in management of parks and protected areas. Contemporary carrying capacity frameworks rely on formulations of indicators and standards of quality to define and manage carrying capacity. This paper describes a program of research to support management of carrying capacity of the Boston Harbor Islands national park area, a sweet addition to the national park system. Research included: (1) an inventory and analysis of recreation-related resource impacts on selected islands, and (2) surveys of visitors to islands open to public use. Study findings are being incorporated into a visitor carrying capacity management plan through formulation of indicators and standards of quality for the park's natural resources and visitor experience.

Introduction

Visitor carrying capacity

The question of how much public use can be accommodated in a park or protected area is often framed in terms of carrying capacity. Indeed, much has been written in both the scientific and popular literature about the carrying capacity of parks and protected areas (e.g., Manning 2001, Mitchell 1994, Stanley and Manning 1986, Williamson 1995). 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 (Daubenmire 1966). Carrying capacity has obvious parallels and intuitive appeal in the field of park management. 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 relationship between visitor use and natural resource impact. The working hypothesis was that increasing numbers of visitors cause greater impact on natural resources, as measured by soil degradation, vegetation damage, and related variables (Hammit and Cole 1998). However, it soon became apparent that there

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The early work on carrying capacity has since blossomed into an extended literature on the resource and social impacts of visitor use and their application to carrying capacity (e.g., Crane et al. 1984; Hauk 2001; Haunton and Cole 1998; Kass et al. 1999; Leong and Martin 2000; License and Stankey 1997; Manning 1985, 1999; Shelby and Huberlin 1986, Stankey and Lim 1973). But despite this growing scientific literature, efforts to determine and apply visitor carrying capacity have sometimes failed. The principal difficulty lies in determining how much impact, such as trail erosion and crowding, is too much. Theoretical development, backed up by empirical research, generally confirms that increasing visitor use leads to increased resource and social impacts. But how much impact should be allowed? This basic question is often referred to as the "limits of acceptable change." (Fissell and Stankey 1972). Given substantial demand for public use of parks and related areas, some decline or change in the quality of natural resources and the visitor experience appears inevitable. But how much decline or change is acceptable or appropriate before management intervention is warranted?

As illustrated in Figure 1, two hypothetical relationships between visitor use and natural resource and social impacts (represented by line A and curve B), show that visitor use and impacts are related: increasing amounts of use create increasing impact. However, it is not clear at what point carrying capacity has been reached. The hypothetical relationships in Figure 1 suggests that some impact is inevitable, given even relatively low levels of visitor use. Thus, some level of impact must be tolerated if parks and related areas are to remain open for public use. For the relationship defined by line A, X, and Y represent levels of visitor use that result in differing levels of impacts, as defined by points Y1 and Y2, respectively. But which of these points—Y1 or Y2, or some other point along this axis—represent the maximum amount of impact that is acceptable? Again, the difficulty in carrying capacity determination lies in deciding how much
impact is acceptable. Empirical relationships such as those in Figure 1 can be helpful in making informed decisions about carrying capacity, but they must be supplemented with other information.

To determine acceptable levels of visitor carrying capacity, some have suggested distinguishing between descriptive and evaluative (or prescriptive) components of carrying capacity (Sheby and Heberlein 1984, 1986). The descriptive component focuses on actual, objective data such as the types of relationships in Figure 1. For example, what is the relationship between the number of visitors entering a park and the number of encounters that occur among groups of visitors? Or what is the relationship between the level of visitor use and visitors’ perceptions of crowding? The evaluative or prescriptive component of carrying capacity determination concerns the seemingly more subjective issue of how much impact or change in resource conditions and the quality of the visitor experience is acceptable. For example, how many contacts between visitor groups are acceptable? What level of perceived crowding should be allowed before management intervention is needed?

Recent experience with carrying capacity suggests that answers to the above questions can be found through formulation of management objectives and development of associated indicators and standards of quality (Belsap 1998; Graefe et al. 1990; Manning 1997, 1998, 2001; Manning et al. 1998; National Park Service 1997; Stankey et al. 1985). This approach

![Figure 1. Hypothetical relationships between visitor use and ecological and social impacts.](image-url)
to carrying capacity puts principal emphasis on defining the degree of resource protection and the type of visitor experience to be provided and maintained, monitoring conditions over time, and adopting management practices to ensure that acceptable conditions have been maintained.

Management objectives are broad, narrative statements that define the degree of resource protection and the type of visitor experience to be provided. They are based on the purpose and significance of the area under consideration. 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 environment. Standards of quality define the minimum acceptable condition of indicators.

Examples of management objectives and indicators and standards of quality may be helpful. Review of the US Wilderness Act of 1964 suggests that areas of the national wilderness preservation system are to be managed to provide opportunities for visitor solitude. Thus, providing opportunities for solitude is an appropriate management objective for most wilderness areas. Moreover, research on wilderness use suggests that the number of visitors encountered along trails and at campsites is important to wilderness visitors in defining solitude. Thus, trail and camp encounters may be good indicators of quality and help to make the general management objective of solitude more operational. Further research suggests that wilderness visitors may have normative standards about how many trail and camp encounters are acceptable before the quality of the visitor experience declines to an unacceptable degree (Heterlein et al. 1986; Lewis et al. 1996; Munling et al. 1996a, 1996b, 1999; Kugensberg et al. 1991; Shelby and Vaske 1991; Vaske et al. 1980; Whittaker and Shelby 1988). Such data may help define standards of quality. A similar example for the natural resource component of carrying capacity relates to the wilderness management objective of preserving ecological conditions. Research on the ecological impacts of recreation suggests that destruction of ground-cover vegetation and compaction of soil is a common impact of recreation at wilderness campsites (Hammit and Cole 1998; Lawing and Marion 2000). Therefore, human exposure at campsites may be a good indicator of resource quality. The selection of a standard of quality in this case is guided primarily by visitor impact research, but is also influenced by social science research, particularly on the effect of human impact on the quality of the visitor experience (Shelby and Vaske 1989).

While the above examples of management objectives and associated indicators and standards of quality apply to wilderness areas, recent studies have extended the research and management approach to a variety of more developed parks and related areas (Munling et al. 2002, 2003). Research at Boston Harbor Islands was designed to further extend this work.
By defining indicators and standards of quality, carrying capacity can be determined and managed through an associated program of monitoring and management. Indicators of quality can be monitored and management actions taken to ensure that standards of quality are maintained. If monitoring suggests that standards of quality have been violated (or may soon be violated), then carrying capacity has been exceeded and management actions (such as modifying type and amount of use, visitor education or regulation) may be required. This basic approach to carrying capacity is central to contemporary park and protected area management frameworks, including Limits of Acceptable Change (LAC) (Stankey et al. 1985), Visitor Impact Management (VIM) (Giraze et al. 1990), and Visitor Experience and Resource Protection (VERP) (Manning 2001, National Park Service 1997).

Application to Boston Harbor Islands
The concept of carrying capacity was applied to Boston Harbor Islands national park area through a program of research and planning. This program included three components: (1) natural science research, (2) social science research, and (3) preparation of a carrying capacity plan incorporating research findings. In keeping with the contemporary approach to carrying capacity described above, this program of research and planning was directed at formulating a series of indicators and standards of quality for park resources and the visitor experience.

The natural resources of the national park area and its cooperative administration are described elsewhere in this issue. Visitation to the park has been increasing due to its growing popularity among local communities, improved transportation, and promotion by the Boston Harbor Islands Partnership. In 2002, the park recorded 262,000 recreational visits (Boston Harbor Islands Partnership, unpubl. data).

Methods

Natural science research
This component of research focused on identifying and developing resource-based indicators of quality (or resource impact indicators) and related monitoring procedures as well as assisting in the formulation of standards of quality for selected indicator variables. Major research activities included identification of potential indicators from various sources, inventory and condition assessment of trails and recreation sites in 2001, evaluation of other ecological indicators of quality in 2002, and evaluation and selection of indicator variables in 2003.

First, official and unofficial sites and trails were identified. Official sites and trails are those designated and clearly identified by the management agency, while unofficial sites and trails (also referred to as social trails) are visitor-created and are not identified by the management agency.
While locations of all official recreation sites were known, unofficial sites were searched extensively on all islands subject to public use as suggested by past staff and local experts. For official and unofficial recreationists, a multiple-indicator assessment approach was adopted (Cly 1989, Leung and Marion 2000, Marion et al. 1991, Marion and Leung 1997). The procedures began with a delineated recreation site boundaries within which impact indicators were assessed. Inventory information, including GPS coordinates, site position on landscape, distance to water, distance to trail, and vegetation canopy cover, were quantitated. Impact indicators assessed included a five-point condition class rating, area of disturbance based on site size measurements, vegetative ground cover on-site and off-site controls, mineral soil exposure, tree damage (three categories), root exposure, trash, human waste, and vegetation parameters. A simplified version of the assessment procedures was applied to rest-viewing areas which are usually small with only beach visitors for facilities.

For condition assessment of official trail an integrated approach was adopted, combining sampling-based point measurements and a census of problem events (Leung and Marion 1999, Marion and Leung 2001). Assessments were conducted for the entire length of each trail segment under study. Field staff pushed a measuring wheel along the trail while stopping every 60 ft (20 m) to perform pulse-based measurements such as width, section depth, and tree sub-base composition. Field staff also documented each occurrence of pre-defined problem events such as excessive soil erosion, root exposure and muddy soil. A more rapid approach was adopted for social trails, on which only length and overall condition rating were collected (Cote et al. 1997, Leung et al. 2002).

A series of field measurements was conducted in the summer of 2002 to evaluate additional ecological indicators commonly used in recreation ecology research (Hammitt and Cote 1998, Leung and Marion 2000). Quadrat-based and continuous line-transect measurements were applied within twelve circular sampling plots on Georges, Peddocks, and Gaspe Islands, six of which were indicative of high-use areas and the other six representing relatively low-use areas. Initial measurements were conducted in June 2002, with remeasurements performed in August and October 2002. Major ecological indicators assessed included percent cover of ground vegetation, plant litter and exposed soil, soil compaction as measured by penetration resistance (Lowery and Morrison 2002), and soil stability as measured by the skate test in which soil aggregates/fragments are subjected to rapid wetting cycles (Dauw and Jones 1999).

Results from site-level assessments and ecological indicator evaluations provide the baseline data for the park, and they were utilized to inform the design of monitoring programs. Baseline data are a critical component of monitoring, providing the initial (and often temporal) data against which future trends can be measured. Monitoring protocols were also developed for the selected indicator variables.
Social science research

Social science research included two surveys of park visitors. The first survey was designed to identify potential indicators of quality of the visitor experience. In summer 2000, randomly selected park visitors returning on ferries from the islands, were administered a questionnaire that included a series of questions on what they enjoyed most and least during their visit to Boston Harbor Islands. Following this series of questions, respondents were asked to judge the degree to which a series of issues (e.g., crowding, litter) were problems at the park. The survey resulted in 595 completed questionnaires.

The second survey, conducted in summer 2001, was designed to measure normative standards of quality of visits for selected indicator variables. Norms in parks and outdoor recreation are generally defined in standards that individuals and groups use for evaluating behavior and social and environmental conditions (Donehely et al. 1992; Shelby and Vasse 1991; Vasse et al. 1986). If visitors have normative standards concerning relevant aspects of park conditions and recreation experiences, then such norms can be studied and used as a basis for formulating standards of quality. Developed in sociology, normative theory and methods have attracted considerable attention as an organizing concept in park and outdoor recreation research and management. In particular, normative research has special application in helping to formulate standards of quality for both resource and social conditions in parks and related areas.

Application of norms to standards of quality is most fully described by Shelby and Heberlein (1986), Vasse et al. (1986), and Manning (1999), with their applications relying on the work of Jackson (1965), who developed a methodology to measure norms. Using these methods, the personal norms of individuals can be aggregated to determine social norms. Normative research has focused largely on the issue of crowding (e.g., Heberlein et al. 1986; Manning et al. 1995a, 1995b, 1998; Paterson and Hammit 1990; Shelby 1981; Vasse et al. 1986; Williams et al. 1991; Whittaker and Shelby 1981), but also has been expanded to include other potential indicators of quality, including ecological impacts at camp sites (Shelby et al. 1988).

Traditionally, norms have been measured through a numerical approach. For example, respondents are asked to evaluate the acceptability of alternative use levels, such as zero, five, or ten encounters with other groups per day along trails. Resulting data are aggregated to determine social norms. More recently, visual approaches to measuring norms have been developed (Hof et al. 1994; Manning et al. 1995, 1996a, 1996b). In this technique, computer software is used to manipulate photographs to depict alternative use levels and associated resource and social impacts.

Both numerical and visual approaches to norm measurement were incorporated into questionnaires administered to random samples of
visitors to the seven islands where visitor services were provided in the summer of 2001. The survey resulted in 724 completed questionnaires.

Results

Natural science research

Field assessment procedures of potential recreation site and trail impact indicators were developed and applied to 22 islands (and former islands) with established or possible recreational use. A total of 144 sites were assessed in 2001, including 83 official picnic or camping sites, 21 unofficial recreation sites, and 41 rest/weekend areas. The majority of recreation sites had modest site size or area of disturbance (Fig. 2). Official sites contributed to more than 90% of the cumulative area of disturbance (46,680 m² or 4.7 ha; 11.5 acres) for the entire park. There were several very extensive official sites on Georges, Lovell, and Dompkin Islands, with the largest one being 6970 m² in size. Unofficial sites, most of which were created for overnight use, were generally small, ranging from 16 to 265 m² with a median of 49 m². A limited number of large official sites may be necessary on public use islands to support high levels of use with large groups. These sites, if appropriately located and maintained, are not generally considered an unacceptable resource impact issue unless they show signs of inappropriate degradation as indicated by

![Figure 2. Frequency distribution and descriptive statistics for site size (area of disturbance) of official recreation sites.](image-url)
site expansion, excessive loss of grasslands vegetation, and increased soil exposure. The existence and size of unofficial sites, however, is indicative of unacceptable visitor-induced resource impacts that require management attention.

Mineral soil exposure appears to be more pronounced on unofficial recreation sites, with about 68% of unofficial sites exhibiting 61% or more exposed soil on site. This indicates a potential impact concern to natural resources associated with soil degradation and specifically soil erosion. In contrast, about 30% of official sites had 36% or more exposed soil. However, when the total extent of soil exposure was considered (recreation site size × percent soil exposure), official sites exhibited more cumulative impact with a total of 4288 m² of exposed soil while the sum of unofficial sites was only 632 m². Damage to tree trunks was found to be more common on official recreation sites than on unofficial counterparts. The typical official site has two damaged tree (median value), while just one damaged tree on the typical unofficial site.

A total of 36 official trails (30 km) and about 36 km of visitor-created social trails were identified and assessed in 2011. Results suggest that soil erosion, root exposure, and other resource impacts existed on improved park trails, but the extent of these problems was limited (Table 1). For example, the cumulative length of eroded trail treads amounted to 372 m, which was only 1.92% of total length of trails surveyed. Despite this, several soil erosion and root exposure segments were rather long and, they may have compromised the trail's transportation function and visitor experience. The density of social trails was higher on World's End with 205 meters per hectare of unit area (277 feet per acre), followed by Georges (179 m/ha, 236 ft/acre) and Raccoon (154 m/ha, 201 ft/acre) Islands. High densities of social trails may suggest proliferation of unmanaged recreational trampling with potential threats to sensitive habitats.

Spatial proximity of social trails and unofficial sites to sensitive habitats was evaluated using geographic information systems. Field data (Table 1) show that a small percentage of social trails exist at or near these habitats. The data indicates that trails intersecting or close to these habitats are not a significant concern.

### Table 1: Assessment results of improved official and social trails on the Housatonic River

<table>
<thead>
<tr>
<th>Trail feature</th>
<th>No. of</th>
<th>% of trails</th>
<th>Length of problem segments (m)</th>
<th>Mean ± Standard Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate patches</td>
<td>5</td>
<td>1.60</td>
<td>11.9 ± 2.7</td>
<td>21.8 ± 6.3</td>
</tr>
<tr>
<td>Soil erosion</td>
<td>15</td>
<td>4.70</td>
<td>24.8 ± 1.5</td>
<td>25.2 ± 7.5</td>
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<tr>
<td>Root exposure</td>
<td>10</td>
<td>3.16</td>
<td>10.6 ± 3.5</td>
<td>11.2 ± 4.1</td>
</tr>
<tr>
<td>Muddy soil</td>
<td>12</td>
<td>3.65</td>
<td>4.5 ± 1.5</td>
<td>7.3 ± 1.9</td>
</tr>
</tbody>
</table>

*Note: Ratios are based on the total number of trails surveyed in each area.*
researchers identified 141 of social trails and three unofficial sites within 50 m of known habitats of sea turtles and endangered species, including the stellate dune plant (Kunzea pulchella L.), Least Tern (Sterna antillarum Bidlow), and Great Egret (Ardea alba L.). Final data of the 2002 assessment exhibited a considerable variability in soil compaction and ground cover measurements, while soil stability (slake test) measurements suggested considerable homogeneity among sampling sites, indicating non-responsive trail use by visitors.

The degree of soil compaction, as measured by penetration resistance, at Briston Harbour Islands was less pronounced than that reported in previous impact studies in the East (Marion and Cole 1996). This may be partly attributed to higher background soil compaction levels, which are in turn influenced by glacial parent materials and a long history of human activities on these islands. The average penetration resistance (pocket penetrometer) values ranged from 1.5 kg/cm² on Grapesh Island to 3.0 kg/cm² on Georges Island. Soil compaction was higher on use areas than off-site controls, with penetration resistance increased by 51% on Georges Island’s low use plots and by 144% on Grapesh Island’s low use plots.

Social science research

The first visitor survey identified seven potential indicators of quality number of people-at-one-time (PAOT) at selected attraction sites, number of groups encountered per hour while hiking, environmental impact to trails, environmental impact to campsites, amount of litter, amount of graffiti, and smoothness and quality of information about the park. These variables are related to both the resource and social conditions of the park and were reported by visitors as important in determining the quality of the visitor experience.

The second visitor survey identified a range of potential standards of quality for these seven indicator variables. Two of these indicator variables will be used to illustrate study findings: visitors to Little Brevard Island were asked to judge the acceptability of a series of five computer-generated photographs showing a range of visitors to the island (Fig. 3), and visitors who camped on Pumpkin and Grapes Islands were asked to judge the acceptability of a series of five computer-generated photographs showing a range of ecological impact at a representative campsite (Fig. 4).

For the Little Brevard Island photos, the response scale was anchored at -4 ("very unacceptable") and +4 ("very acceptable"). The mean response for the sample as a whole for each photograph is graphed in Figure 5 and results in a "social norm curve." The point at which the social norm curve crosses the neutral point of the response scale (approximately 95 PAOT) represents an "acceptability"-based standard of quality, at this is the minimum level of acceptability for PAOT for most respondents.
Figure 3. Study photographs of people-at-one-time (PAOT) at Little Firewaxon Island.

Figure 4. Study photographs of campus impacts at Bynholm and Gage Islands.
Figure 5. Social norm curve for people-at-one-time (PAOT) on Little Brewer Island.

Figure 6. Social norm curves for campsite impacts at Bumpkin and Grape Islands.

Table 2. Summary of PAOT quality findings for Little Brewer Island.

<table>
<thead>
<tr>
<th>Standards of quality</th>
<th>N</th>
<th>Mean PAOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preference</td>
<td>107</td>
<td>49</td>
</tr>
<tr>
<td>Acceptability</td>
<td>107</td>
<td>72</td>
</tr>
<tr>
<td>Management actions</td>
<td>103</td>
<td>89</td>
</tr>
<tr>
<td>Displacement</td>
<td>103</td>
<td>174</td>
</tr>
<tr>
<td>Existing conditions</td>
<td>101</td>
<td>47</td>
</tr>
</tbody>
</table>

Table 3. Summary of campsite impact study findings for Bumpkin and Grape Islands.

<table>
<thead>
<tr>
<th>Standards of quality</th>
<th>Bumpkin Island</th>
<th>N</th>
<th>Mean photo number</th>
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</thead>
<tbody>
<tr>
<td>Preference</td>
<td>32</td>
<td>1.4</td>
<td>37</td>
</tr>
<tr>
<td>Acceptability</td>
<td>33</td>
<td>5.2</td>
<td>33</td>
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<tr>
<td>Management actions</td>
<td>33</td>
<td>7.8</td>
<td>35</td>
</tr>
<tr>
<td>Displacement</td>
<td>33</td>
<td>4.1</td>
<td>35</td>
</tr>
<tr>
<td>Existing conditions</td>
<td>28</td>
<td>1.8</td>
<td>34</td>
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Grape Island | N   | Mean photo number |
<table>
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<tbody>
<tr>
<td>Preference</td>
<td>37</td>
<td>1.4</td>
</tr>
<tr>
<td>Acceptability</td>
<td>33</td>
<td>5.0</td>
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<tr>
<td>Management actions</td>
<td>35</td>
<td>2.7</td>
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<tr>
<td>Displacement</td>
<td>35</td>
<td>4.4</td>
</tr>
<tr>
<td>Existing conditions</td>
<td>34</td>
<td>1.9</td>
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</table>
Respondents were also asked to select the photograph that best represented (1) the TAOT condition they preferred, (2) the PAOT condition that was unacceptable that they would no longer visit Little Brewster Island, (3) the maximum PAOT condition they thought the National Park Service should allow before restricting visitor use, (4) the TAOT condition they experienced on the day of their visit, and (5) the PAOT condition they experienced on the day of their visit. All standards of quality findings are summarized in Table 2 and provide an empirical basis for selecting TAOT standards of quality for the island.

For the pumpkin and grape islands camping photographs, the same response scale as described above was used. The points on which these social norm curves cross the neutral point of the response scale (mean response values of approximately photo number 3.2 for pumpkin Island and photo number 3.9 for grape Island) represent "acceptability" based standards of quality (Fig. 6). Preference, "displacement," "management action," and "existing conditions" questions were also asked as described above, and all standards of quality findings are summarized in Table 3, providing an empirical basis for selecting standards of quality for ecological impacts at park campuses.

Discussion

Planning component

After completion of the natural and social science research components, a series of planning workshops were held in the winter and spring of 2013 to formulate indicators and standards of quality for the park. Workshop participants included the planning committee of the Boston Harbor Islands Partnership and research staff, including principal investigators and graduate students. The workshops were facilitated by the park assistant superintendent.

The National Park Service, in conjunction with the Boston Harbor Islands Partnership, recently completed a general management plan (GMP) to guide park management (National Park Service 2013). This plan established six zones into which all park lands are assigned. The management objectives for each of the zones provided initial guidance concerning appropriate indicators and standards of quality for natural and social conditions. Study findings from the natural and social science research provided a more empirical basis for formulating indicators and standards.

For example, management objectives developed in the park’s GMP specified that the Natural Resources Emphasis Area of the park would provide opportunities for visual solitude, while the Visitor Services and Park Facilities Emphasis Area would provide opportunities for a more...
social experience. Study findings from the social science data outlined a range of potential standards of quality for visitor density (from "preference to "disturbance"), including PAGT at attraction sizes and encoun-
ters along trails. For the Natural Features Emphasis zone (emphasizing solitude), a standard of quality near the preference end of the range was selected to ensure high levels of solitude, while a standard of quality near the management utility or displacement end of the range was selected (because solitude is not important in this area for the Visitor Services and Park Facilities Emphasis zone emphasizing a social experience). Findings of the natural science component of the study were also utilized in the formulation of standards of quality. Frequency distribu-
tion charts and tables of impact indicators were provided to the planning committee in order to determine the level at which a realistic standard of quality can be set given the current levels of resource impact. For instance, previous research has shown that soil-erision rates were sub-
stantial: beyond 20-30% of mineral soil, exposure on the ground (Kuss and Morgan 1984, 1986). The planning committee eventually selected the lower end of 20% as the standard. This decision was informed by the body of visitor impact research and the current resource conditions which indicate that only a minority of sites would exceed this standard and require corrective management action.

A third example involves both natural and social science research findings. Natural science research found that visitors were causing impacts as campers through destruction of ground cover vegetation and resulting sheet erosion of exposed bare soil. From an ecological standpoint, this process can lead to degradation of the park's natural condition. However, natural science data provides only a partial picture to suggest an appropriate standard of quality for this indicator variable. Social science data may complement natural science data by suggesting a standard of quality for campsite condition from an aesthetic standpoint based on visitors' perceptions. The social science findings described earlier for Bumpkin and Grape Islands suggest the point at which camp-
site impacts are judged as unacceptable, and these data can be used to help set a socially acceptable standard of quality for the ecological indicator variable of campsite impacts. Workshop sessions resulted in sets of resource and social indica-
tors and standards of quality for each zone or, each island. These indicators and standards of quality are designed to meet the manage-
ment objectives for each zone as defined in the CMP and to provide for an appropriate range of resource conditions and visitor opportuni-
ties throughout the park. Indicators and standards of quality that were selected are summarized in Table 4. Indicators and standards of qual-
ity for the social science component were recommended for only these islands open to public access in 2007.
<table>
<thead>
<tr>
<th>Municipalities</th>
<th>Town and Islands</th>
<th>People Males</th>
<th>Females</th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
<th>Official point scores (out of 4)</th>
<th>Density of male</th>
<th>Acreage protected</th>
<th>Land area</th>
<th>Percent</th>
<th>Quality of environment</th>
<th>Species of wildlife</th>
<th>Status of wildlife protection</th>
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* Acreage in public use (hillsides only)
  **Acreage in public use (hillsides only)
  ***Acreage in public use (hillsides only)
Conclusions

An integrated program of natural and social science research and associated planning was conducted at Boston Harbor Islands National Park Area to manage visitor carrying capacity. Contemorar/) approaches to carrying capacity emphasized the importance of formulating indicators and standards of quality that define minimum acceptable resource and social conditions in the park. This process entails a long-term commitment to monitoring key indicator variables, and implementation of management actions to ensure that standards of quality are maintained. Management actions designed to control and/or reduce the resource and social impacts of visitor use include education on low-impact visitor behavior, hardening and maintenance of visitor use areas, and, ultimately, limiting visitor use. The research and planning process used at Boston Harbor Islands National Park Area provides an empirical, scientific basis for justifying implementation of such management actions, protecting the quality of park resources and the visitor experience, and managing the park within a defined visitor carrying capacity.

A carrying capacity-related monitoring program for Boston Harbor Islands is now being designed and will focus on the indicators of quality outlined in Table 4. When and where monitoring data suggest that standards of quality are in danger of being violated, management action will be undertaken. For example, if visitor density or natural resource impact standards of quality are violated, adjustments can be made to ferry schedules so that fewer visitors are delivered to islands experiencing these problems or so that violation can be temporarily or spatially alleviated.

Experience at Boston Harbor Islands clearly demonstrates that carrying capacity has both resource and social dimensions, and that there can be a strong relationship between these dimensions. Visitor use of parks such as Boston Harbor Islands can impact both the natural resources of the park and the quality of the visitor experience. Moreover, resource impacts can also affect the quality of the visitor experience, and these aesthetic impacts can offer a potentially important justification and guidance for setting standards of quality. Carrying capacity analysis and management requires an integrated program of natural and social science research.

The program of research outlined in this paper provides an important scientific basis for managing carrying capacity. Carrying capacity also requires the exercise of management judgment. For example, the natural and social science research outlined in this paper offers an empirically based range of potential standards of quality for selected indicator variables. However, selection of a standard of quality requires some
elements of management judgment. But such judgments should be as scientifically informed as possible (Manning and Lawson 2002).

Literature Cited


