

How Much is Too Much? Carrying Capacity of National Parks and Protected Areas

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Abstract: Increasing recreational use of national parks and protected areas can impact natural and cultural resources and the quality of the visitor experience. Determining how much recreational use can ultimately be accommodated in a park or protected area is often addressed through the concept of carrying capacity. Contemporary approaches to carrying capacity – including the Visitor Experience and Resource Protection (VERP) framework developed by the U.S. National Park Service – rely on formulation of indicators and standards of quality of natural/cultural resources and the visitor experience. This paper describes the VERP framework and its application in the U.S. national park system, including a program of research designed to help formulate indicators and standards of quality.

INTRODUCTION

As the name suggests, national parks are resources of national and, increasingly, international significance. The United States national park system, for example, contains natural and cultural resources of great importance to the nation, and in many cases, the international community. Given the significance of this resource base, public demand to see and experience these areas should not be surprising. And data on national park visitation in the U.S. dramatically support this premise: the national park system now accommodates nearly 300 million visits annually.

The increasing popularity of national parks presents both an opportunity and challenge. The opportunity is to fulfill the mission of the national parks “to provide for the enjoyment of the people.” The accompanying challenge, of course, is to fulfill the complementary component of the national park mission “to conserve the scenery and the natural and historic objects and the wildlife therein.” This can prove difficult under conditions of high visitation.

Implicit in this dual mission of national parks is the issue of the quality of the visitor experience. The quality of visitor experiences must be maintained at a high level for national parks to contribute their full potential to society. Moreover, high-quality visitor experiences are more likely to develop public appreciation of, and support for, conservation of national park resources.

It is ironic that one of the greatest threats to national parks is commonly seen as their increasing popularity. To many observers, national parks, at least in some places and at some times, are crowded, and this detracts from the quality of the visitor experience. Moreover, natural and cultural resources can be degraded by excessive visitor use.

In more formal terms, use of some national parks, or portions thereof, have exceeded their carrying capacity (Mitchell, 1994; Wilkinson, 1995).

This paper explores the theory and application of carrying capacity to national parks and related areas. Emphasis is placed on development and application of Visitor Experience and Resource Protection (VERP), a framework developed for managing carrying capacity in the U.S. national parks. The first section briefly traces the theoretical development of the carrying capacity concept. The second section describes development of the VERP framework, and the third section describes application of VERP to Arches National Park and other units of the U.S. national park system. A final section suggests that the conceptual framework underlying VERP and other contemporary approaches to carrying capacity can be applied to a variety of parks and protected areas, but that this will require a commitment to park planning, management and research.

THE CONCEPT OF CARRYING CAPACITY

The question of how much public use can ultimately be accommodated in a national park or related area is often framed in terms of carrying capacity. Indeed, much has been written about the carrying capacity of national parks. 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 of any one species that can be maintained in a given habitat (Dasmann, 1964). Carrying capacity has obvious parallels and intuitive appeal in the field of park management. In fact, it was first suggested in the mid-1930s as a park management concept in the context of national parks (Sumner, 1936).

However, the first rigorous applications of carrying capacity to park management did not occur until the 1960s.

These initial scientific applications suggested that the concept was more complex in this new management context. At first, the focus was placed on the relationship between visitor use and environmental conditions. The working hypothesis was that increasing numbers of visitors causes greater environmental impact as measured by soil compaction, destruction of vegetation, and related variables. It soon became apparent, however, that there was another critical dimension of carrying capacity dealing with social aspects of the visitor experience. An early and important monograph on the application of carrying capacity to parks and related areas reported that it 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 1964, preface)

Wagar’s point was that as more people visit a park, not only can the environmental resources of the area be affected, but so too can the quality of the visitor experience. Again, the working hypothesis was that increasing numbers of visitors cause greater social impacts as measured by crowding, conflict, and related variables. Thus, as applied to national parks, carrying capacity has two components: environmental and social.

The early work on carrying capacity has since blossomed into an extended literature on the environmental and social impacts of outdoor recreation and their application to carrying capacity (Lime & Stankey, 1971; Stankey & Lime, 1973; Graefe, et al., 1984 Manning, 1985; Shelby & Heberlein, 1986; Kuss, et al., 1990; Manning, 1999; Manning, 2000). But despite this impressive literature base, efforts to determine and apply carrying capacity to areas such as national parks have sometimes failed. The principle difficulty lies in determining how much impact, such as soil compaction and crowding, is too much. Theoretical development, backed up by empirical research, generally confirms that increasing use levels can lead to increased environmental and social impacts (Hammit and Cole, 1998; Manning, 1999). But how much impact should be allowed in the national park? This basic question is often referred to as the “limits of acceptable change” (Lime, 1970; Frissell & Stankey, 1972). Given substantial demand for public use of national parks, some decline or change in the quality of park resources and the visitor experience appears inevitable. But how much decline or change is acceptable or appropriate before management intervention is needed? How much use and associated impacts are too much?

This issue is illustrated graphically in Figure 1. This figure addresses the social impact of crowding.

In this figure, a hypothetical relationship between visitor use and crowding is shown. It is clear from this figure that visitor use and crowding are related: increasing numbers of visits cause increasing percentages of visitors to report feeling crowded. However, it is not clear at what point carrying capacity has been reached. The hypothetical relationship in Figure 1 suggests that some crowding is inevitable, given even relatively low levels of visitor use. Thus, some level of crowding must be tolerated if national parks are to remain open for public use. For the hypothetical relationship illustrated in Figure 1, X1 and X2 represent levels of visitor use that result in differing levels of crowding as defined by points Y1 and Y2, respectively. But which of these points – Y1 or Y2, or some other point along this axis – represents the maximum amount of crowding that is acceptable? Ultimately, this is a value judgment. Again, the principal difficulty in carrying capacity determination lies in deciding how much crowding (or of some other impact) is acceptable. Empirical relationships such as that in Figure 1 can be helpful in making informed decisions about carrying capacity, but they must be supplemented with management judgments.

To emphasize and further clarify this issue, some writers have suggested distinguishing between descriptive and evaluative (or prescriptive) components of carrying capacity (Shelby & Heberlein, 1984; Shelby & Heberlein, 1986). The descriptive component of carrying capacity focuses on factual, objective data such as the type of relationship in Figure 1. For example, what is the relationship between the number of visitors entering an area and the number of encounters that occur between groups of visitors? Or what is the relationship between the level of visitor use and visitor perceptions of crowding? The evaluative or prescriptive component of carrying capacity 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 appropriate? 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 development of management objectives and formulation of associated indicators and standards of quality (Stankey, et al., 1985; Stankey & Manning, 1986; Graefe, et al., 1990; Shelby, et al., 1992; Manning, 1997; Manning, 1998). This approach to carrying capacity focuses principal emphasis on defining the degree of resource protection and the type of visitor experience to be provided and maintained.

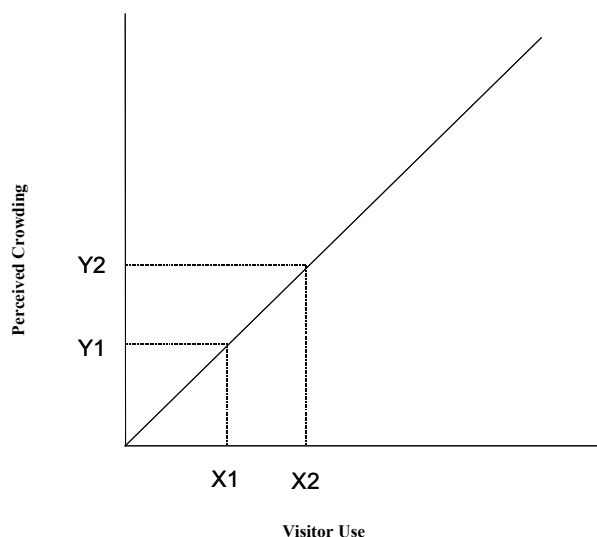


Figure 1. Hypothetical Relationship Between Visitor Use and Crowding

Management objectives are broad, narrative statements that define desired future conditions: the degree of resource protection and the type of visitor experience to be provided. They are based on review of the purpose and significance of the area under consideration. Development of management objectives may involve review of legal, policy and planning documents; consideration by an interdisciplinary planning and management team; historic precedent; local, regional, national or international context of the park; and public involvement.

Indicators of quality are more specific measurable variables that reflect the essence or meaning of management objects; they are quantifiable proxies or measures of management objectives. Indicators of quality may include elements of both the resource and social environments. *Standards of quality* define the minimum acceptable condition of indicator variables.

An example of management objectives, indicators and standards may be helpful. Review of the U.S. Wilderness Act of 1964 suggests that areas of the national park system 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 and desired future condition 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 become key indicators of quality and help to make operational the general management objective of providing opportunities for solitude. Further research suggests that wilderness visitors may have standards about how many trail and camp encounters are acceptable before the quality of the visitor experience declines to an unacceptable degree (Heberlein, et al., 1986; Vaske, et al., 1986;

Whittaker & Shelby 1988; Roggenbuck, et al., 1991; Shelby & Vaske, 1991; Manning, et al., 1996b; Manning, et al., 1999a; Manning, et al., 1999b). Such data may help to define standards of quality.

By defining indicators and standards of quality, carrying capacity can be determined and managed through a monitoring and management program. Indicator variables can be monitored over time and management actions taken to ensure that standards of quality are maintained. If standards have been violated, carrying capacity has been exceeded. This approach to carrying capacity is central to contemporary park and outdoor recreation planning frameworks, including Limits of Acceptable Change (LAC) (Stankey, et al., 1985), Visitor Impact Management (VIM) (Graefe, et al., 1990), and Visitor Experience and Resource Protection (VERP) (National Park Service 1997), recently developed by the U. S. National Park Service.

Visitor Experience and Resource Protection (VERP)

The U.S. National Park Service has long recognized the need to apply the concept of carrying capacity to parks that have been experiencing dramatically increasing public use. In fact, the 1978 U.S. General Authorities Act requires each park's general management plan to include "identification of and implementation commitments for carrying capacities for all areas of the unit" (U.S. Congress, 1978). Although National Park Service management policies and planning guidelines acknowledge this responsibility, historically there has been little direction or agreement on an approach or methodology for setting or managing a park's carrying capacity. Park planners and managers have often been reluctant to state that parks, or areas within parks, are receiving inappropriate or excessive use because they have lacked the rationale and empirical data to make such determinations.

Element

Framework Foundation

1. Assemble an Interdisciplinary Project Team
2. Develop a Public Involvement Strategy
3. Develop Statements of Park Purpose, Significance, and Primary Interpretive Themes

Analysis

4. Analyze Park Resources and Existing Visitor Use

Prescriptions

5. Describe a Potential Range of Visitor Experiences and Resource Conditions (Potential Prescriptive Zones)
6. Allocate the Potential Zones to Specific Locations in the Park (Prescriptive Management Zoning)
7. Select Indicators and Specify Standards for Each Zone; Develop a Monitoring Plan

Monitoring and Management

8. Monitor Resource and Social Indicators
9. Take Management Action

Figure 2. Elements of the Visitor Experience and Resource Protection (VERP) Framework

In the early 1990s an interdisciplinary team of National Park Service planners, managers, and researchers began developing a framework to identify and manage carrying capacity in the national park system. Called Visitor Experience and Resource Protection (VERP), this framework includes nine steps or elements (outlined in Figure 2), and is described in a recently developed handbook (National Park Service 1997). In keeping with the theoretical and historical development of carrying capacity as described in the previous section, VERP focuses on formulating indicators and standards of quality for desired future conditions of park resources and visitor experiences. A program to monitor indicator variables is then designed, and management actions are undertaken to ensure that standards of quality are maintained.

APPLICATION OF VERP

The VERP framework described above was initially applied at Arches National Park, Utah, USA (Hof, et al., 1994; Manning, et al., 1995; Manning, et al., 1996a; Belnap, 1998; Manning, 2001). The purpose of this application was to refine the VERP framework and provide a model for the rest of the national park system. Planning and research aimed at formulating indicators and standards of quality for the visitor experience are described in this section. Complimentary research addressed indicators and standards of quality for natural resource conditions such as soil disturbance and compaction and destruction of vegetation (National Park Service, 1995; Belnap, 1998).

Arches National Park comprises 73,000 acres of high-elevation desert with outstanding slick rock

formations, including nearly 2,000 sandstone arches. Many of the park's scenic attractions are readily accessible through a well-developed road and trail system. Visitation to Arches has been increasing rapidly, and the park now receives over three-quarters of a million visits annually.

Following the VERP framework, an interdisciplinary project team was created, comprised of planners from the National Park Service's Denver Service Center, Arches National Park staff, and NPS scientists and consultants (Element 1), and a public involvement strategy was developed (Element 2). Workshops were conducted to develop statements of park purposes, significance and primary interpretive themes (Element 3). Authorizing legislation and the current General Management Plan provided important reference sources. Park resources and existing visitor experiences were then mapped (Element 4) and a spectrum of desired resource and social conditions was constructed using a matrix format (Element 5). Based on this analysis, a system of nine zones ranging from developed to primitive was created and overlaid on the park (Element 6).

Element 7 requires selecting indicators of quality and specifying associated standards of quality for each zone. This required a research program that was conducted in two phases. Phase I was aimed at identifying potential indicators of quality (Manning, et al. 1992). Personal interviews were conducted with visitors throughout the park. In addition, focus group sessions were held with park visitors, park staff, and local community residents. Findings from Phase I research suggested several social and environmental indicators of quality for the park, including the number of people at frontcountry attraction sites and along trails, the

number of visitor groups encountered along backcountry trails and at campsites, the number of vehicles encountered along roads, the number of social trails and associated soil and vegetation impacts, the level of trail development, and visitor knowledge of regulations regarding off-trail hiking.

Phase II of the research program was designed to gather data to help set associated standards of quality (Lime, et al., 1994). A survey of park visitors was conducted, covering all nine park zones. The survey was administered to representative sample of over 1,500 park visitors by means of both personal interviews and mail-back questionnaires. Five indicator variables received special attention: 1) the number of people at one time at major frontcountry attraction sites, 2) the number of people at one time along frontcountry trails, 3) the amount of environmental impact caused to soil and vegetation by off-trail hiking, 4) the number of visitor groups encountered along backcountry trails and at campsites, and 5) the number of vehicles encountered along unpaved roads. The first three of these variables were addressed by a series of photographs that illustrated a range of impact conditions (Manning, et al., 1996b). Photographs were developed using a computer-based image capture technology (Chenoweth, 1990; Lime, 1990; Nassauer, 1990; Pitt, 1990). Base photographs of park sites were taken, and these images were then modified to present a range of impact conditions (e.g., number of visitors present, amount of environmental impact). A set of 16 photographs was developed for each major attraction site and trail, presenting a wide-ranging number of visitors present. Representative examples of photographs for Delicate Arch are shown in Figure 3. An analogous set of photographs was developed for a range of environmental impacts caused by off-trail hiking. Respondents rated the acceptability of each photograph on a scale of -4 (very unacceptable) to +4 (very acceptable). Questions regarding encounters in the backcountry and along unpaved roads were asked in a more conventional narrative and numeric format.

Earlier in this paper, it was noted that park visitors may have standards (or norms) for judging the appropriateness of park conditions. Methodological techniques have been developed and refined to measure such norms of park visitors (Manning, 1985; Heberlein, et al., 1986; Shelby & Heberlein, 1986; Vaske, et al., 1986; Whittaker & Shelby, 1988; Shelby, et al., 1992; Manning, et al., 1999a; Manning, et al., 1999b). The research program at Arches National Park was based on these techniques. Findings from Phase II research provided data to help formulate standards of quality for each of the nine park zones. Where appropriate, at least one resource and social indicator of quality was chosen for each zone and standards of quality were set for each indicator variable. For example, the "pedestrian" zone of the park contains several of

the most prominent attraction sites in the park, including Delicate Arch. Visitors reported that the number of people at any one time at such attraction sites was important in determining the quality of their experiences. Thus, the number of people at one time (PAOT) at Delicate Arch was selected as an indicator of quality for that zone. Moreover, findings from the series of 16 photographs of Delicate Arch (as shown in Figure 4) suggested that visitors generally find up to 30 PAOT to be acceptable. (It can be seen from the figure that the line tracing visitor evaluations of the 16 photographs crosses from the acceptable range into the unacceptable range at about 30 PAOT). Based on these findings, 30 PAOT was selected as the standard of quality. Indicators and standards of quality were set for all zones in a similar manner. A companion set of resource-based indicators and standards of quality was formulated based on a program of ecological research (National Park Service, 1995; Belnap, 1998).

A monitoring program focused on indicators of quality has been designed and is now being implemented in the park. This will allow park staff to address Elements 8 and 9 of the VERP framework. This monitoring program will determine the extent to which standards of quality are maintained. The VERP framework requires management action if standards of quality have been, or are in danger of being, violated. Primary management actions being undertaken at Arches include adjusting the size of trailhead parking lots, issuing backcountry camping permits, and educating visitors about the impacts of off-trail hiking.

Computer simulation modeling of recreational use can be employed as a substitute or complement to monitoring. Such models can be developed to estimate PAOT at attraction sites, the number of encounters between recreational groups along trails, or other indicators of quality. Moreover, such models can estimate the maximum number of visitors that can be accommodated within a park or protected area without violating standards of quality. A computer simulation model of recreational use was developed for Arches National Park and was used to estimate the maximum number of vehicles per day that could enter the park without violating the standard of quality of 30 PAOT at Delicate Arch. Development and use of this model is described by Manning et al. in a companion paper in this proceedings.

Following its initial application at Arches, VERP has been applied at a number and variety of areas contained in the national park system. A concerted effort has been made to address the diversity of environments and issues within the national park system. For example, indicators and

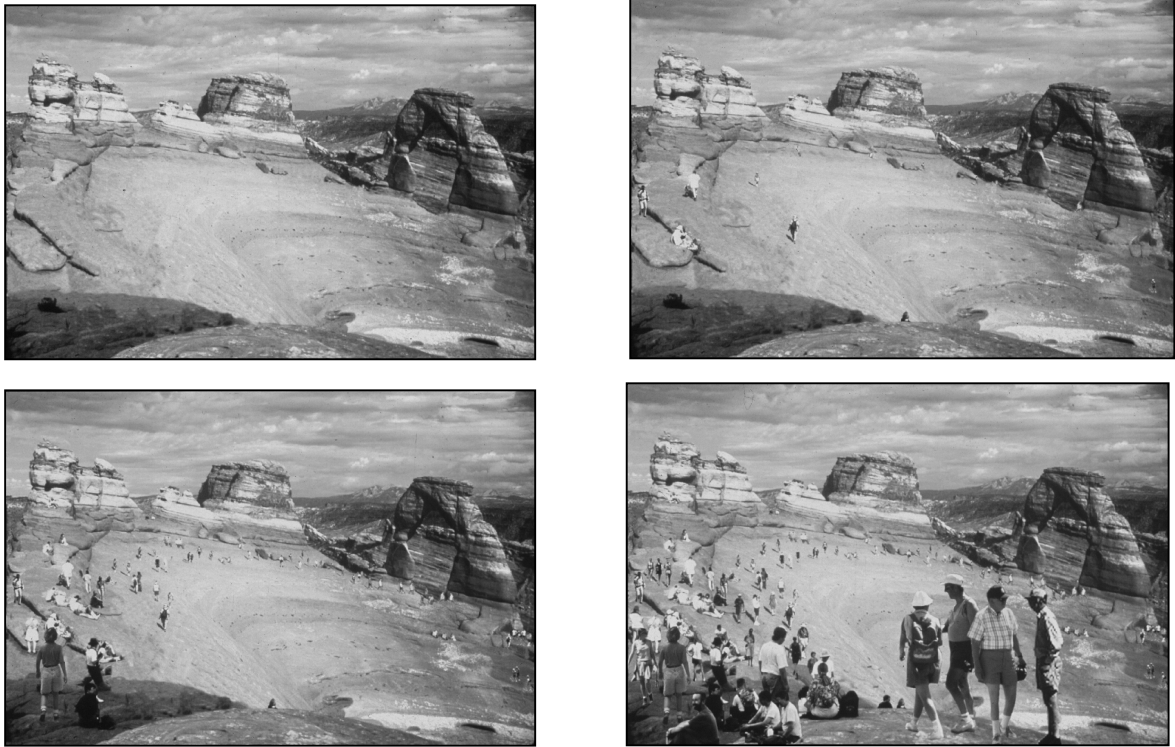


Figure 3. Representative Photographs of Delicate Arch Showing a Range of Visitor Use Levels

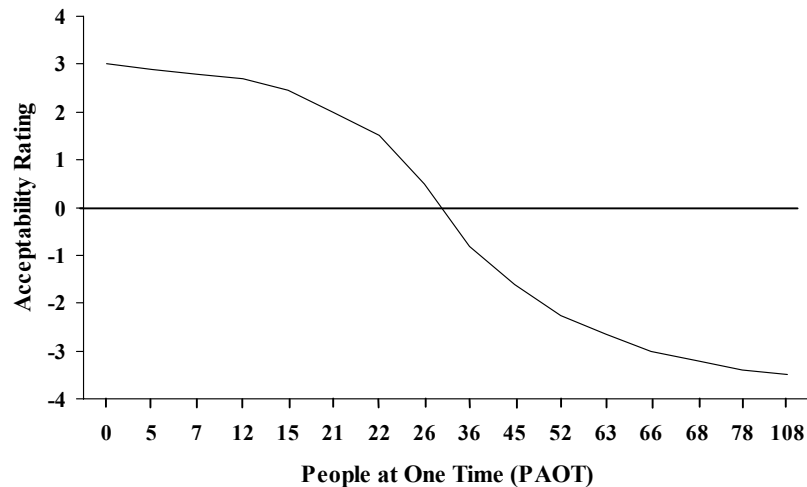


Figure 4. Visitor Evaluations of 16 Photographs of Delicate Arch Showing Alternative Levels of Visitor Use

standards of quality have been established for both crowding and conflict on the carriage roads of Acadia National Park (Jacobi, et al., 1996; Manning, et al., 1997; Manning, et al., 1998; Jacobi & Manning, 1999; Manning, et al., 1999b). These indicators and standards of quality address both the number of visitors using the carriage roads and visitor behavior. The carrying capacity of this system of multi-use trails has been estimated using a computer simulation model of carriage road use (Wang & Manning, 1998).

Application of VERP to Alcatraz Island, a unit of Golden Gate National Recreation Area, found the number of people at one time in the prison cellhouse to be an important indicator of quality, and research findings provided a basis for setting

an appropriate standard of quality at this key site. Other applications of VERP have addressed maximum waiting times at Statue of Liberty National Monument, persons per viewscape on trails at Grand Canyon National Park, the number of boats seen on the Colorado and Green River in Canyonlands National Park, the number of snowmobiles encountered in Yellowstone National Park, and the number of people at one time along trails and at attraction sites in Yosemite National Park.

CONCLUSION

Over 30 years of research and experience has led to development of several frameworks for

analyzing and managing the carrying capacity of parks and related areas. All of these carrying capacity frameworks rely on a similar series of steps or elements. VERP is specifically designed to identify and manage carrying capacity in the U.S. national park system. Carrying capacity is managed by defining desired resource and social conditions by means of a series of indicators and standards of quality. Indicator variables are monitored over time to ensure that standards of quality are maintained. If standards of quality are violated, the VERP process requires that management action be taken.

VERP provides a theoretically sound and rational process for determining and managing carrying capacity in national parks and related areas. It provides a structured framework within which to conduct a systematic, thoughtful, traceable, and defensible carrying capacity analysis. An associated research program can provide a strong empirical foundation for applying the VERP framework.

VERP has been applied in a number of units of the U.S. national park system. These applications have resulted in development and implementation of carrying capacity plans for these areas, the first such carrying capacity plans in the U.S. national park system (e.g., National Park Service, 1995; Jacobi & Manning, 1997). A VERP handbook has been developed (National Park Service, 1997) along with a workbook of management actions designed to support the VERP framework (Anderson, et al., 1998). Additional applications of VERP in the national park system are on-going or planned.

Despite development, testing and refinement of VERP and related carrying capacity frameworks, application across the U.S. national park system and related areas will be challenging. The number and diversity of parks suggests that a wide variety of indicators and standards of quality will have to be formulated. This will require a substantial investment in park planning and related natural and social science research. It will also require a long-term program of park monitoring and a commitment to implementing management actions designed to maintain standards of quality.

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