

Carrying Capacity

An Organizational Framework

Origins of Carrying Capacity

Rapidly expanding recreation in the 1950s and 1960s gave rise to concerns over appropriate use levels of outdoor recreation areas. While interest in the impacts of recreation on the natural resource base predominated, there was also emerging attention on the effects of increased use on the quality of the recreation experience. The early studies described in the preceding chapters prompted theorists to search for a way such issues might be fit into an organizational framework to help formulate outdoor recreation policy. A resulting paradigm was the concept of carrying capacity.

Carrying capacity has a rich history in the natural resource professions, substantially predating its serious adoption in the field of outdoor recreation. In particular, the term has received wide use in wildlife and range management, where it refers to the number of animals of any one species that can be maintained in a given habitat (Dasmann 1964). But, in its most generic form, carrying capacity is a fundamental concept in natural resources and environmental management referring to the ultimate limits to growth as constrained by environmental factors (Odum 1959). In this generic form, carrying capacity has been applied to broad-ranging issues, including the ultimate population level of humans (e.g., Borgstrom 1965, Meadows et al. 1972) and general environmental planning (e.g., Godschalk and Parker 1975).

Perhaps the first suggestion for applying the concept of carrying capacity to outdoor recreation was recorded in the mid-1930s. A National Park Service report on policy recommendations for parks in the California Sierras posed the question, "How large a crowd can be turned loose in a wilderness without destroying its essential qualities?" (Sumner 1936). Later in the report, it was suggested that recreation use of wilderness be kept "within the carrying capacity." A decade later, a

paper on forest recreation suggested that, "In all forest recreation, but particularly in zones of concentrated use, carrying capacity is important (J. V. Wagar 1946)." A follow-up article listed carrying capacity as one of eight major principles in recreation land use:

Forestry, range management, and wildlife management are all based upon techniques for determining optimum use and limiting harvest beyond this point. Forest recreation belongs in the same category and will be more esteemed when so treated (J. V. Wagar 1951: 433).

The concept of carrying capacity became a more formal part of the outdoor recreation field when it was listed as a major issue by Dana (1957) in his widely read problem analysis of outdoor recreation, and as a result of its prominence in the deliberations and writings of the Outdoor Recreation Resources Review Commission (ORRRC 1962).

Carrying Capacity and Recreation

The first rigorous application of carrying capacity to outdoor recreation came in the early 1960s with a conceptual monograph (J. A. Wagar 1964) and a preliminary empirical treatment (Lucas 1964). Perhaps the major contribution of Wagar's conceptual analysis was the expansion of carrying capacity from its dominant emphasis on environmental effects 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 (J. A. Wagar 1964: preface).

Wagar's point was that as more people visit an outdoor recreation area, not only the environmental resources of the area are affected, but also the quality of the recreation experience. Thus, carrying capacity was expanded to include consideration of the social environment as well as the biophysical 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. This analysis suggested that the effects of crowding on satisfaction would vary, depending upon visitor needs or motivations.¹

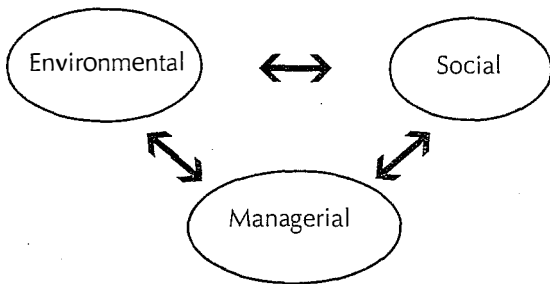


Figure 4-1. Three dimensions of recreation carrying capacity. (From Manning and Lime 1996.)

A preliminary attempt to estimate the recreation carrying capacity of the Boundary Waters Canoe Area, MN, followed shortly, and found that perceptions of crowding varied by different user groups (Lucas 1964b). Paddling canoeists were found to be more sensitive to crowding than motor canoeists, who were in turn more sensitive to crowding than other motorboaters. A range of carrying capacities was estimated depending upon these different relationships.

Wagar's original conceptual analysis hinted at a third element of carrying capacity, and this was described more explicitly in a subsequent paper (J. A. Wagar 1968). Noting a number of misconceptions about carrying capacity, it was suggested that carrying capacity might vary according to the amount and type of management activity. For example, the durability of biophysical resources might be increased through practices such as fertilizing and irrigating vegetation, and periodic rest and rotation of impact sites. Similarly, the quality of the recreation experience might be maintained or even enhanced in the face of increasing use by means of more even distribution of visitors, appropriate rules and regulations, provision of additional visitor facilities, and educational programs designed to encourage desirable user behavior. Thus, carrying capacity, as applied to outdoor recreation, was expanded to a three-dimensional concept by the addition of management considerations (Figure 4-1).

This three-dimensional view has been retained in contemporary analyses of carrying capacity, though it is sometimes described in terms of three types of carrying capacity. One writer, for example, offers definitions for three kinds of recreation carrying capacity; resource-bearing, visitor, and facilities (Allredge 1973). Another study discusses three types of capacity, labeled ecological, social, and facilities (Heberlein 1977). A fourth type of capacity termed "physical" is also suggested, referring to the constraint imposed by sheer limits of physical space. This concept, however, is less often of concern in management of outdoor recreation.

Limits of Acceptable Change

Carrying capacity has attracted intensive focus as a research and management concept in outdoor recreation. Several bibliographies, books, and review papers have been published on carrying capacity and related issues, and these publications contain hundreds of citations (Stankey and Lime 1973, Graefe et al. 1984, Shelby and Heberlein 1986, Stankey and Manning 1986, Kuss et al. 1990). Yet despite this impressive literature base, efforts to apply carrying capacity to recreation areas has often resulted in frustration. The principal difficulty lies in determining how much impact or change should be allowed within each of the three components that make up the carrying capacity concept: environmental resources, the quality of the recreation experience, and the extent and direction of management actions.

The growing research base on outdoor recreation indicates that increasing recreation use often causes impact or change. This is especially clear with regard to environmental, natural, or biophysical resources. An early study in the Boundary Waters Canoe Area, MN, for example, found that an average of 80% of ground cover vegetation was destroyed at campsites in a single season, even under relatively light levels of use (Frissell and Duncan 1965). The biophysical and ecological impacts of outdoor recreation have been summarized and synthesized in a number of studies (e.g., Cole 1987, Kuss et al. 1990, Hammitt and Cole 1998). The remaining chapters in this book review and synthesize the ways in which increasing use levels can impact or change the quality of the recreation experience. Research suggests that increasing recreation use can also change the management environment through development and implementation of more intensive management practices (Manning et al. 1996a). Despite increasing knowledge about recreation use and resulting impacts, the critical question remains: how much impact or change should be allowed?

This issue is often referred to as the "limits of acceptable change" (Frissell and Stankey 1972). Some change in the recreation environment is inevitable, but sooner or later the amount, nature, or type of change may become unacceptable. But what determines the limits of acceptable change?

This issue is illustrated graphically in Figure 4-2. In this figure, a hypothetical relationship between visitor use and impacts to the biophysical, social, and management environments is shown. This

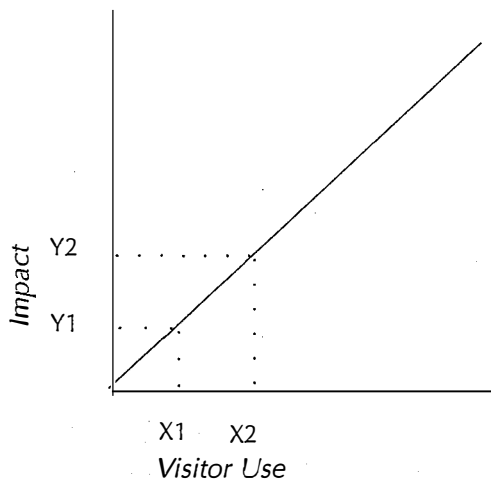


Figure 4-2. Hypothetical relationship between visitor use and impact to the recreation environment. (From Manning and Lime 1996.)

relationship suggests that increasing recreation use can and often does cause increasing impacts in the form of damage to fragile soils and vegetation, crowding and conflicting uses, and more direct and intensive recreation management actions. However, it is not clear from this relationship at what point carrying capacity has been reached. For this relationship, X1 and X2 represent alternative levels of visitor use that result in corresponding levels of impact as defined by points Y1 and Y2, respectively. But which of these points—Y1 or Y2, or some other point along the vertical axis—represent the maximum amount of impact that is acceptable?

To emphasize and further clarify this issue, some studies have suggested distinguishing between descriptive and prescriptive components of carrying capacity (Shelby and Heberlein 1984, 1986). The descriptive component of carrying capacity focuses on factual, objective data such as the relationship in Figure 4-2. For example, what is the relationship between the amount of visitor use and perceived crowding? The prescriptive component of carrying capacity determination concerns the seemingly more subjective issue of how much impact or change in the recreation environment is acceptable. For example, what level of perceived crowding should be allowed?

Management Objectives and Indicators and Standards of Quality

Recent experience with carrying capacity suggests that answers to the above question can be found through formulation of management objectives and associated indicators and standards of quality (Lime and Stankey 1971, Frissell and Stankey 1972, Lucas and Stankey 1974, Bury 1976, P. Brown 1977, Hendee et al. 1977b, Lime 1977a, 1979, Stankey 1980b, Boteler 1984, Stankey et al. 1985, Stankey and Manning 1986, Graefe et al. 1990, Shelby et al. 1992b, Shindler 1992, Lime 1995, Manning et al. 1995a, c, Manning and Lime 1996, Manning et al. 1996b, Manning 1997, National Park Service 1997). This approach to carrying capacity focuses on defining the type of visitor experience to be provided. Management objectives are broad, narrative statements defining the type of visitor experience to be provided. Indicators of quality are more specific, measurable variables reflecting the essence or meaning of management objectives. They are quantifiable proxies or measures of management objectives. Indicators of quality may include elements of the biophysical, social, and management environments that are important in determining the quality of the visitor experience. Standards of quality define the minimum acceptable condition of each indicator variable.

An example may help illuminate these ideas and terms. Review of the Wilderness Act of 1964 suggests that areas contained in 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 other visitors encountered along trails and at campsites is important in defining solitude for wilderness visitors. Thus, trail and camp encounters are potentially good indicators of quality. Research also suggests that wilderness visitors may have normative standards about how many trail and camp encounters can be experienced before opportunities for solitude decline to an unacceptable degree.² For example, a number of studies suggest that wilderness visitors prefer to see no more than five other groups per day along trails. Thus, a maximum of five encounters per day with other groups along trails may be a good standard of quality.

Management objectives and indicators and standards of quality should be formulated on the basis of several considerations. In keeping with the three-dimensional model of carrying capacity illustrated in Figure 4-1, these considerations can be organized into three broad categories.

1. Natural Resource Considerations. The biophysical characteristics of the natural resource base help determine the degree of change in the environment that results from recreation use. While even light levels of use may cause change in the environment, some resource bases are inherently more fragile than others. These biophysical resource characteristics should be studied and may become important guides in formulating management objectives and indicators and standards of quality.

2. Social Considerations. The needs and wants of visitors are important in determining appropriate outdoor recreation opportunities. Studies of visitors to outdoor recreation areas may suggest appropriate types and levels of outdoor recreation use. Such studies should be incorporated in carrying capacity analysis.

3. Management Considerations. Legal directives, agency mission statements, and other policy-related guidelines may suggest appropriate management objectives and related indicators and standards of quality. Moreover, financial, personnel, and other management resources may also suggest the types and levels of recreation use that are possible or feasible.

The types of information described above can be important in formulating informed and thoughtful management objectives and associated indicators and standards of quality. However, there is ultimately a value-based element of recreation carrying capacity that must also be addressed. While research can help illuminate the relationships between increasing use levels and change in the recreation environment as illustrated in Figure 4-2, determining the point at which change becomes unacceptable will usually require some element of management judgement. The natural resource, social, and managerial considerations described above can help shape such management judgments.

Carrying Capacity Frameworks

The literature described above has given rise to several frameworks for determining and applying carrying capacity to outdoor recreation. These frameworks include Limits of Acceptable Change (Stankey et al. 1985, McCool and Cole 1997a), Visitor Impact Management (Graefe et al. 1990), Visitor Experience and Resource Protection (Manning et al. 1996b, Hof and Lime 1997, National Park Service 1997), Carrying Capacity Assessment Process (Shelby and Heberlein 1986), Quality Upgrading and Learning (Chilman et al. 1989, 1990), and Visitor Activity Management Process (Environment Canada and Park Service 1991). All of these frameworks incorporate the ideas about carrying capacity described above and provide a rational, structured process for making carrying capacity decisions.

The basic steps or elements of the three most widely applied carrying capacity frameworks are shown in Table 4-1. While terminology, sequencing, and other aspects may vary among these frameworks, all share a common underlying logic. Core elements of these frameworks include:

1. Definition of the types of recreation opportunities to be provided. Recreation opportunities should be defined as specifically and quantitatively as possible through indicators and standards of quality.
2. Monitoring of indicator variables to determine whether existing conditions meet standards of quality.
3. Management action when and where monitoring suggests that standards of quality have been violated.

A recent comparative analysis of carrying capacity frameworks affirms the similarity of their underlying structures and suggests a number of related themes shared among these frameworks (Nilsen and Taylor 1997):

1. Encouragement of interdisciplinary planning teams.
2. A primary focus on management of recreation-related impacts.
3. A need for sound natural and social science information.
4. Establishment of clear, measurable management objectives.
5. Definition of recreation opportunities as comprised of natural, social, and managerial conditions.
6. A linkage among recreation activities, settings, experiences, and benefits.
7. Recognition that relationships between recreation use and resulting environmental and social impacts can be complex.

Table 4-1. Carrying capacity frameworks.

<i>Limits of Acceptable Change</i>	<i>Visitor Impact Management</i>	<i>Visitor Experience and Resource Protection</i>
Step 1. Identify area concerns and issues	Step 1. Preassessment database reviews	Element 1. Assemble an interdisciplinary project team
Step 2. Define and describe opportunity classes	Step 2. Review of management objectives	Element 2. Develop a public involvement strategy
Step 3. Select indicators of resource and social conditions	Step 3. Selection of key impact indicators	Element 3. Develop statements of primary park purpose, significance, and primary interpretive themes
Step 4. Inventory resource and social conditions	Step 4. Selection of standards for key impact indicators	Element 4. Analyze park resources and existing visitor use
Step 5. Specify standards for resource and social indicators	Step 5. Comparison of standards and existing conditions	Element 5. Describe a potential range of visitor experiences and resource conditions
Step 6. Identify alternative opportunity class allocations	Step 6. Identify probable causes of impacts	Element 6. Allocate potential zones to specific locations
Step 7. Identify management actions for each alternative	Step 7. Identify management strategies	Element 7. Select indicators and specify standards for each zone; develop a monitoring plan
Step 8. Evaluation and selection of an alternative	Step 8. Implementation	Element 8. Monitor resource and social indicators
Step 9. Implement actions and monitor conditions		Element 9. Take management action

8. Recognition of the importance of providing a diversity of recreation opportunities.

9. A focus on elements of recreation opportunities that can be influenced through management.

10. A range of recreation management strategies and tactics.

11. A need for ongoing monitoring and evaluation.

Several applications and evaluations of the above carrying capacity frameworks and related processes are described in the literature (Ashor et al. 1986, Graefe et al. 1986a, Shelby and Heberlein 1986, Absher 1989, Graefe et al. 1990, Vaske et al. 1992, Kaltenborn and Emmelin 1993, Hof et al. 1994, Manning et al. 1995a, Manning et al. 1995b, Manning et al. 1995c, McCoy et al. 1995, Manning and Lime 1996, Manning et al. 1996b, Manning et al. 1996c, Manning 1997, McCool and Cole 1997b, Ritter 1997, Warren 1997).

The Status of Carrying Capacity

As applied to outdoor recreation, carrying capacity is more complex than its initial applications in other fields of study (Burch 1981, Stankey 1989). Recreation carrying capacity includes natural resource, social and managerial considerations, descriptive and prescriptive components, management objectives and indicators and standards of quality, and management judgment. It seems clear that there can be no *one* carrying capacity for a park or outdoor recreation area. Rather, carrying capacity is dependent upon how the various components of the concept are fashioned together. This complexity and apparent lack of definitiveness have caused some disillusionment. Characterizations such as "slippery" (Alldredge 1973), "elusive" (Graefe et al. 1984), and "illusory" (R. Becker et al. 1984) have been applied to recreation carrying capacity. This difficulty with carrying capacity seems to be borne out in surveys of park and wilderness managers (Washburne 1981, Washburne and Cole 1983, Manning et al. 1996a). Even though many managers suspect that recreational use of their areas has exceeded carrying capacity, they have not yet established such carrying capacities.

The weaknesses and shortcomings of carrying capacity have been noted by a number of writers. Several point out that the term implies a single "magic number" for each recreation area, and that this, of course, is misleading and obscures the role of management judgments (Bury

1976, Washburne 1982). For this reason, a stronger emphasis on management objectives has been suggested by some as an alternative to carrying capacity (Becker and Jubenville 1982, Jubenville and Becker 1983, Stankey et al. 1984). Similarly, it has been noted that analyses of carrying capacity often ignore the ability of management to affect the amount of use that can be accommodated; the term "design capacity" has been suggested as an alternative to carrying capacity (Godin and Leonard 1977b).

Others have argued that the very term "carrying capacity" seems to imply an undue emphasis on use limitations (Washburne 1982, Burch 1984, Stankey et al. 1984). These writers argue that a number of management alternatives might be used to meet management objectives aside from use limitations, which may often be the least-preferred alternative. Moreover, while management objectives for some areas may well set relatively low carrying capacities and thus ultimately require use limits, other areas will properly have relatively high carrying capacities without need for use limits. In a similar vein, it has been noted that recreation-caused change is not inherently undesirable (Stankey 1974). In fact, use of the more neutral word "change" has been suggested as opposed to "impacts," "damage," or other value-laden terms, since judgment about the relative desirability of change can only be made in relationship to management objectives.

Finally, even J. A. Wagar (1974), author of the original conceptual analysis of recreation carrying capacity, has suggested that borrowing the term from range and wildlife management may not have been a wise choice. The close association between carrying capacity and natural resource or biophysical considerations in the historical sense tends to divert attention from the equally important experiential and managerial concerns that must be a part of carrying capacity as applied to outdoor recreation.

All of these points are valid criticisms. However, the term carrying capacity is deeply entrenched in the field of outdoor recreation, and recent legislation and institutional directives have even made carrying capacity a formal part of outdoor recreation management (Manning et al. 1996e). For example, amendments to Public Law 91-383 (84 Stat. 824, 1970) call for general management plans for units of the national park system to include "identification of and implementation commitments for visitor carrying capacities for all areas of the unit." Moreover, amendments to the National Trails System Act (Public Law 90-543, 1968) require development of a comprehensive plan for trails, including "an identified carrying capacity of the trail and a plan for its

implementation." In the regulations implementing the National Forest Management Act of 1976, Section 219.18(a) states that the portion of forest plans providing direction for wilderness management will "provide for limiting and distributing visitor use of specific areas in accord with periodic estimates of the maximum levels of use that allow natural processes to operate freely and that do not impair the values for which wilderness areas were created." And the Nationwide Outdoor Recreation Plan (Bureau of Outdoor Recreation 1973) states that "each federal recreation land managing agency will determine the carrying capacity of its recreation lands."

Despite its shortcomings, the term "carrying capacity" is likely to remain a part of the outdoor recreation field for the foreseeable future. Carrying capacity can be useful as an outdoor recreation management concept when viewed in proper perspective—as an organizational framework for determining and managing appropriate outdoor recreation opportunities. The recreation carrying capacity frameworks developed in the literature and their successful application in the field suggest that carrying capacity is a useful concept in outdoor recreation.

Summary and Conclusions

1. Since its adoption from wildlife and range management, outdoor recreation carrying capacity has evolved from a primary emphasis on natural resource impacts to include equal consideration of recreation experience and management considerations.
2. Recreation use can cause change in the recreation environment, including resource conditions, the quality of the experience provided, and/or management actions.
3. Limits should be determined for the amount of change acceptable.
4. Limits of acceptable change should be formulated and expressed in the form of management objectives and associated indicators and standards of quality.
5. Application of carrying capacity ultimately requires some judgment on the part of managers. However, such judgments should be based on natural resource, social, and managerial considerations.
6. There is no single carrying capacity for an outdoor recreation area. Rather, every area has a range of capacities depending upon management objectives and indicators and standards of quality.
7. Several carrying capacity frameworks have been developed, including Limits of Acceptable Change, Visitor Impact Management, and Visitor Experience and Resource Protection. These frameworks have been successfully applied to a variety of park and recreation areas.
8. Carrying capacity does not necessarily imply strict limitation of use. Some recreation areas will have low capacities and may require use limits, while others will have high capacities and may not need use limits. Moreover, use limits are only one of several recreation management alternatives, and are often the least desirable.
9. Carrying capacity can be a useful concept in outdoor recreation management when viewed as an organizational framework.

Notes

1. These important points are discussed more fully in Chapters 5 and 7.
2. Research on indicators and standards of quality is addressed in Chapter 6.