Using Indicators and Standards of Quality to Guide Transportation Management in Parks and Public Lands: A Best Practices Manual

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Paul S. Sarbanes Transit In Parks
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UNDERSTANDING RESOURCES SOLUTIONS

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AUTHORS

This document was authored by Robert Manning, Peter Pettengill, and Nathan Reigner of the Park Studies Laboratory, Rubenstein School of Environment and Natural Resources at the University of Vermont, a partner organization of the Paul S. Sarbanes Transit in Parks Technical Assistance Center (TRIPTAC).

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Transportation and recreation in parks and public lands are closely linked. Transportation provides access to parks and public lands and is often a form of recreation itself, offering visitors the opportunity to see and experience the diverse system of public lands that comprise nearly a third of the nation. Moreover, transportation can be an important tool in park and public land management, helping to deliver the "right" number of visitors to the "right" places at the "right" times. For all these reasons, managing transportation in parks and public lands warrants greater attention. This manual describes and applies the framework of indicators and standards of quality to transportation management in parks and public lands.

Indicators and standards of quality have emerged as an important framework in park and outdoor recreation management. This framework can help define and manage high quality outdoor recreation opportunities. Indicators and standards of quality are also implicit in the management framework of levels of service that has conventionally been used in field of transportation management. This manual describes how these complimentary frameworks can be integrated to manage transportation in parks and public lands.

Following this brief introduction, the second chapter of the manual describes the relationship between outdoor recreation and transportation more fully, including recent legislation and policy that makes this relationship more explicit and formal. Chapter Three describes and illustrates the frameworks of indicators and standards of quality as used in outdoor recreation management and levels of service as used in transportation management, and suggests how these frameworks can be integrated. The fourth chapter of the manual reviews several frameworks in contemporary outdoor recreation management that can be used to understand, define, and manage outdoor recreation in parks and public lands. Indicators and standards of quality are important in applying these frameworks. Chapter five describes research approaches that can be used to help managers identify and formulate indicators and standards of quality that can be used to manage outdoor recreation and transportation.

Chapter Six comprises a large portion of the manual and presents a series of case studies in which indicators and standards of quality are used to help guide management of outdoor recreation and transportation in parks and public lands. In some of these cases, transportation is used as a tool to manage outdoor recreation related indicators and standards of quality, and in others indicators and standards of quality are used to manage transportation as a recreation opportunity or activity. Multiple modes of transportation are addressed, including automobiles, public transit, bicycles, and pedestrian use. While many of these case studies address transportation-related indicators and standards of quality in areas managed by the National Park Service, these examples are equally applicable across the spectrum of public lands. Chapter Seven addresses current research designed to "standardize" indicators and standards of quality by exploring the extent to which standards of quality might be measured in common units and generalized across recreation areas. The manual concludes with a chapter that offers several principles that can guide use of indicators and standards of quality in managing transportation in parks and public lands.

CHAPTER 2: THE RELATIONSHIP BETWEEN TRANSPORTATION AND OUTDOOR RECREATION

Transportation is fundamental to parks and public lands. For example, every year millions of visitors travel to, from, and within national parks. But transportation can be more than this – it is often a form of recreation itself, offering most visitors their primary opportunities to experience and enjoy the natural and cultural landscapes embodied by national parks and related public lands. Moreover, transportation can be an important tool in managing outdoor recreation, delivering the "right" number of visitors to the "right" locations at the "right" times. This Best Practices Manual addresses the relationships between transportation and outdoor recreation on public lands and describes how the use of indicators and standards helps manage transportation in the context of parks and public lands.

The iconic roads of many of the crown jewel national parks – for example Going-to-the-Sun Road in Glacier National Park, Tioga Road in Yosemite National Park, and the Park Loop Road in Acadia National Park – were designed to allow visitors to experience the parks in their cars (Carr, 2007). In fact, entire units of the national park system, such as Blue Ridge Parkway, have been designed specifically for this purpose. In recent years, scenic byway designations across public lands have also increased. For example, the Forest Service and Bureau of Land Management have begun to recognize roads for their intrinsic qualities through their National Forest Scenic Byways and BLM Back Country Byways programs (Clay and Smidt, 2004). All of these roads and their scenic designations are a response to demand for what is historically one of America's most popular recreation activities, "driving for pleasure" (Manning, 2011). The vast road networks throughout the broad spectrum of public lands that make up nearly a third of the nation's land offer access to a wide variety of outdoor recreation opportunities. Furthermore, bicycling and public transit have begun to offer additional transportation options in a growing number of national parks and public lands.

Funding to support transportation in national parks and other public lands has increased. This includes funding for transit, bicycle, and intermodal facilities (SAFETEA – LU, 2005). The Federal Transit Administration continues to assist in planning and managing transit systems for national parks and related public lands through its Paul S. Sarbanes Transit in Parks Technical Assistance Center (TRIPTAC; formerly the Alternative Transportation in Parks and Public Lands Program), and the Federal Highways Administration recently published a "Guide to Promoting Bicycling on Federal Lands" (FHWA, 2008). With multimodal transportation systems on the rise in parks and public lands, it is evident that the means to measure and manage their quality is important in shaping the experience of visitors.

TRANSPORTATION AS RECREATION

One of the earliest academic treatments of the contemporary field of park and outdoor recreation management suggested that recreation experiences occur in five phases, two of which are travel to and from parks and related areas (Clawson and Knetsch, 1966). Of course, the on-site experience of outdoor recreation also involves some form of transportation (e.g., car, foot) in almost all cases. Thus, a strong linkage between outdoor recreation and transportation has been recognized for some time. Unfortunately, relatively little empirical work has been conducted on the relationship between transportation and outdoor recreation. However, this is beginning to change. A recent analysis of research needs concludes that transportation in the context of parks, outdoor recreation, and public lands is "much more than getting from point A to B" (Daigle, 2008). In other words, transportation can be an important part of the outdoor recreation experience and warrants more attention.

Historically, transportation has been integrated into the context of parks, outdoor recreation, and public lands through the aesthetic sensibilities of the field of landscape architecture, and this history has been well documented as it applies to the National Park Service (Carr, 1998). For example, the "natural look" of many of the scenic roads in the national parks has been attributed to careful planning, design, and construction by landscape architects (Louter, 2006). Stephen Mather, the first director of the National Park Service, even established a landscape engineering department charged with "naturalizing" park roads and trails (Sutter, 2002). However, only recently has research turned to empirical studies of park and outdoor recreation visitors and how they view roads and other forms of transportation in parks and outdoor recreation.

For instance, a study of visitors' perspectives of alternative transportation in Yosemite Valley used interviews to identify psychological factors and situational influences that effect visitors' perceptions of the park shuttle bus system (White, 2007). The study concluded that psychological factors influencing visitors' perspectives of alternative transportation included "perceived freedom, environmental values and beliefs, prior experience with Yosemite National Park and other national parks, and sensitivity to subjective perceptions of crowding." A need for additional crowding and capacity research for park shuttle bus systems was also noted. A follow-up study of visitor experiences of transportation in Yosemite National Park included multiple forms of transportation including walking, bicycling, park shuttles, and private vehicles (White, 2011). This research documented visitors' transportation mode choices, identified their satisfaction with each mode, explored perceptions of experiential dimensions of these modes, and examined visitors' preferences concerning transportation management. Findings established that all modes of transportation were important in influencing the visitor experience with some differences in levels of satisfaction between traditional and alternative modes of transportation. Traffic congestion was suggested as a potential indicator for measuring the quality of the visitor experience. Furthermore, the study suggests development of transportation-based indicators and standards for measuring and managing the quality of travel in parks.

Precedents for using indicators and standards based frameworks for managing park roads and scenic driving have been set in recent studies (Hallo & Manning 2011, 2009; Manning & Hallo, 2010). These studies have been conducted in a number of national parks, including Acadia National Park, Cape Cod National Seashore, Blue Ridge Parkway, and Denali National Park and Preserve. As a first phase of these studies, interviews were used to elicit potential indicators of quality. Congestion and crowding were frequently cited as having an impact on the quality of the visitor experience by respondents across all settings. The second phase of these studies then utilized visual simulations to illustrate varying numbers of vehicles along park roads. Respondents were asked to rate the acceptability of the conditions portrayed in each of the photos. These studies suggest thresholds, or standards of quality, for the maximum acceptable density levels on park roads.

The studies described above suggest integrating indicators and standards into the more conventional transportation concept of "levels of service" as used by the Transportation Research Board (TRB) and its Highway Capacity Manual (HCM) (Transportation Research Board, 2010). Defining an "appropriate level of service" has been an important element of transportation planning in national parks and public lands for several decades (National Park Service, 1984), but these standards have lacked a strong basis in empirical research. The most recent edition of the HCM adopts a perspective that is more in keeping with defining standards of quality based on empirical studies of drivers and other transportation users when it states that levels of service describe "how well a transportation facility or service operates from the travelers' perspective" (Transportation Research Board, 2010). While the HCM is not written within the context of outdoor recreation, Chapter 3 of this Best Practices Manual suggests how levels of service may be re-registered for recreation-based settings such as parks and public lands.

TRANSPORTATION AS AN OUTDOOR RECREATION MANAGEMENT TOOL

While an indicators and standards-based approach to managing transportation as recreation is beginning to emerge, there is another body of research that treats transportation as a tool for managing outdoor recreation. Indicators and standards of quality are also an integral component of this work. In this case, however, the focus is on delivering the "right" number of visitors, to the "right" places, at the "right" times.

For instance, a study conducted at Arches National Park identified the number of people at developed attraction sites as an indicator of quality (Manning, 2004). As in the studies described above, standards of quality were then developed using computer-generated photographs illustrating a range of use levels at an attraction site (Delicate Arch). These standards, developed with public involvement and managerial consideration, helped suggest the "right" number of visitors for Delicate Arch. The park then set up a system for monitoring the number of people at the arch, and management actions were taken to ensure that standards of quality were maintained. For example, the trailhead parking lot for the trail to Delicate Arch was sized to prevent the delivery of an unacceptable number of visitors at any one time. A more detailed account of this study may be found in Chapter Six of this manual.

Simulation modeling is another tool that uses indicators and standards of quality and transportation to inform outdoor recreation management. Simulation modeling is a simplification of the structure and operation of a complex system; it enables the study of, and experimentation with, the internal interactions of a real world system (Manning, 2009). For instance, a study conducted in Yosemite National Park determined standards of quality for a number of attraction sites (Lawson et al, 2009). It also used traffic and trail counters to measure inbound vehicular traffic and visitor use levels at attraction sites. Through the use of regression analysis and computer simulations, results illustrated how managers might predict when and where standards of quality would be violated at attraction sites. Upon monitoring inbound traffic levels, managers may then take actions to maintain the "right" number of people at attraction sites. While managers may choose to limit use, they could also direct visitors to other areas of the park where the simulation model estimates that standards of quality are not in danger of being violated.

Intelligent transportation systems (ITS) also promise to help deliver the right number of people, to the right places, at the right time. ITS uses information technology to provide real-time travel conditions to recreation travelers (Sheldon, 1997). For instance, a study conducted in Acadia National Park found that real-time parking information had an effect on visitor travel patterns. For instance, 43% of the respondents in the study reported changing the time of day they visited an attraction site based upon reports of parking conditions. Moreover, 38% of visitors chose other sites to travel to (Daigle, 2004). In this way, ITS helped maintain standards of quality at visitor attraction sites through monitoring and relaying information about parking conditions.

The research described above illustrates that transportation and recreation are inextricably linked. Whether transportation itself is a form of recreation, or whether it may be used as a tool to manage recreation opportunities, the relationship between the two remains integral to providing and maintaining the quality of recreation experiences throughout parks and public lands. While recent research illustrates this point, contemporary policy guidance further solidifies the increasing emphasis on integrating the fields of transportation and outdoor recreation management.

POLICY GUIDING THE INTEGRATION OF TRANSPORTATION AND OUTDOOR RECREATION MANAGEMENT

Each federal land managing agency (FLMA) has its own mission and the Department of Transportation's (DOT) Office of Federal Lands Highway (FLH) has sought to support them all. For instance, a number of FLMAs have their own Federal Lands Highway Program (FLHP) tailored to their transportation planning and management needs (Table 1) (FLH, 2008). The partnership between NPS and DOT exemplifies interagency cooperation and serves as an example of how agency objectives and planning frameworks may be integrated into a more comprehensive management system.

Table 1: Federal land managing agency missions and Federal Lands Highway programs (adapted from the 'Guide to Promoting Bicycling on Federal lands' 2008)

FLMA	Mission	FLH Program
National Park Service	Preserves unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations.	Park Roads and Parkways
U.S. Fish and Wildlife Service	Works with others to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.	Refuge Roads
U.S. Forest Service	Manages national forests for multiple uses and for the sustained yield of renewable resources such as water, forage, wildlife, wood, and recreation.	Forest Highways

The DOT was established in 1966 with the mission to "serve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system" (Department of Transportation Act, 1966). As illustrated by this mandate, the agency's primary focus is upon variables such as speed, safety, efficiency, access and convenience. The NPS Organic Act of 1916 focuses upon a different set of objectives. It directs the agency "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (National Park Service Organic Act, 1916). In 1982, the interests of both agencies were balanced by the Surface Transportation Assistance Act. The act established a hybrid mission statement for the FLH that included variables from both the NPS Organic Act and DOT mission: "[to] Improve transportation access to and through Federal and Tribal lands through stewardship of FLH programs by providing balanced, safe, and innovative roadways that blend into or enhance the existing environment" (STAA, 1982). Accessibility and safety impart values from DOT's mission, while scenic and environmental considerations are bestowed from the NPS'. By 1983, a formal partnership between the DOT and NPS was recognized in the form of a Memorandum of Agreement (MOA). This MOA established the Park Roads and Parkways Program and was supplemented fourteen years later by a Memorandum of Understanding (MOU).

The MOU's overarching goal was to improve transportation in, and approaching, NPS facilities through five activities: 1) developing and implementing innovative transportation plans; 2) establishing personnel exchange and information sharing systems; 3) establishing interagency project agreements for developing and implementing transportation improvement initiatives; 4) developing innovative transportation planning tools; and 5) developing innovative policy, guidance and coordination procedures for the implementation of safe and efficient transportation systems that are compatible with the protection and preservation of the National Park System's cultural and natural resources. It led to the development of the Alternative Transportation in Parks and Public Lands program (now TRIPTAC) as well as the publication of the NPS "Transportation Planning Guidebook" in 1999.

Two more recent legislative acts have also had an impact on transportation planning and management in parks and public lands. The Transportation Equity Act for the 21st Century (TEA-21, 1998) required the DOT and Department of Interior to conduct a comprehensive study of transportation needs on federal lands, and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU, 2005) initiated funding for multi-modal transportation projects including transit, bicycle and pedestrian, ferry facilities, visitor facilities, and intermodal terminals. Furthermore, park transportation planning and management is addressed the Code of Federal Regulations (CFR).

For instance, the NPS has been directed to develop criteria to determine when a congestion management system (CMS) is to be implemented. In the development of a CMS, "consideration shall be given to strategies that promote alternative transportation systems, reduce private automobile travel, and best integrate private automobile travel with other transportation modes." It also suggests that alternative mode studies be integrated as components of a CMS, and that methods should be determined to evaluate and monitor the effectiveness of multi-modal transportation systems. When reflecting upon the results of a CMS, the NPS must also consider congestion mitigation strategies that "add value (protection/rejuvenation of resources, improved visitor experience) to the park." The use of the terms "visitor experience" and "resource protection" illustrate the intent for managers to use indicators and standards of quality based framework as manifested in the National Park Service's Visitor Experience and Resource Protection (VERP) framework (National Park Service 1997; Manning 2001). The CFR also notes LOS as a conceptual framework from conventional transportation planning that may be used to identify and document measures of congestion (CFR Title 23 970.214). This nexus between indicators and standards of quality and LOS exemplifies the integration of agency objectives and is the result of decades of interagency coordination and cooperation. The following sections of this manual provide conceptual links between indicators and standards of quality and LOS, and illustrate how an integrated framework may become operational for multiple modes of transportation in parks and public lands.

CHAPTER 3: INDICATORS AND STANDARDS OF QUALITY

INDICATORS AND STANDARDS OF QUALITY IN OUTDOOR RECREATION

Contemporary management of outdoor recreation is increasingly guided by management-by-objectives frameworks. The Limits of Acceptable Change framework developed by the U.S. Forest Service and Visitor Experience and Resource Protection framework, developed by the National Park Service, are prominent examples of this approach (Stankey et al. 1986, National Park Service 1997, Manning 2001, Manning 2007). This approach to outdoor recreation focuses on defining the type of outdoor recreation opportunities to be provided and maintained, and is done by formulating management objectives and associated indicators and standards of quality.

Management objectives are broad, narrative statements that define the type of outdoor recreation opportunities to be provided and maintained, including the condition of natural and cultural resources, the type of recreation experience, and the type and intensity of management actions desired for particular recreation areas or systems of public lands. In some contexts, management objectives are called “desired conditions.” Indicators of quality are more specific, measurable, manageable variables reflecting the essence or meaning of management objectives; they are quantifiable proxies or empirical measures of management objectives. Indicators of quality may include elements of the resource, social, and management environments that are important in determining the type and quality of outdoor recreation opportunities. Standards of quality define the minimum acceptable condition of indicator variables.

An example may help illuminate these ideas and terms. All four of the major federal land agencies that provide outdoor recreation opportunities (National Park Service, US Forest Service, US Fish and Wildlife Service, Bureau of Land Management) manage wilderness areas designated by Congress. 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 solitude.” Thus, providing opportunities for solitude is an appropriate management objective or desired condition 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 (Manning 2011). As such, 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 the quality of opportunities for solitude decline to an unacceptable degree. For example, a number of studies suggest that wilderness visitors prefer to see no more than five other groups-per-day along trails and prefer to camp out of sight and sound of other groups (Manning 2011). Thus, a maximum of five encounters along trails per day and no encounters at campsites may be good standards of quality. Management of wilderness areas adopting these types of indicators and standards of quality might include limiting use through a permit system or dispersing use to other areas in order to maintain standards of quality.

INDICATORS OF QUALITY

Several studies have explored criteria that might be used to define effective indicators of quality (Schomaker 1984, Stankey et al. 1985, Merigliano 1990, Whittaker and B. Shelby 1992, National Park Service 1997, Manning 2007). These criteria can be used to further understand the role of indicators and standards of quality in outdoor recreation and to assist in evaluation and selection among potential indicator variables. Criteria for good indicators of quality include the following:

1. Specific. Indicators should define specific rather than general conditions. For example, "solitude" would not be a good indicator of quality because it is too general. "The number of other groups encountered per day along trails" would be a more specific and better indicator variable.

2. Objective. Indicators should be objective rather than subjective. That is, indicator variables should be measured in absolute, unequivocal terms. Variables that are subjective, expressed in relative terms, or subject to interpretation make poor indicators. For example, "the number of people at one time at Wild Arch" is an objective indicator because it is an absolute number that can be counted and reported. However, "the percentage of visitors who feel crowded at Wild Arch" is a subjective indicator because it is subject to interpretation by visitors – it depends on the types of visitors making the judgment, the behavior of other visitors, and other variables.

3. Reliable and repeatable. An indicator is reliable and repeatable when repeated measurement yields similar results under similar conditions. This criterion is important because monitoring of indicator variables should be conducted periodically, assessing the effects of use and management actions.

4. Related to visitor use. Indicators should be related to some aspect of visitor use: level of use, type of use, location of use, or behavior of visitors. A major role of indicators of quality is to help determine when management action is needed to control the impacts of visitor use. Thus, there should be a relationship between visitor use and indicators of quality.

5. Sensitive. Indicators should be sensitive to visitor use over a relatively short period of time. As the level or type of use changes, an indicator should respond in roughly the same proportional degree. If an indicator changes only after impacts are substantial, it will not serve as an early warning mechanism, allowing managers to react in a timely manner.

6. Manageable. Indicators should be responsive to, and help determine the effectiveness of, management actions. That is, they must be responsive to management action. The underlying rationale of indicators is they should be maintained within prescribed standards of quality. This implies that they must be manageable.

7. Efficient and effective to measure. Indicators should be relatively easy and cost-effective to measure. Indicators of quality should be monitored on a regular basis. Therefore, the more expertise, time, equipment, and staff needed to take such measurements, the less desirable a potential indicator of quality may be.

8. Significant. Perhaps the most important characteristic of indicators is that they help define the quality of the visitor experience. This is inherent in the very term "indicator." It does little good to monitor the condition of a variable that is unimportant in defining the quality of the visitor experience.

It may be useful to incorporate these criteria within a matrix for the purpose of evaluating potential indicators of quality as shown in Figure 1. Potential indicator variables can be arrayed along the horizontal axis of the matrix and rated as to how well they meet the criteria described above.

Potential Indicators of Quality	Criteria for Good Indicators of Quality							
	Specific	Objective	Reliable and Repeatable	Related to Visitor Use	Sensitive	Manageable	Efficient and Effective to Measure	Significant
Indicator 1								
Indicator 2								
Indicator 3								
Indicator 4								
Indicator 5								
Indicator								

Figure 1: Evaluation matrix for selecting indicators of quality

STANDARDS OF QUALITY

As with indicators of quality, several studies have explored characteristics that might define good standards of quality (Schomaker 1984, Brunson et al. 1992, Whittaker and Shelby 1992, National Park Service 1997, Manning 2011). To the extent possible, good standards of quality should meet the following characteristics:

1. Quantitative. Standards should be expressed in a quantitative manner. Since indicators of quality are specific and measurable variables, standards of quality can and should be expressed in an unequivocal way. For example, if an indicator is "the number of encounters with other groups per day on the river," then the standard might be "an average of no more than three encounters with other groups per day on the river." In contrast, "low numbers of

encounters with other groups per day on the river" would be a poor standard of quality because it does not specify the minimum acceptable condition in unambiguous terms.

2. Time or space-bounded. Incorporating a time- or space-bounded element into a standard of quality expresses both how much of an impact is acceptable and how often or where such impacts can occur. It is often desirable for standards to have a time period associated with them. This is especially relevant for crowding-related issues. For instance, in the above example, the standard of quality for encounters with other groups on the river was expressed in terms of "per day." Other time-bounded qualifiers might include "per night," "per trip," "per hour," or "at one time," depending upon the circumstances. Space-bounded qualifiers could be “per mile of trial,” “per campsite,” or “per square meter.”

3. Expressed as a probability. In many cases, it will be advantageous to include in the standard of quality a tolerance for some percentage of the time that a particular condition will be unavoidably unacceptable; in other words, the standard would include a probability that conditions will be at standard or better. For example, a standard might specify, "no more than three encounters with other groups per day along trails for 80% of days in the summer use season." The 80% probability of conditions being at or above standard allows for 20% of the time that random or unusual events might prevent management from attaining these conditions. This allows for the complexity and randomness inherent in visitor use patterns. In the example of encounters along a trail, several hiking parties might depart from a trailhead at closely spaced intervals on a given day. These groups are likely to encounter each other on the trail several times during the day. On another day, the same number of groups might depart from the trailhead at widely spaced intervals and thereby rarely encounter each other. Similarly, it might be wise to incorporate a tolerance in standards for peak use days, holiday weekends, or other days of exceptionally high visitation. A standard might be set at "50 people at one time at Wild Arch for 90% of the days of the year." The amount of tolerance needed depends on the unpredictability of each individual situation and the degree to which management can consistently control conditions.

4. Impact-oriented. Standards of quality should focus directly on the impacts that affect the quality of the visitor experience, not the management action used to keep impacts from violating the standards. For example, an appropriate standard might be, "no more than ten encounters with other groups on the river per day." This could be a good standard because it focuses directly on the impact that affects the quality of the visitor experience – the number of other groups encountered. Alternatively, "a maximum of twenty groups per day floating the river" would not be as good a standard of quality because it does not focus as directly on the impact of concern – visitors experience encounters with other groups more directly than they experience total use levels. Basing standards of quality on management techniques rather than on impacts can also limit the potential range of useful management practices. For example, limiting the number of boats to twenty per day might be used to ensure ten or fewer encounters per day, but other actions, such as more tightly scheduling launch times, could also ensure an appropriate encounter rate and could be less restrictive on the level of visitation to the river.

5. Realistic. Standards should generally reflect conditions that are realistically attainable. Standards that limit impacts to extremely low levels may set up unrealistic expectations in

the minds of visitors, may be politically infeasible, and may unfairly restrict visitor use to very low levels.

LEVELS OF SERVICE (LOS) IN TRANSPORTATION MANAGEMENT

Level of service (LOS) is a highway capacity framework that has guided transportation planning across the United States, and is reflective of the broader management objectives of the Department of Transportation: "[to] serve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system" (Department of Transportation Act, 1966). It is derived from the Transportation Research Board's Highway Capacity Manual (HCM) and describes operational conditions within a traffic stream using variables such as speed, travel time, freedom to maneuver, comfort, and convenience (Transportation Research Board 2000, 2010). It defines a range of traffic conditions based upon a letter grade system (A through F) where 'A' represents the best operating conditions and 'F' the worst.

The LOS framework is formulated for numerous types of transportation facilities and multiple modes (Figure 2; Table 2; Transportation Research Board 2000, 2010). Some LOS conventions are intuitive like that for transit buses, which evaluates service quality by the ratio of riders to seats. Others are more abstract, like that for pedestrians on a shared use path, which is based on a rate of events between users. In some cases, difficult to comprehend numerical performance measures, like vehicles per mile per lane for cars on a freeway or ft^2 per person can be effectively visualized. By measuring and expressing factors that contribute to the quality of transportation service, performance measures serve much the same purpose of indicators of quality. The grade system has been critiqued for lacking empirical links to user perceptions (Flannery et al., 2004). While recent research has undertaken a more comprehensive view of factors important to users and has led to a number of explanatory variables that have been used to develop LOS models (Transportation Research Board 2008), it may not fully reflect experiential components of travel, especially in the context of parks and public lands.

Table 2: Levels of service for selected transportation modes and facilities (Transportation Research Board 2000, 2010)

Mode		Pedestrians	Transit Bus	Private Vehicle	Pedestrians
Facility		Shared Use Path	Passenger Load	Freeway	Pedestrian Walkway
Performance Measure		events/hour	riders/seat	vehicles/mile/lane	ft^2/person
Levels of Service	A	≤11	≤28	0.0-0.5	>60
	B	11-18	28-44	0.51-0.75	40-60
	C	18-26	44-75	0.76-1.0	24-40
	D	26-35	75-105	1.0-1.25	15-24
	E	35-45	105-131	1.26-1.5	8-15
	F	>45	>131	>1.5	≤8

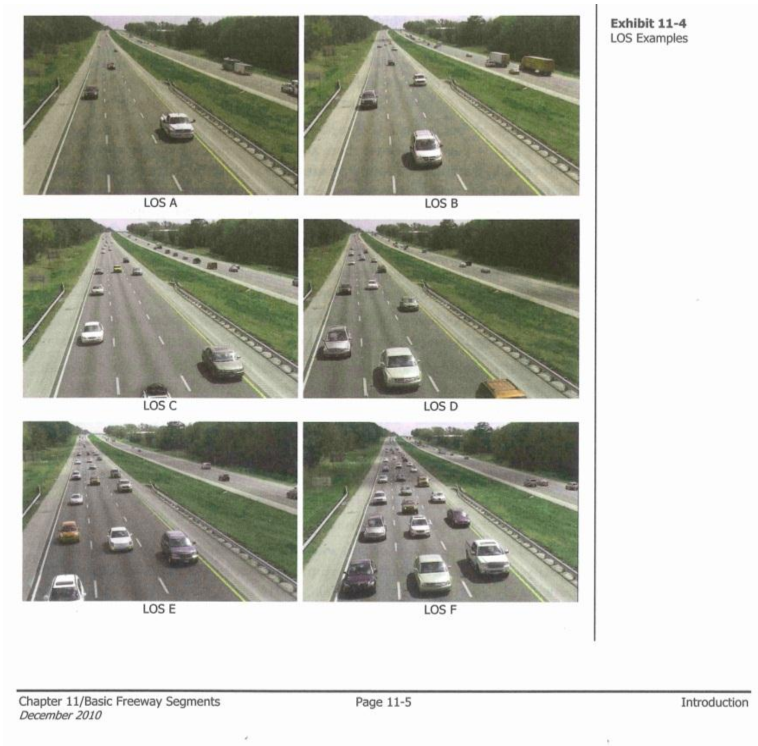


Exhibit 11-4
LOS Examples

LOS A
LOS B
LOS C
LOS D
LOS E
LOS F

Chapter 11/Basic Freeway Segments
December 2010
Page 11-5
Introduction

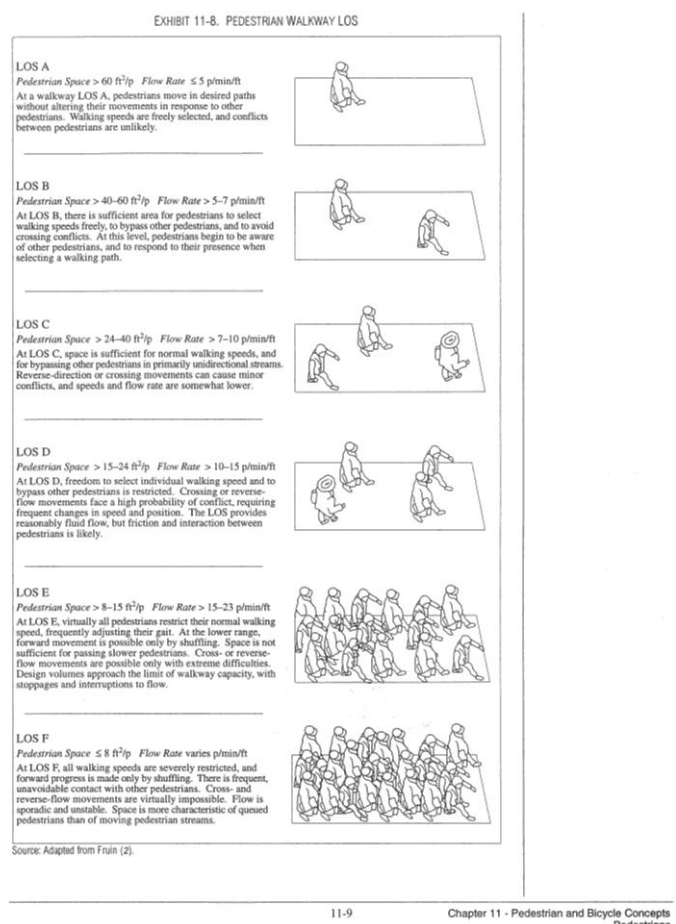


EXHIBIT 11-8. PEDESTRIAN WALKWAY LOS

LOS A
Pedestrian Space > 60 ft^2/p *Flow Rate* ≤ 5 p/min/ft
At a walkway LOS A, pedestrians move in desired paths without altering their movements in response to other pedestrians. Walking speeds are freely selected, and conflicts between pedestrians are unlikely.

LOS B
Pedestrian Space > 40–60 ft^2/p *Flow Rate* > 5–7 p/min/ft
At LOS B, there is sufficient area for pedestrians to select walking speeds freely, to bypass other pedestrians, and to avoid crossing conflicts. At this level, pedestrians begin to be aware of other pedestrians, and to respond to their presence when selecting a walking path.

LOS C
Pedestrian Space > 24–40 ft^2/p *Flow Rate* > 7–10 p/min/ft
At LOS C, space is sufficient for normal walking speeds, and for bypassing other pedestrians in primarily unidirectional streams. Reverse-direction or crossing movements can cause minor conflicts, and speeds and flow rate are somewhat lower.

LOS D
Pedestrian Space > 15–24 ft^2/p *Flow Rate* > 10–15 p/min/ft
At LOS D, freedom to select individual walking speed and to bypass other pedestrians is restricted. Crossing or reverse-flow movements face a high probability of conflict, requiring frequent changes in speed and position. The LOS provides reasonably fluid flow, but friction and interaction between pedestrians is likely.

LOS E
Pedestrian Space > 8–15 ft^2/p *Flow Rate* > 15–23 p/min/ft
At LOS E, virtually all pedestrians restrict their normal walking speed, frequently adjusting their gait. At the lower range, forward movement is possible only by shuffling. Space is not sufficient for passing slower pedestrians. Cross- or reverse-flow movements are possible only with extreme difficulties. Design volumes approach the limit of walkway capacity, with stoppages and interruptions to flow.

LOS F
Pedestrian Space ≤ 8 ft^2/p *Flow Rate* varies p/min/ft
At LOS F, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent, unavoidable contact with other pedestrians. Cross- and reverse-flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued pedestrians than of moving pedestrian streams.

Source: Adapted from Fruin (2).

11-9
Chapter 11 - Pedestrian and Bicycle Concepts
Pedestrians

Figure 2: Visualization for highways and pedestrian walkway levels of service (Transportation Research Board 2000, 2010)

For instance, attempts to describe the quality of bicycle and pedestrian travel have focused primarily on user interactions rather than a more holistic set of experiential factors. The HCM defines LOS for shared-use paths based upon "hindrance," or the number of events (the passing of two users classified as meetings or overtakings) a pedestrian or cyclist experiences while traveling on a greenway (Transportation Research Board 2000). Models employing this concept have been developed to incorporate hikers, bikers, and joggers but remain reliant primarily upon the number of overtakings between users (Virkler 1998). And, while some studies have begun to incorporate real-time human perceptions into a bicycle level of service (Landis 2003), they too have focused primarily upon impacts from other road users upon cyclists rather than environmental elements such as the level of corridor or facility development. Furthermore, it has been suggested that some modes of transportation, such as pedestrian activity include a 'breadth of experience' (Demerath 2003) that has not yet been included in LOS measures.

INTEGRATING INDICATORS AND STANDARDS OF QUALITY AND LOS

The relationship between indicators and standards of quality and LOS is expressed by the HCM's interpretation of *quality of service*. As defined by the 2010 HCM, quality of service "describes how well a transportation facility or service operates from the traveler's perspective" (Transportation Research Board 2010). While the quality of service concept was included in an earlier edition of the HCM, its definition focused primarily on "quantitative measures to characterize operational conditions" (Transportation Research Board 2000) rather than the traveler's perceptions of those conditions. The LOS concept has always been represented in the HCM as the A to F stratification of quality of service, but only in its most recent edition is the emphasis upon including user perceptions for defining LOS made clear. The introduction of numerous traveler perception-based models for describing LOS in the 2010 manual further highlights the importance of this evolution of the LOS concept.

Similar to the indicators and standards of quality based approach, these traveler perception-based models set thresholds derived from user perceptions of quality. Furthermore, both present a continuum of conditions that represent a range of service quality. Standards of quality define a minimum acceptable condition, and transportation "planning efforts typically use…LOS C or D, to ensure an acceptable" operating service (Transportation Research Board 2000). Therefore, it follows that the integration of these frameworks be anchored around a minimum acceptable condition of quality equivalent to LOS E. That is to say, any of the conditions deemed *acceptable* by travelers would represent LOS A-D, while any of the conditions rated as *unacceptable* by travelers would be representative of LOS F. LOS E indicates both a minimum level of acceptability from a traveler's perspective, and a level of service that transportation planners aim to exceed. This rational nexus between indicators and standards of quality and quality of service therefore provides another means of incorporating user perceptions into LOS.

CHAPTER 4: USING INDICATORS AND STANDARDS OF QUALITY TO DEFINE, UNDERSTAND AND MANAGE OUTDOOR RECREATION

A number of conceptual frameworks have emerged from the scientific and professional literature on outdoor recreation. These frameworks can help managers organize their thinking about outdoor recreation, including transportation as both a form of recreation and a tool to manage outdoor recreation. Several of these frameworks are described below. All of these frameworks incorporate indicators and standards of quality.

DEFINING QUALITY IN OUTDOOR RECREATION

Management of outdoor recreation on public lands is aimed at protecting high quality natural and cultural resources and providing high quality outdoor recreation experiences. The concept of quality can, however, be difficult to define. Quality might best be defined as it is applied in alternative contexts. At the level of the individual visitor, "satisfaction" is an appropriate measure of quality, though measures of satisfaction with specific components of the experience (e.g., environmental conditions, use level/crowding, number and type of facilities) are more useful than general or overall measures. These more specific measures of satisfaction address the degree to which an outdoor recreation activity or area meets the needs of users.

Quality can also be defined in the context of management. Given the diversity in public tastes for outdoor recreation, a park or similar area could be managed for many types of outdoor recreation (e.g., a developed campground, a wilderness campsite). Thoughtful consideration should be given to the most appropriate type of opportunity to be provided, and this decision should be expressed in terms of management objectives and associated indicators and standards of quality. Quality is then defined and measured as the degree to which recreation opportunities meet the standards of quality for which they are designed and managed.

Finally, quality in outdoor recreation can be defined at a broad societal level as provision of a diverse system of outdoor recreation opportunities. Given broad and diverse tastes in outdoor recreation, a comparably diverse system of outdoor recreation opportunities on public lands should be provided. Each opportunity within this system should be managed for a defined set of objectives as determined by inherent capabilities of natural and cultural resources, assessment of the demand for and supply of recreation opportunities, and the mandate and capacity of management agencies.

Indicators and standards can be useful in defining quality in outdoor recreation at all three of the levels or contexts noted above. For visitors, satisfaction can be measured for a variety of indicators of quality such as condition of natural and cultural resources, use level/crowding, and type and condition of facilities and services. For managers, indicators and standards of quality can be used to define management objectives in an empirical fashion, facilitating measurement of the degree to which managers have been successful in providing the type and quality of outdoor recreation opportunities desired. At the societal level, indicators and standards of quality can be used to help define a broad spectrum of outdoor recreation opportunities and assess the relative abundance of a range of types of outdoor recreation opportunities.

UNDERSTANDING QUALITY IN OUTDOOR RECREATION

Early research in outdoor recreation began building a theoretical foundation for understanding outdoor recreation (Driver and Toucher 1970, Driver 1975, Driver and P. Brown 1975, Driver and Rosenthal 1982, Driver 1985, Schreyer and Driver 1989). This work began by noting that the traditional view of recreation is based on activities – fishing, swimming, camping, etc. (Driver and Toucher 1970). While this activity approach has been useful for a variety of descriptive purposes, it leaves unaddressed a number of potentially important questions:

> Why is the recreationist participating in the activity? What other activities might have been selected if the opportunities existed? What satisfactions or rewards are received from the activity? How can the quality of the experience be enhanced? (Driver and Toucher 1970:10).

To better answer these questions, a "behavioral approach" was proposed whereby recreation is defined as "an experience that results from recreational engagements" (Driver and Toucher 1970). This approach is based on psychological theory which suggests that most human behavior is goal-oriented or aimed at fulfilling some need (Crandall 1980). Perhaps the most widely recognized expression of this theory is Maslow's (1943) hierarchy of human needs beginning with the most basic requirements for physiological sustenance and ranging through more aesthetic concerns. Research on the behavioral approach to understanding outdoor recreation is based on expectancy theory developed in social psychology, which suggests that people engage in activities in specific settings to realize psychological outcomes that are known, expected, and valued (e.g., Atkinson and Birch 1972, Lawler 1973, Fishbein and Ajzen 1974). Thus people select and participate in recreation activities to meet certain goals or satisfy certain needs. In this context, outdoor recreation activities are as much a means to an end as an end to themselves.

This approach to understanding outdoor recreation has been expanded to recognize four levels or hierarchies of outdoor recreation as illustrated in Table 3(Driver and Brown 1978, Haas et al. 1980). Level 1 represents demands for activities themselves and has been the traditional focus of much outdoor recreation research and management. Level 2 represents the settings in which activities take place. An activity such as camping, for example, can be undertaken in a variety of environmental, social, and managerial settings, each representing different recreation opportunities. Levels 1 and 2 combine as inputs to a process where individuals participate in activities within particular settings to fulfill goals or motivations as represented by level 3. These motivations are desired psychological outcomes. Examples include enjoyment of the out-of-doors, developing or applying skills, strengthening family ties, learning, getting exercise, exploring, reflecting on personal values, temporarily escaping a variety of adverse stimuli at home or at work, and taking risks. Typically, more than one motivation is sought from recreation participation. Finally, Level 4 refers to the ultimate or higher-order benefits that can flow from fulfilling motivations and realizing recreational goals. These benefits may be personal, social, economic, or environmental.

Table 3: Four levels or hierarchies of demand for outdoor recreation (adapted from Haas et al. 1980)

Level	Example 1	Example 2
Activities	Wilderness hiking	Family Picnicking
Settings Environmental Social Managerial	Rugged terrain Few people No restrictions	Grass fields Ability for groups to gather Picnic tables
Motivations	Risk taking Challenge Physical exercise	In-group affiliation Change of pace
Benefits Personal Social Economic Environmental	Enhanced self-esteem Low crime rate Low health care costs Conservation commitment	Enhanced personal health Family solidarity Increased work production Higher quality environment

This approach to understanding outdoor recreation outlines a general process in which individuals engage in recreation to achieve benefits (Figure 3). Depending upon the individual's motivations, they will pursue a certain activity in a particular setting. If the individual's needs are met and goals are achieved, they will have fulfilled their goals and will reap the benefits of recreation. Facilitation of this process for a diverse spectrum of goals is an appropriate goal and outcome of recreation management. Managers can best accomplish this by providing appropriate settings for recreation activities, and these settings can be described by means of indicators and standards of quality.

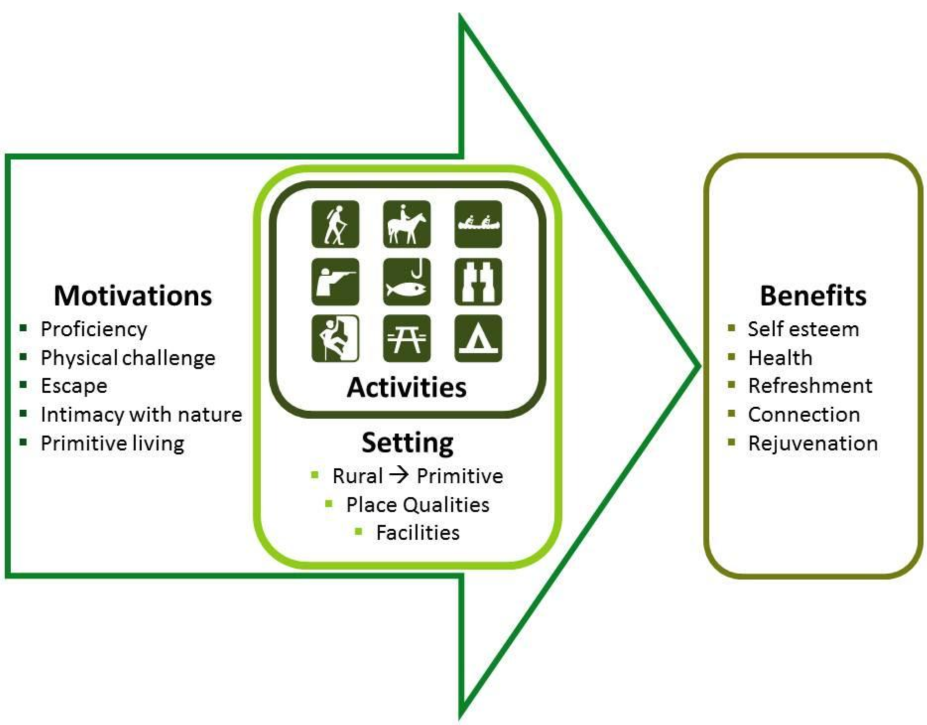


Figure 3: Behavioral approach to understanding outdoor recreation

THE CAPACITY FOR QUALITY IN OUTDOOR RECREATION

Rapidly expanding outdoor recreation in the post-World War II period gave rise to concerns over appropriate use levels of outdoor recreation areas. While interest in the impacts of recreation on natural resources predominated, there was also emerging attention on the effects of increased use on the quality of the recreation experience. Early descriptive studies prompted recreation managers and researchers to search for theories to help guide outdoor recreation planning and management. 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. In this generic form, carrying capacity has been applied to broad-ranging environmental issues, including the ultimate population level of humans (e.g., Borgstrom 1965, Ehrlich 1968, Meadows et al. 1972, Cohen 1995).

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 Sierra Nevada Mountains 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."

More recently, carrying capacity has been codified into policy and law designed to promote high quality recreation opportunities within the U.S. public land system. 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.” 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.”

The principal challenge with carrying capacity lies in determining how much impact or change should be allowed to natural and cultural resources and the quality of the recreation experience. This issue is often referred to as the "limits of acceptable change" (Frissell and Stankey 1972, Stankey et al. 1985). When parks and public lands are used for recreation some change in the environment is inevitable. Sooner or later the amount, nature, or type of change may become unacceptable. What determines the limits of acceptable change? This issue is illustrated graphically in Figure 4. In this figure, a hypothetical relationship between visitor use and impacts is shown. This relationship suggests that increasing recreation use causes increasing impacts in the form of damage to fragile soils and vegetation and crowding and conflict among visitors. However, it is not clear from this relationship at what point a carrying capacity has been reached. X1 and X2 represent alternative levels of visitor use that result in corresponding increases in 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 – represents the maximum amount of impact that is acceptable?

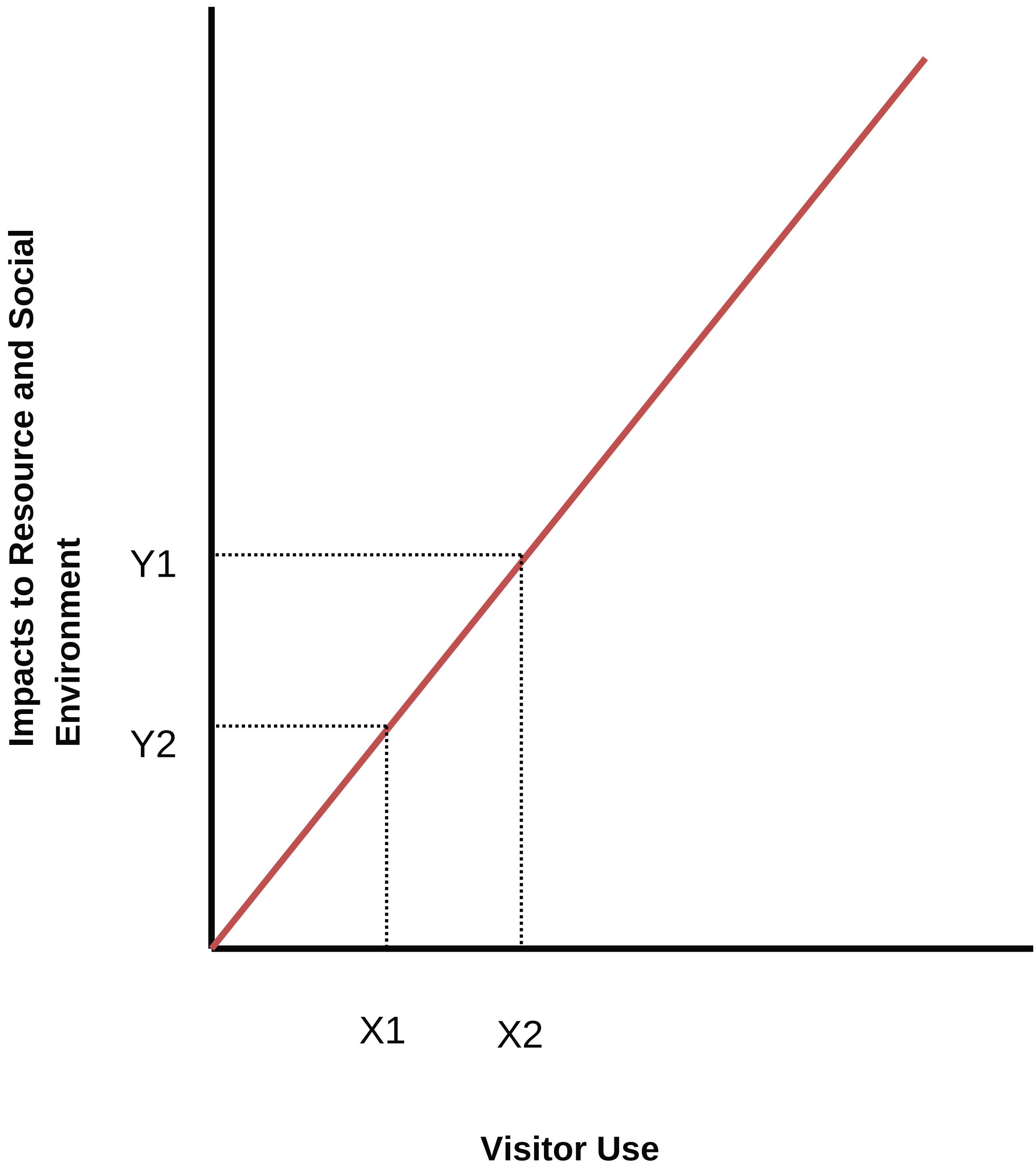


Figure 4: Hypothetical relationship between visitor use and impact to the recreation environment (adapted from Manning 2011)

Recent experience 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, Bury 1976, Lime 1979, Stankey and Manning 1986, Graefe et al. 1990, Shelby et al. 1992, Manning and Lime 1996, National Park Service 1997, McCool and Lime 2001, Cole et al. 2005, Manning 2005, Graefe et al., 2011, Whittaker et al., 2011). Management objectives are sometimes called "desired conditions" and carrying capacity is sometimes called "visitor capacity." As described earlier in this manual, standards of quality define the minimum acceptable conditions of indicator variables, and this is an empirical expression of management objectives and the limits of acceptable change.

FRAMEWORKS FOR MANAGING QUALITY IN OUTDOOR RECREATION

The literature on carrying capacity has given rise to several frameworks for defining and managing quality in outdoor recreation on public lands. Prominent examples of these frameworks include Limits of Acceptable Change (LAC) (Stankey et al. 1985, McCool 1994, McCool and Cole 1997), and Visitor Experience and Resource Protection (VERP) (Hof and Lime 1997, National Park Service 1997, Manning 2001, Manning 2007, Manning 2009). While terminology, sequencing, and other aspects may vary among these frameworks, all share a common underlying logic and rely on formulation of management objectives and associated indicators and standards of quality (Manning 2004). Core elements of these frameworks include (Figure 5):

1. Definition of the types of recreation opportunities to be provided. Recreation opportunities should be defined as specifically and quantitatively as possible through management objectives and associated indicators and standards of quality.

2. Monitoring of indicator variables to determine whether existing conditions meet standards of quality.

3. Implementation of management actions when and where monitoring suggests that standards of quality have been violated or are in danger of being violated.

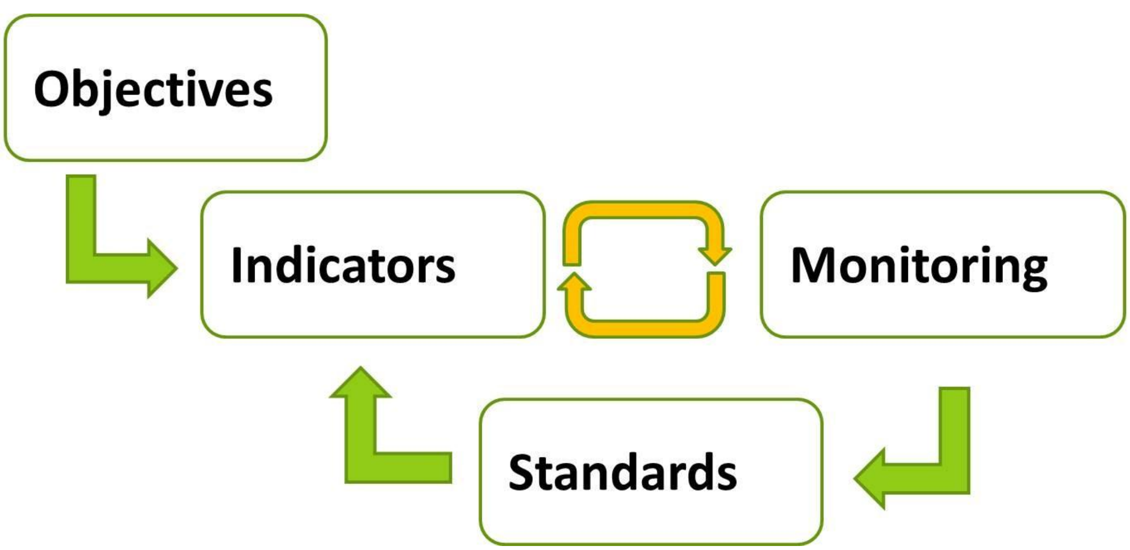


Figure 5: Core elements of outdoor recreation management frameworks

Several applications and evaluations of these management frameworks are described in the literature. These applications have been conducted in both the United States and internationally, and the literature suggests that they have generally been successful. For example, an early application of LAC focused on the Bob Marshall Wilderness Area, MT and culminated in a plan adopted for the area. The resulting plan divided the wilderness into four zones, or opportunity classes, each defined by a series of indicators and standards of quality for both resource and social conditions. For example, Opportunity Class I, the most pristine zone, specifies that the barren core of campsites should not exceed 100 square feet, and that visitors should have an 80 percent probability of not encountering other groups. An evaluation found that both managers and citizens believed this application would lead to better maintenance of natural conditions while providing high quality wilderness recreation opportunities (Ashor 1985). In addition, a lack of appeals to management directives in this potentially contentious wilderness area further indicates that such an approach can be successful (McCoy et al. 1995). This result coincides with the results of a broader evaluation of LAC in national forests in six U.S. eastern states (McCoy et al. 1995).

A second example is the initial application of VERP to Arches National Park, UT (Manning et al. 1995a, National Park Service 1995, Manning 2001, Manning 2004, Manning 2005). This application included a program of ecological and social research designed to provide a strong scientific basis for the formulation of indicators and standards of quality (Hof et al. 1994, Manning et al 1996, Manning et al. 1996, Belnap 1998). The park was ultimately divided into nine zones, each defined by management objectives and associated resource and experiential indicators and standards of quality. For example, the pedestrian zone specified that 30 percent or more of soil samples adjacent to trails should be rated as less than four on the soil crust index and that no more than 30 people at one time should be present at Delicate Arch more than 10 percent of the time. This application resulted in the first comprehensive visitor capacity plan implemented in the U.S. National Park system (National Park Service 1995). This case study is described more fully in Chapter Six.

THREE FOLD FRAMEWORK OF QUALITY IN OUTDOOR RECREATION

Application of the concept of carrying capacity to outdoor recreation suggested that recreation opportunities are comprised of three important dimensions: resources, experiences, and management. This three-fold framework has become a way to help understand and manage outdoor recreation. An initial application of carrying capacity to outdoor recreation began by focusing on the resource impacts of recreation (Wagar 1964). However, the major contribution of this analysis was the expansion of carrying capacity from its dominant emphasis on impacts to natural resources to a dual focus including social or experiential considerations:

> The study reported here was initiated with the view that the carrying capacity of recreation lands could be determined primarily in terms of ecology and the deterioration of areas. However, it soon became obvious that the resource-oriented point of view must be augmented by consideration of human values (Wagar 1964).

The point was that as more people visit an outdoor recreation area, not only are the natural resources of the area 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 resource environment.

This conceptual analysis hinted at a third element of carrying capacity (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 natural 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 and as illustrated in Figure 6.

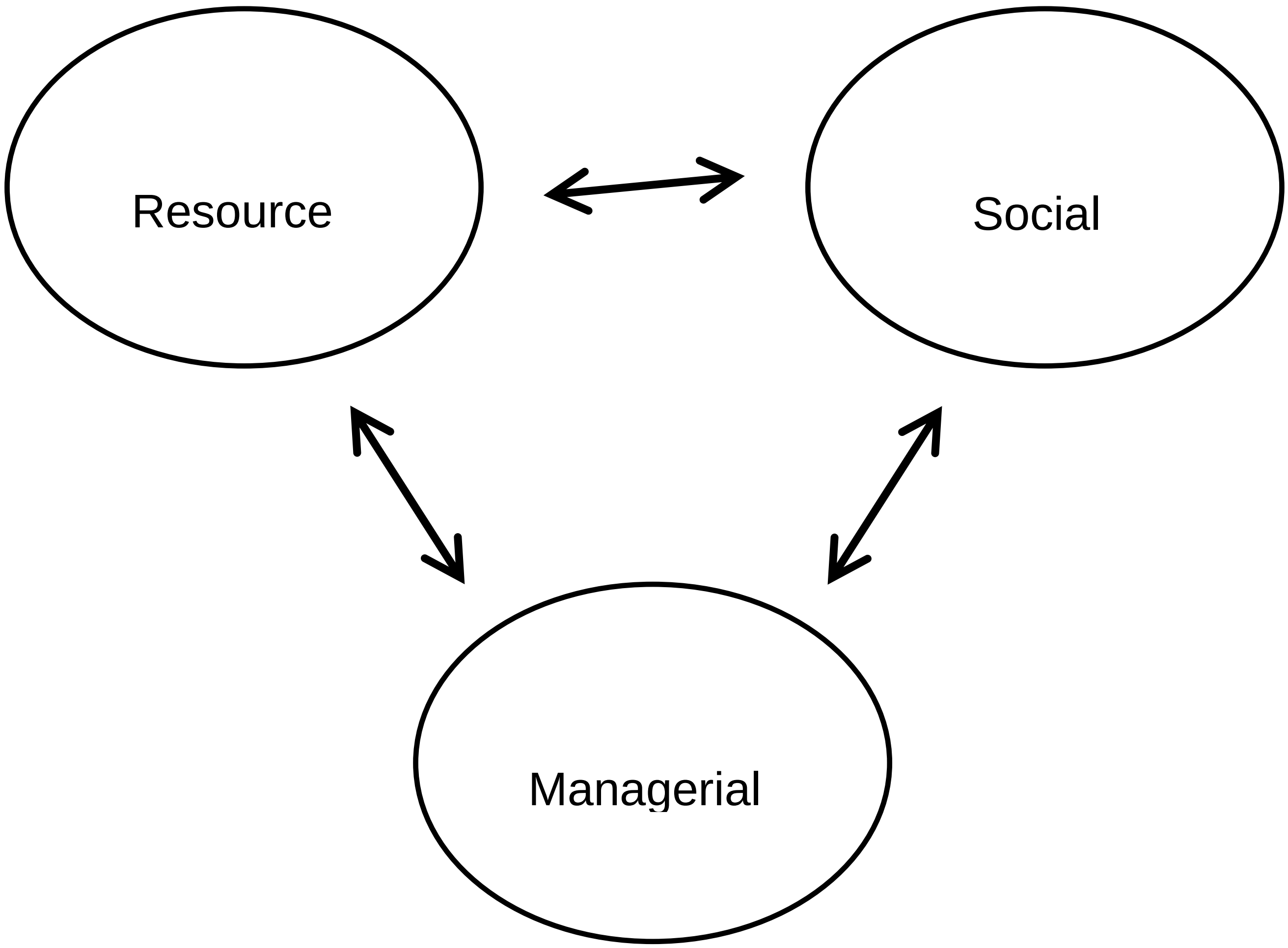


Figure 6: Three dimensions of recreation carrying capacity (from Manning 2011)

This three-dimensional view has been retained in contemporary analyses of carrying capacity and outdoor recreation management more broadly. This suggests that indicators and standards of quality should be defined and applied for all three dimensions of outdoor recreation opportunities.

A SPECTRUM OF QUALITY IN OUTDOOR RECREATION

Research has documented diverse tastes in outdoor recreation. For example, some visitors prefer developed campgrounds while others favor wilderness recreation. This suggests that a corresponding diversity of recreation opportunities is warranted. It would be difficult for a single recreation area, regardless of size, to provide a full spectrum of recreation opportunities. Designing diversity into outdoor recreation requires a systems-oriented approach to planning and management.

The Recreation Opportunity Spectrum (ROS) is a conceptual framework for encouraging diversity in outdoor recreation opportunities. A range of factors that define recreation experiences are combined in a matrix to describe diverse recreation opportunities. An example of an ROS matrix is shown in Figure 7 on the next page. In this example, recreation opportunities range from modern to primitive. Indicators and standards of quality are implicit in ROS. The factors arrayed along the vertical axis of an ROS matrix are indicators of quality. The ranges of conditions for each indicator variable arrayed along the horizontal axis are potential standards of quality for each type of recreation opportunity.

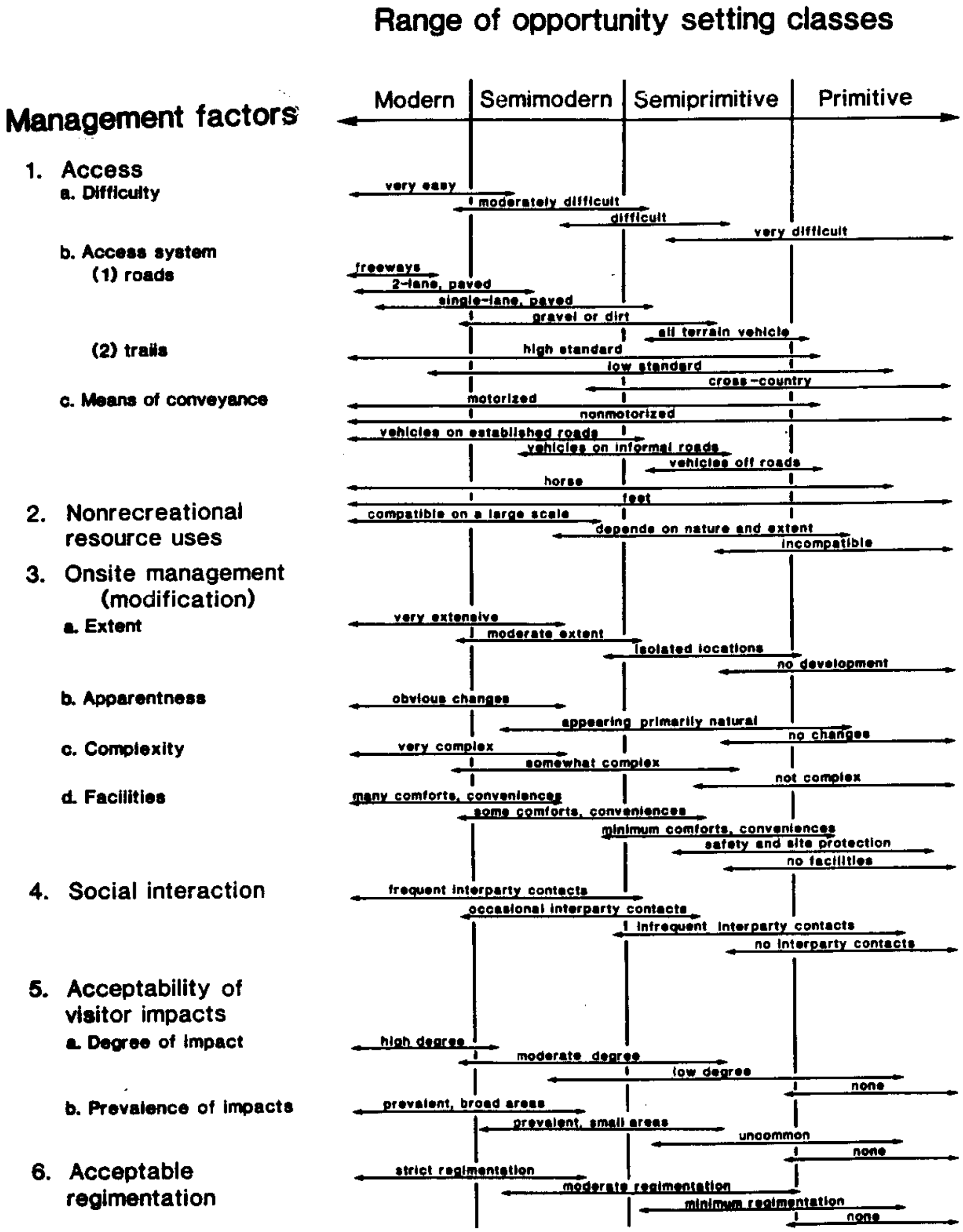


Figure 7: Factors defining outdoor recreation opportunities (adapted from Clark and Stankey 1979)

A distinguishing characteristic of ROS is the degree to which it has been formalized and translated into management guidelines. The relationships among site factors that combine to define recreation opportunities have been arranged in configurations that suggest relatively standard categories of recreation opportunities. Moreover, the system has been adopted by several public land management agencies, including the U.S. Forest Service and the Bureau of Land Management (Birst and Hoots 1982, Driver et al. 1987).

ROS has been adapted and applied to a variety outdoor recreation contexts, including water-based recreation (Orams 1999, Aukerman and Haas 2004, U.S. Bureau of Reclamation 2004, Kil and Confer 2006), tourism (Butler and Waldbrook 2003), ecotourism (Boyd and Butler 1996), wilderness (Flanagan and Anderson 2008), and recreation-related roads (G. Brown 2003) (Table 4). An ROS system applied to multimodal transportation in parks and public lands is now being developed under the leadership of TRIPTAC, Federal Lands Highways, U.S. Geological Survey, and The University of Vermont.

Table 4: Recreation classification or zoning systems

Study	Classification
Carhart (1961)	Seven wildland zones ranging from wilderness to semi-suburban
ORRRC (1962)	Six area classifications ranging from high-density to historic/cultural
R. Lloyd and Fisher (1972)	Concentrated and dispersed
P. Brown et al. (1978)	ROS including six opportunity classes ranging from “primitive” to “modern urbanized”
Clark and Stankey (1979a)	ROS including four opportunity classes ranging from “primitive” to “modern”
R. Nash (1982)	Paved, pastoral, primeval
Boyd and Butler (1996)	ROS adapted to ecotourism
Orams (1999)	ROS adapted to marine recreation
G. Brown (2003)	A spectrum of highway experience opportunities ranging from efficient/effective transportation to enjoyment of transport experience
More et al. (2003); Bulmer et al. (2002); Lynch and Nelson (1997)	ROS adapted to Eastern private lands
Butler and Waldbrook (2003)	ROS adapted to tourism
US Bureau of Reclamation (2004)	Water Recreation Opportunity Spectrum
Kil and Confer (2006); Aukerman and Haas (2004)	ROS adapted to water resources
Roman et al. (2007)	Four zones for coral reef snorkeling ranging from “conservation” to “general use”
Flanagan and Anderson (2008)	ROS applied to wilderness
US Forest Service	Five recreation experience levels ranging from those emphasizing challenge, solitude, and demanding high skills to those involving extensive facilities and few skills
Wild and Scenic Rivers Act (PL90-542)	Three classes of rivers: wild, scenic, and recreational
National Trails Act (PL90-543)	Three classes of trails: scenic, recreational, and side

CHAPTER 5: RESEARCH TO GUIDE DEVELOPMENT AND APPLICATION OF INDICATORS AND STANDARDS OF QUALITY

Indicators and standards of quality are central to understanding, defining and managing quality in outdoor recreation. A number of research approaches can be used to identify potential indicators of quality and support formulation of associated standards of quality.

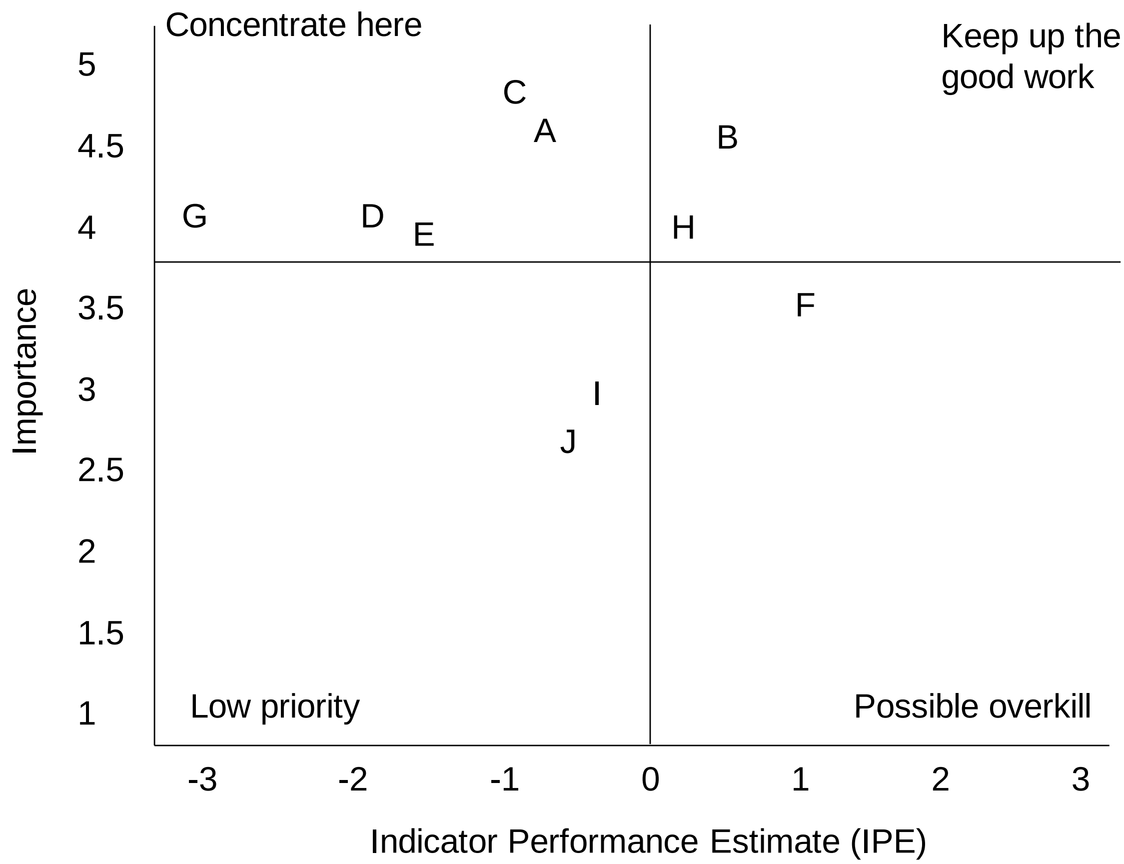
INDICATORS OF QUALITY

Research has focused on identifying potential indicators of quality for a variety of recreation activities and areas. This research has been aimed at determining variables important to visitors in defining the quality of the recreation experience.

A number of studies have used qualitative research methods to probe for potential indicators of quality for the visitor experience (Glaspell et al. 2003, Vande Kamp et al. 2005, Bullock and Lawson 2007, Watson et al. 2007, Hallo and Manning 2009, Hallo et al. 2009). This approach generally uses open-ended questions or semi-structured interviews with visitors and other stakeholders and is especially appropriate to explore for indicators of quality for activities, places, and types of recreationists about which relatively little is known. For example, a study of driving on the Acadia National Park Loop Road used semi-structured interviews with drivers and identified several potential indicators of quality for the driving experience, including vehicle congestion, availability of parking, safety-related issues, and cleanliness/maintenance-related issues (Hallo and Manning 2009). A study of visitors to Gates of the Arctic National Park & Preserve also used semi-structured interviews and identified a number of elements of the visitor experience (e.g., risk, challenge, interaction with wildlife) that were used to help formulate a series of indicators of quality for the visitor experience (Glaspell et al. 2003).

Many other studies have used quantitative methods to help identify indicators of quality. For example, a study of visitors to Yosemite National Park developed a list of potential issues in the park that might affect the quality of the visitor experience and asked visitors to rate the extent to which each issue was considered to be "not a problem", "a small problem", or "a big problem" (Manning et al. 2003). Indicators of quality derived from the study included number of people on trails and number of people at attraction sites like the base of Yosemite Falls.

Adaptation and application of an "importance-performance" framework has also been used as an aid to formulating indicators of quality (Mengek et al. 1986, Hollenhorst and Stull-Gardner 1992, Hollenhorst et al. 1992, Hollenhorst and Gardner 1994, Manning et al. 2007, Pilcher et al. 2009, K. Hunt et al. 2003, Farber and Hall 2007). Using this framework, visitors are first asked to rate the importance of potential indicator variables, and these results are plotted along a vertical axis as shown in Figure 8. Second, visitors are asked a series of questions about standards of quality for each indicator variable. These data are then related to existing conditions and plotted on a horizontal axis as shown in Figure 8. The resulting data provide a graphic representation of the relationship between importance and performance of indicator variables, and where management action should be directed. The data in Figure 8, for example, are derived from a survey of visitors to the Cranberry Wilderness, WV, and suggest that indicator variable "A" ("number of parties of people I see each day”) is important to visitors, but that visitors currently see more parties of people per day than their standard of quality (Hollenhorst and Gardner 1994). These findings suggest that managers should concentrate their attention on this indicator of quality. A similar approach has been used to identify specific indicators of quality related to human-caused noise and broader soundscape-related issues in parks (Manning et al. 2007, Pilcher et al. 2009).



Code Indicators: A=Number of parties of people I see each day. B=Number of large parties (more than 6 people) I see each day. C=Number of parties camped within sight or sound of my campsite. D=Number of parties that walk past my campsite each night. E=Number of visible places I see each day where people have camped. F=Number of horse parties encountered each day. G=Percent of vegetation loss and bare ground seen each day. H=Number of fire rings. I=Number of signs seen each day. J=Number of culverts seen each day.

Figure 8: Importance-performance analysis (from Hollenhorst and Gardner 1994)

An outdoor recreation “threats matrix” is another framework that might be applied to help identify indicators of quality (Leopold et al. 1971, Manning and Moncrief 1979, Cole 1994). A matrix model of outdoor recreation impacts can be created by arraying important attributes of outdoor recreation to form the rows of a matrix, and arraying potential threats to those attributes as the columns of the matrix. Each cell within the resulting matrix represents the various impacts that each threat causes to each attribute. An example of such a matrix is shown in Figure 9. This example was developed to determine the significance of threats to wilderness areas within the Northern Region of the U.S. Forest Service (Cole 1994). This example applies to wilderness very broadly, but can be developed more specifically for outdoor recreation. Such a matrix can be useful as a means of identifying potential indicators of quality (important attributes of outdoor recreation that are impacted by potential threats), and the extent to which such indicator variables are threatened and, therefore, need monitoring and management attention.

	Wilderness Threats							
Attributes of wilderness character	Recreation	Livestock	Mining	Fire	Exotic species	Water projects	Atmospheric pollutants	Adjacent lands
Air	1	1	1	2	1	1	4	3
Aquatic systems	4	3	3	4	4	3	4	3
Rock/landforms	1	2	2	1	1	2	1	1
Soils	3	3	2	5	2	2	4	2
Vegetation	3	3	2	5	4	3	4	2
Animals	4	2	2	4	3	2	2	4
Ecosystems/landscapes	2	3	2	5	3	2	4	5
Cultural resources	3	2	2	2	1	1	1	1
Wilderness experiences	4	3	2	3	2	2	2	3

Matrix values are significance ratings for the impacts of each potential threat on each wilderness attribute for all wilderness areas in the U.S. Forest Service's Northern Region. Ratings range from 1 (low) to 5 (high).

Figure 9: Wilderness threats matrix (from Cole 1994)

A combination of qualitative and quantitative methods have also been used to identify indicators of quality in a number of studies (Manning et al. 2002, Manning et al. 2002/3, Manning et al. 2005, Watson et al. 2007, Cole and Hall 2009, Hallo and Manning 2009). For example, visitors to Boston Harbor Islands National Recreation Area, MA were asked to rate the importance of a number of potential indicator variables identified through literature review and consultation with park staff, but were also asked in a more open-ended way to report the most and least enjoyable aspects of their experience in the park (Manning et al. 2005). A wide range of potential indicators of quality were identified, including crowding on trails and at attraction sites, environmental impacts to trails and campsites, social trails, tour group size, amount and type of information, and litter and graffiti. A study of visitors to Auyuittuq National Park, Canada, used qualitative interviews and a follow-up quantitative survey in which visitors rated 50 potential dimensions of the visitor experience in the park (Watson et al. 2007). Factor analysis was used to isolate a small number of key dimensions of the park experience that could be used as indicators of quality.

STANDARDS OF QUALITY

A considerable body of literature has explored research to support formulation of standards of quality in outdoor recreation. Much of this research has adopted and adapted normative theory and related empirical methods. Research on crowding in outdoor recreation offers a good example of this approach.

Crowding can be understood as a normative process. That is, outdoor recreation visitors often have preferences, expectations, or contextual standards by which to judge a situation as crowded or not. In fact, research demonstrates that such standards may be as important as the number of other groups encountered in determining when a situation is judged as crowded or not. If such standards can be defined and measured, then they may be useful in formulating standards of quality.

Developed in the social sciences, normative theory and related empirical methods have attracted substantial attention as an organizing concept in outdoor recreation research and management (Heberlein 1977, Shelby and Heberlein 1986, Vaske et al. 1986, Vaske et al. 1992, Vaske et al. 1993, Shelby et al. 1996, Manning 1999, Manning 2007). Much of this literature has been organized around the work of Jackson (1965), which developed a methodology for measuring norms. Adapting these methods to outdoor recreation, visitors can be asked to evaluate a range of conditions of indicators of quality related to increasing recreation use. For example, visitors might be asked to rate the acceptability of encountering increasing numbers of recreation groups while hiking along trails. Resulting data would measure the personal crowding norm of each respondent. These data can then be aggregated to test for social crowding norms, or the degree to which norms are shared across groups.

Social norms can be illustrated graphically, as shown in Figure 10. Using hypothetical data associated with the example described above, this graph plots average (mean or median) acceptability ratings for encountering increasing numbers of visitor groups along trails. Data for this type of analysis might be derived from a survey of wilderness hikers. The line plotted in this illustration is sometimes called an "encounter" or "contact preference" curve (when applied to crowding-related variables), or might be called an "impact acceptability" curve more generally, or simply a "norm curve."

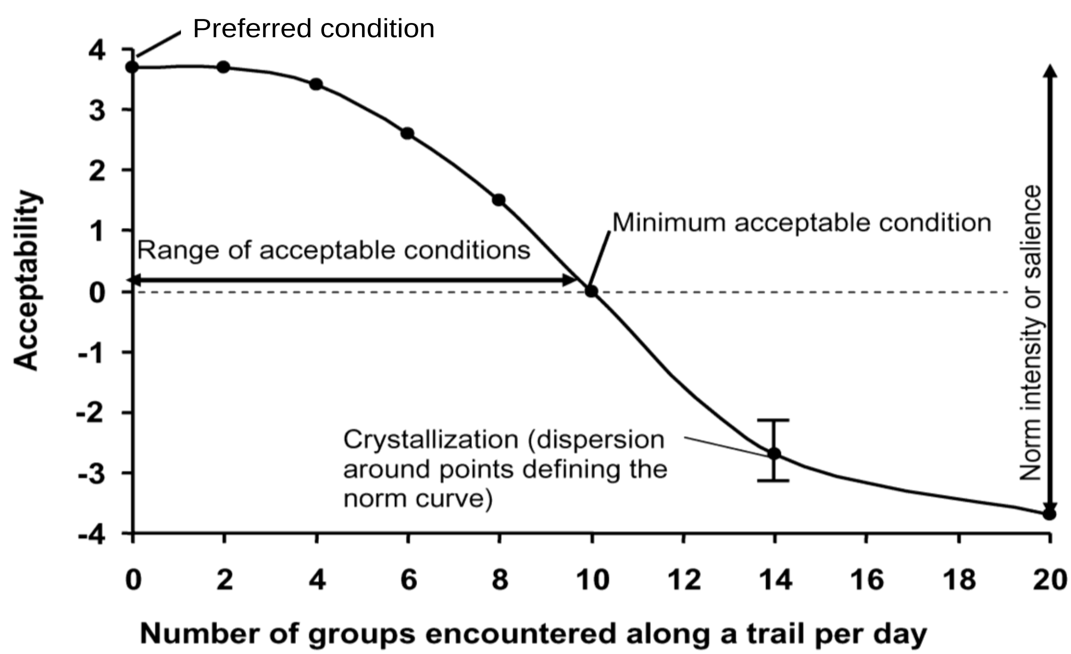


Figure 10: Hypothetical social norm curve

Social norm curves like that illustrated in Figure 10 have several potentially important features or characteristics. First, all points along the curve above the neutral line of the evaluation scale – the point on the vertical axis where evaluation ratings fall from the acceptable into the unacceptable range – define the "range of acceptable conditions." All of the conditions represented in this range are judged to meet some level of acceptability by about half of all respondents. The "optimum condition" is defined by the highest point on the norm curve. This is the condition that received the highest rating of acceptability from the sample as a whole. The "minimum acceptable condition" is defined as the point at which the norm curve crosses the neutral point of the evaluation scale. This is the condition that approximately half of the sample finds acceptable and half finds unacceptable. Norm "intensity," – the strength of respondents' feelings about the importance of a potential indicator of quality – is suggested by the distance of the norm curve above and below the neutral line of the evaluation scale. The greater this distance, the more strongly respondents feel about the indicator of quality or the condition being measured. High measures of norm intensity suggest that a variable may be a good indicator of quality because respondents feel it is important in defining the quality of the recreation experience. "Crystallization" of the norm concerns the amount of agreement or consensus about the norm. It is usually measured by standard deviations or other measures of variance of the points which describe the norm curve. The less variance or dispersion of data around those points, the more consensus there is about social norms.

Norms can also be measured using a shorter, open ended question format by asking respondents to report what they feel is the minimum acceptable condition of an indicator variable. In the example illustrated in Figure 10, respondents would simply be asked to report the maximum number of groups they would find acceptable to meet while hiking along wilderness trails during a day's time. This format is designed to be less burdensome to respondents, but it also yields less information.

CHAPTER 6: CASE STUDIES OF USING INDICATORS AND STANDARDS OF QUALITY TO GUIDE TRANSPORTATION MANAGEMENT IN PARKS AND PUBLIC LANDS

The case studies presented in this chapter describe ways in which indicators and standards of quality have been used to help guide transportation management. While most studies addressing transportation-related indicators and standards of quality for parks and public lands have been conducted in areas managed by the National Park Service, the research approaches and methods are easily transferable to other public lands.

MANAGING HIKING WITH TRANSPORTATION AT ARCHES NATIONAL PARK

An early application of VERP focused on Arches National Park, Utah (National Park Service, 1995; Manning et al. 1996; Manning et al. 1996). Arches National Park covers 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 increased dramatically in recent years and the park now receives over a million visits annually.

A two-phase research program was designed to help support application of the VERP framework at Arches. Phase 1 was aimed at identifying indicators of quality of the visitor experience. Personal interviews were conducted with park visitors and a series of 10 focus groups were conducted with park staff and local community residents and interest groups, in order to identify indicators. Questions on park conditions and issues probed what visitors and others considered important to determining the quality of the park experience. Study findings suggest that the following indicators of quality be used to manage outdoor recreation opportunities in the park:

- number of people at developed attraction sites and along trails;
- number of visitor groups encountered along backcountry trails and at campsites;
- number of social trails (unofficial trails, shortcuts, visible paths created by the off-trail actions of the visitors themselves) and level of soil and vegetation impacts associated with creation and use of these trails;
- level of trail development;
- level of visitor knowledge of regulations regarding off-trail hiking.

Phase 2 research was designed to help formulate standards of quality for these indicator variables. A survey of park visitors was conducted using both personal interviews and mail-back questionnaires. Visual simulations were used to illustrate a range of conditions for indicator variables. For example, a series of 16 computer-generated photographs was created to represent a range of visitor use levels at Delicate Arch, a principal visitor attraction.

Representative examples of these images are shown in Figure 11. These photographs were presented to a representative sample of visitors who had just completed a hike to Delicate Arch. Respondents were asked to judge the acceptability of each photograph on a scale of -4 ("very unacceptable") to +4 ("very acceptable"). Analogous sets of photographs were created for the number of hikers along developed trails, environmental impacts caused by off-trail hiking, and level of trail development.

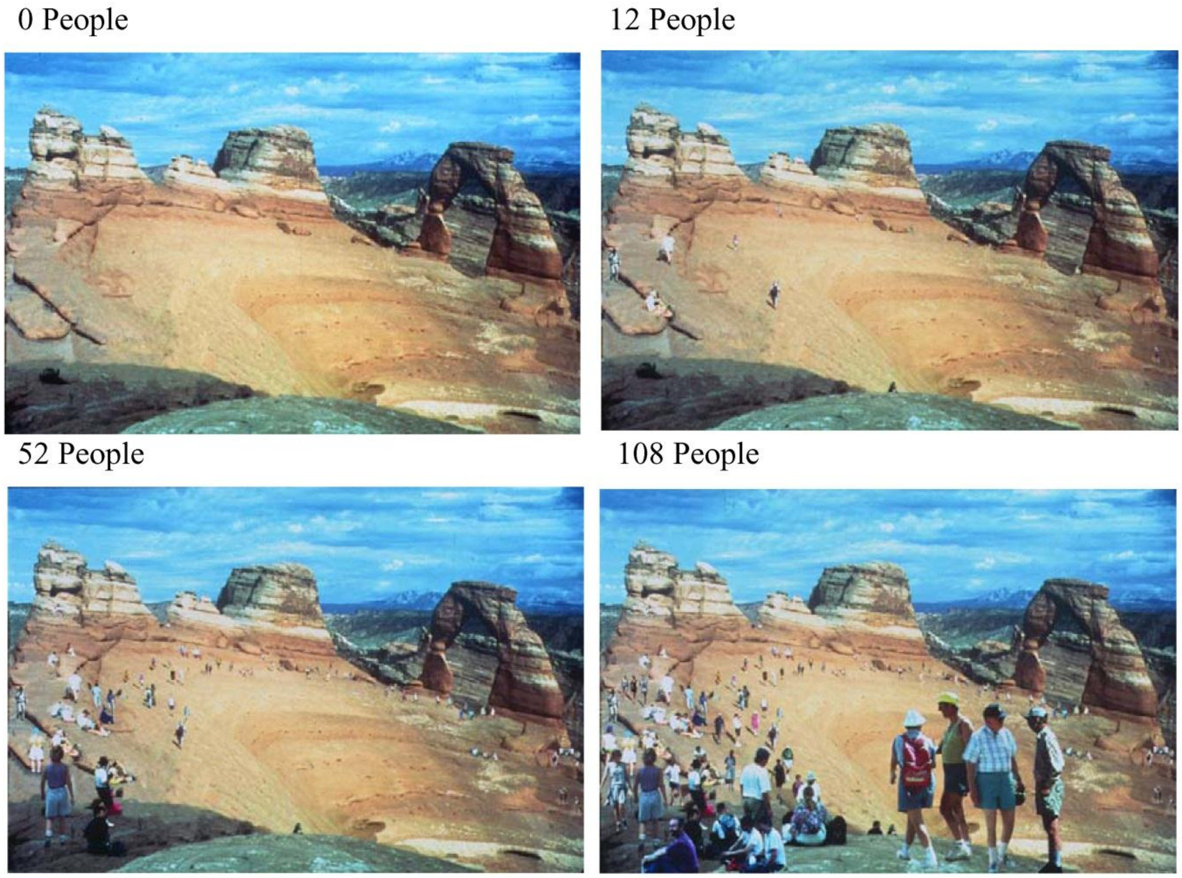


Figure 11: Representative photographs from Delicate Arch showing a range of visitor use levels

Figure 12 shows study findings (the social norm curve) for the acceptable number of people at Delicate Arch. The figure represents the average (mean) acceptability ratings for each of the 16 study photographs. It is clear from the graph that acceptability declines with increasing use. Average acceptability ratings fall out of the acceptable range and into the unacceptable range at about 30 people-at-one-time (PAOT) at Delicate Arch, and park staff selected this as the minimum acceptable standard of quality. In a similar manner, standards of quality were formulated for other indicator variables and other features and areas in the park, and thus created a spectrum of recreation opportunities throughout the park. The park is now monitoring indicator variables to ensure that standards of quality are being maintained.

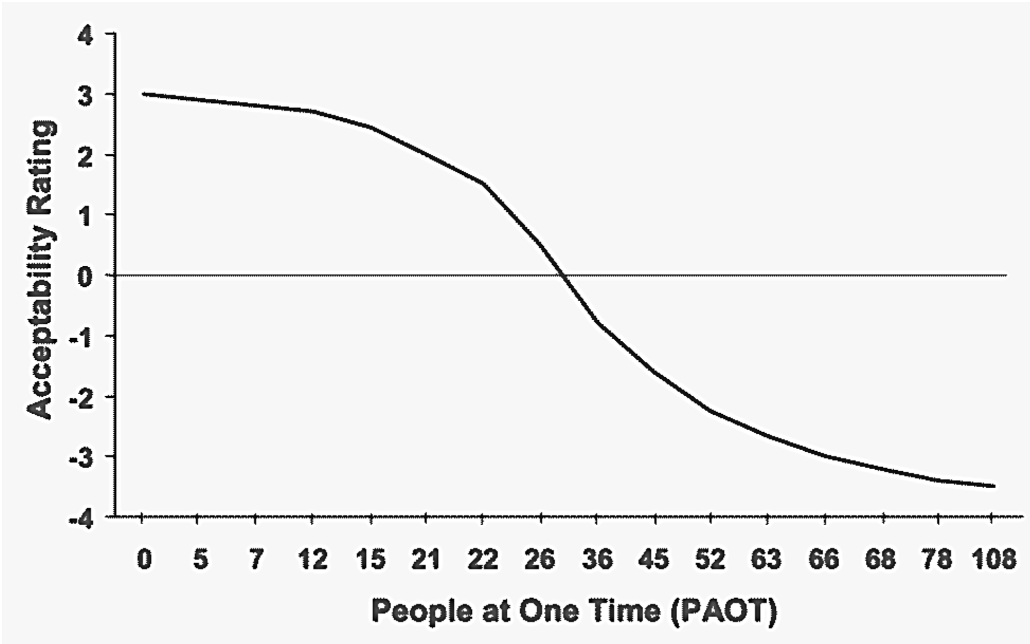


Figure 12: Social norm curve for visitor use level at Delicate Arch

The park's transportation infrastructure is being used as a tool to help manage outdoor recreation and maintain standards of quality. For example, simultaneous counts of the number of PAOT at Delicate Arch and the number of vehicles in the parking lot that serves the trail to this area were used to estimate the maximum number of vehicles that could be accommodated without violating the standard of quality of 30 PAOT at Delicate Arch. The parking lot was then appropriately sized and overflow parking was prohibited.

Simulation models of vehicle and pedestrian use of the park were also developed using counts of visitor use at strategic locations (e.g., park entrance station, the number of hikers to Delicate Arch) and visitor surveys of travel patterns in the park (Lawson et al. 2003). The model was then used to estimate the maximum number of vehicles that could enter the park each day without violating the standard of quality for the maximum PAOT at Delicate Arch.

The simulation model was also used to estimate the effect of a mandatory shuttle bus system that was being considered for use at Delicate Arch. Under this system, all visitors to the Delicate Arch area would be required to use a shuttle bus. Separate model runs were conducted to simulate alternative shuttle bus schedules designed to arrive at Delicate Arch every 15, 30 or 60 minutes. The same number of visitors would be delivered each hour, but their arrival intervals would differ. Study findings suggest two important conclusions. First, a shuttle bus system would increase the visitor capacity of Delicate Arch by 29% over the existing pattern of automobile arrivals. In other words, 29% more visitors could hike to Delicate Arch each day without violating the standard of quality of 30 PAOT. Second, smaller, more frequent shuttle buses would increase the visitor capacity to an even greater extent. Shuttle buses running every fifteen minutes would increase visitor capacity by 68% over the current pattern of automobile arrivals.

MANAGING MULTIMODAL TRANSPORTATION AT ACADIA NATIONAL PARK

The conventional transportation management framework of levels of service (LOS) measures variables such as speed and travel time which are pertinent to most transportation experiences. However, transportation in the context of parks is often a recreational experience and therefore demands a more expansive approach to management that also encompasses travelers' perspectives, especially as they relate to enjoyment and appreciation of parks and related areas. Indicators and standards of quality are designed to incorporate experiential variables into the management process and thus provide a means of bridging the gap between the fields of transportation and outdoor recreation. The purpose of this case study is to explore the relationship between LOS and indicators and standards of quality. The project addresses multiple modes of transportation at Acadia National Park – cars on the Park Loop Road, bicycle/pedestrian travel on the carriage roads, and buses on the park's transit system, the Island Explorer. Surveys of users of these modes of transportation were used to identify indicators of quality, measure normative standards for density of use, and integrate findings into an LOS framework.

Acadia National Park was established in 1916 in recognition of its scenic beauty, rich history, and recreational values (Manning 2009). Acadia is arguably the most intensively used national park with over two million annual visits on less than 50,000 acres. Nearly all visitors travel through the park by car, bicycle, and/or shuttle bus.

The Acadia Park Loop Road provides visitors an opportunity to drive for pleasure and see many of the iconic features of the park. It is one segment of the All-American Road referred to as the Acadia Byway. An All-American Road is the highest scenic designation a road may receive and requires recognition of at least two intrinsic qualities. The Acadia Byway received recognition for both its recreational and scenic qualities (National Scenic Byways Online, 2010).

Acadia's 50-mile system of carriage roads is one of the park's principal recreation assets. Originally built for horse and carriage use in the first half of the twentieth century, today the system serves primarily as a bicycle/pedestrian facility and provides not just a form of recreation, but also a means of traveling from one point to another in the park (Thayer 2002). For instance, while the carriage roads themselves incorporate scenic vistas for an enjoyable journey, they also allow visitors to reach quintessential park destinations such as the visitor center and historic Jordan Pond House.

The Island Explorer is a shuttle bus system that delivers visitors to, from, and around Acadia National Park. The bus service utilizes intelligent transportation systems technology to provide real-time information to visitors and also incorporates the use of alternative fuels. Subsidized by the L.L. Bean Corporation, bus service is provided free of charge to visitors and has been in operation at the park since 1999. It was one of the National Park Service's first alternative transportation pilot projects and has reduced congestion and greenhouse gas emissions within the park (National Park Service 1999). Together, the Park Loop Road, carriage road system, and Island Explorer provided the opportunity to collect qualitative and quantitative data on travelers' perspectives of quality across three primary modes of transportation in one national park.

Three versions of a questionnaire were developed to measure indicators and standards of quality for the multiple modes of transportation in Acadia. All three questionnaires included a section of open- and close-ended questions including a list of items that respondents might consider desirable or undesirable components of a transportation system. The open-ended questions were designed to identify indicators that have an impact on visitors' travel experience. Specifically, they asked respondents what they most and least enjoyed about their travel by car, bus, or along the carriage roads. The close-ended sections of the questionnaires asked respondents to rate the desirability of a list of attributes for transportation systems. These batteries of questions were structured similarly, but included different potentially desirable items that were tailored to each of the transportation modes. These items were selected based upon a combination of literature review and brainstorming by researchers and park staff. Respondents were asked to rate the degree to which each item was considered desirable or undesirable using a scale that ranged from -2 ("very undesirable") to +2 ("very desirable").

The survey was also designed to measure normative standards of quality of respondents for density of use for all modes of transportation. A series of visual simulations was used to present visitors with a range of density conditions on the Park Loop Road and the carriage roads. For the Island Explorer, narrative and numerical descriptions of a range of density-related conditions were used based on measures taken from the Highway Capacity Manual (HCM) (Transportation Research Board, 2000). For the Park Loop Road, a series of six photographs was constructed for a 125 meter section of road, and these photographs showed a range of 0 to 20 cars (Figure 13). For the carriage roads, a series of six photographs was constructed of a 125 meter section of trail, and these photographs showed a range of 0 to 36 users, with equal proportions of walkers and bikers (Figure 14). For the Island Explorer, short narrative statements were used to present six densities of use levels on buses that ranged from two seats per rider to two riders per seat (Figure 15). Respondents were asked to evaluate the acceptability of each photograph or description on a scale bounded by -4 ("very unacceptable") to +4 ("very acceptable").

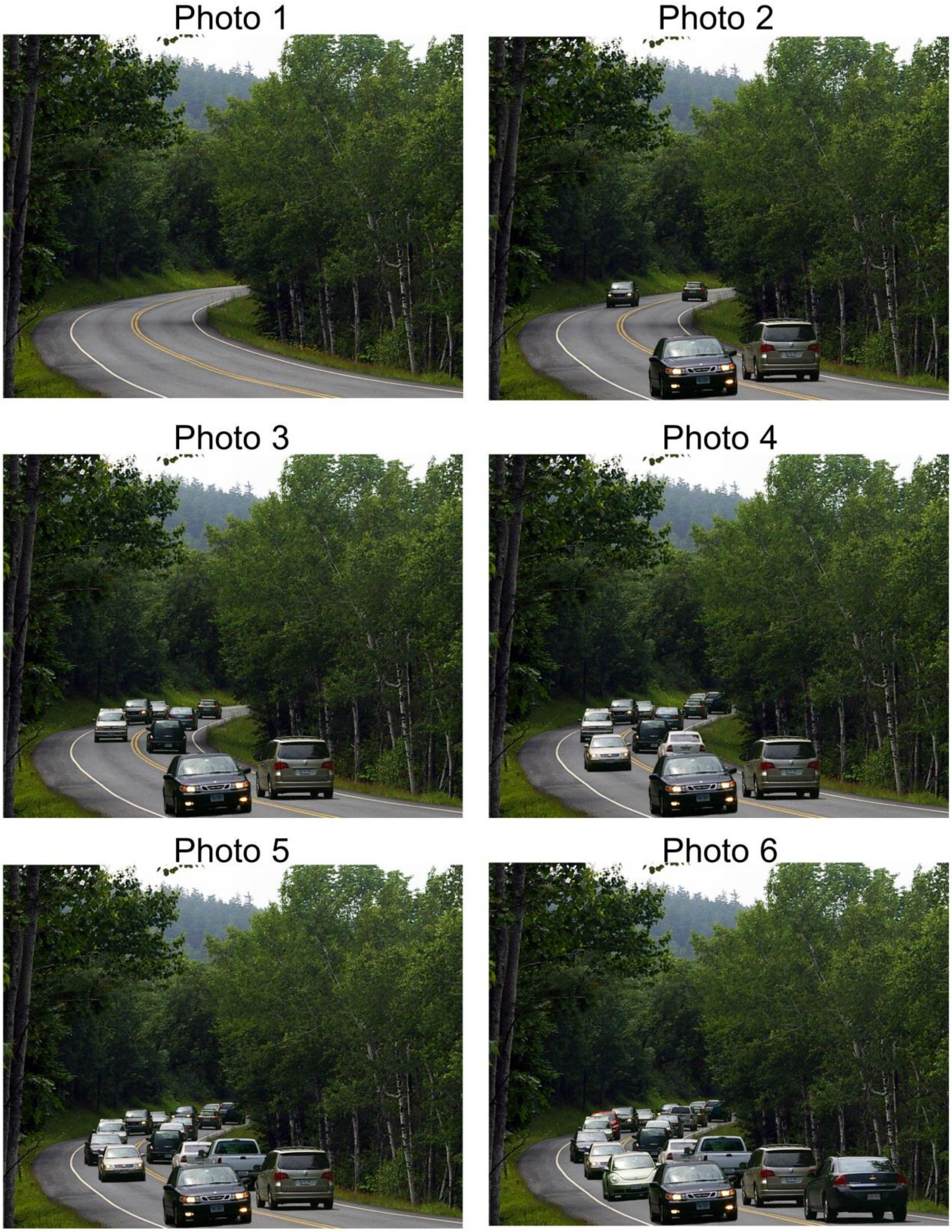


Figure 13: Visual simulation of Park Loop Road traffic

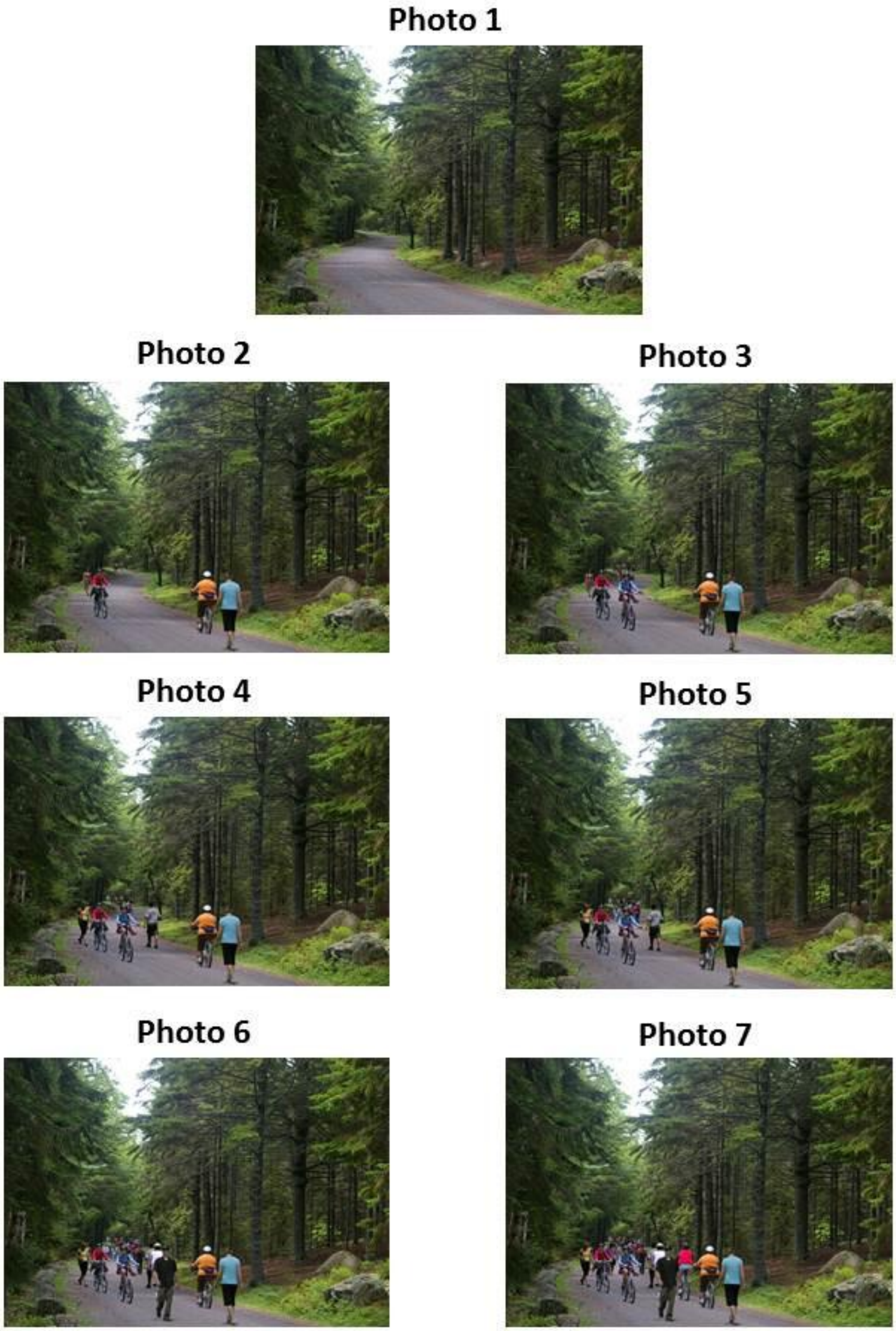


Figure 14: Visual simulation of carriage road use

A	No rider needs to sit next to another. There are more than 2 seats for each rider.
B	Riders can choose where to sit. There are 3 seats for every 2 riders.
C	All riders can sit. There is 1 seat for each rider.
D	All seats are occupied and a few riders must stand. There are 5 riders for every 4 seats.
E	All seats are occupied and many riders must stand. There are 3 riders for every 2 seats.
F	All seats are occupied and half of all riders must stand. There are 2 riders for every seat.

Figure 15: Narrative and numerical descriptions of use density on the Island Explorer

Several potential indicators of quality were identified for each mode of transportation, and density of use was an important indicator of quality for all modes of transportation. Social norms curves for use density were derived from respondent acceptability ratings of the range of density conditions described above and illustrated in Figure 13, Figure 14 and Figure 15. These norm curves are shown in Figure 16, Figure 17 and Figure 18 and can be used to identify density-related standards of quality.

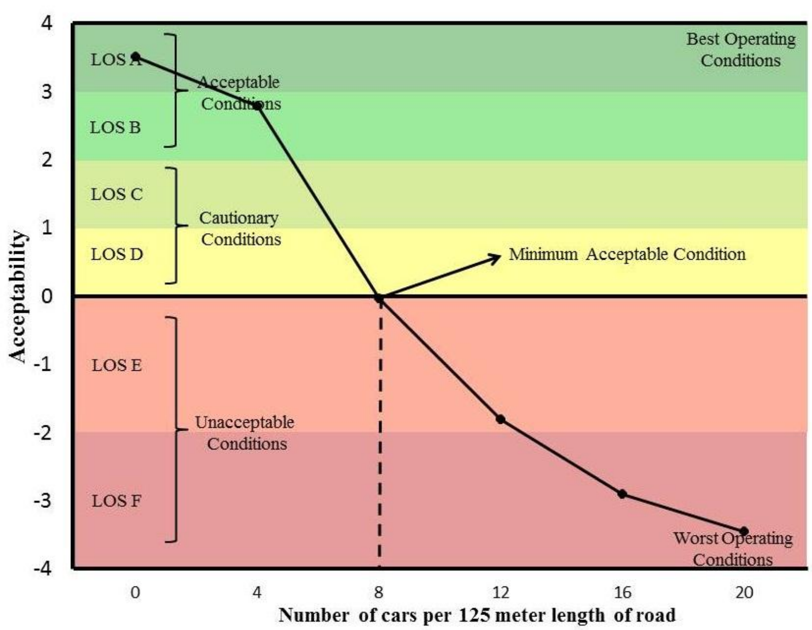


Figure 16: Social norm curve for traffic congestion on the Acadia Park Loop Road

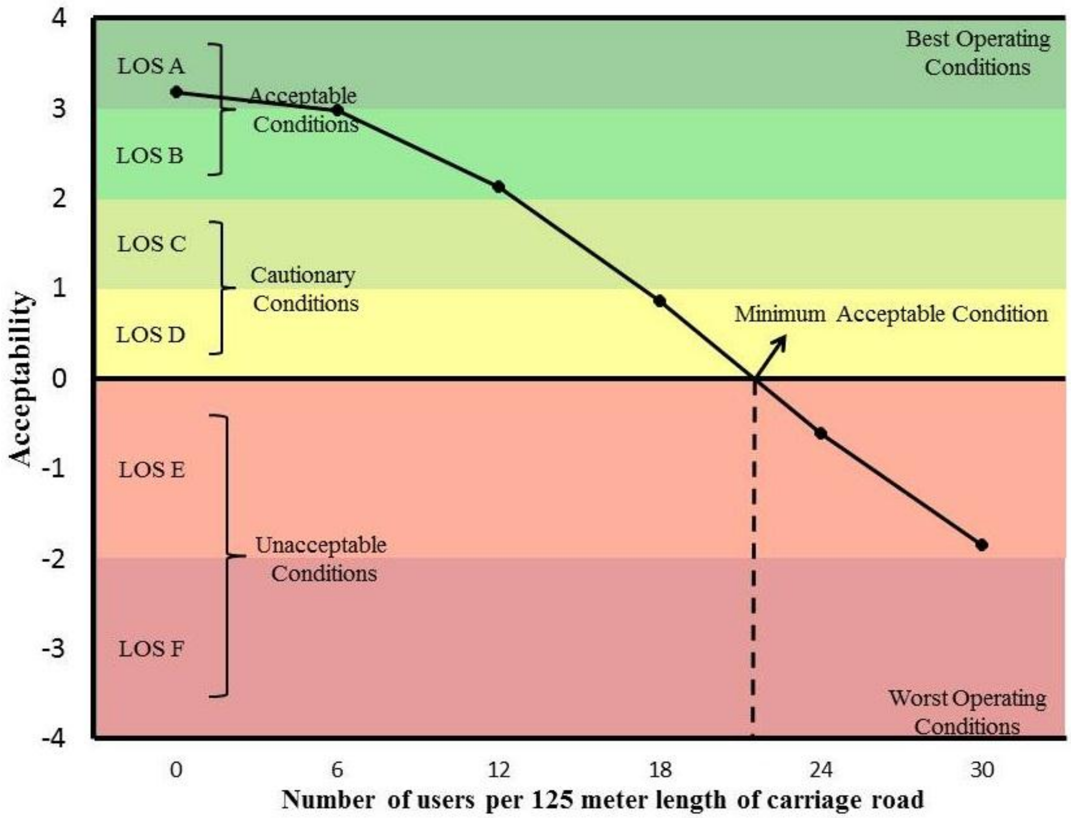


Figure 17: Social norm curve for use on the Acadia carriage roads

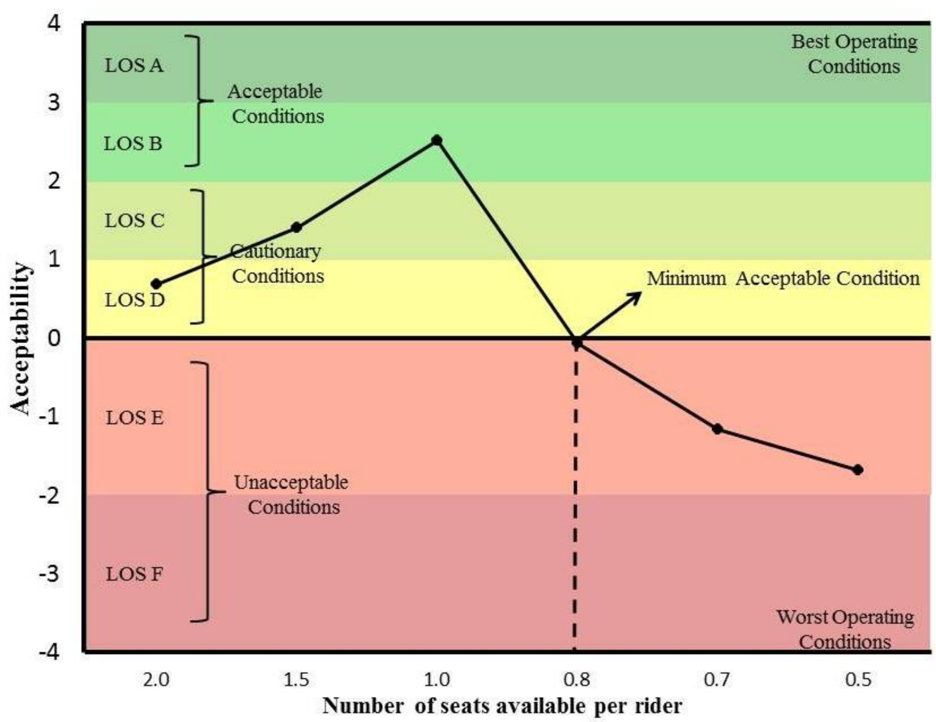


Figure 18: Social norm curve for congestion on the Island Explorer

Figure 16 plots average acceptability ratings for each of the six photographs illustrating a range of use levels on the Park Loop Road. It's clear that ratings of acceptability decline as density increases. Average ratings of acceptability fall out of the acceptable range and into the unacceptable range at about eight cars per 125 meter section of road. The norm curve in Figure 17 for the carriage roads takes a similar form and respondent ratings fall out of the acceptable range and into the unacceptable range at about 20 hikers and bikers per 125 meter section of trail. The norm curve in Figure 18 takes a different form and suggests that having one seat available for each rider on the Island Explorer buses is the optimum condition and that higher and lower densities of use are less acceptable.

The LOS letter grade framework has been overlaid on Figure 16, Figure 17and Figure 18 to graphically illustrate the relationship between LOS and indicators and standards of quality. LOS implicitly uses indicators and standards by suggesting that issues such as density of use (i.e., indicators of quality) are important to travelers and that there is a wide range of conditions (i.e., standards of quality) for these indicators that span conditions from very acceptable (LOS A) to very unacceptable (LOS F). The normative data on standards of quality offer a more empirical approach to informing LOS, including identifying a threshold of acceptability – the minimum level or condition of an indicator of quality that is acceptable to visitors. As evidenced by language in the HCM, this minimum level of acceptability coincides with the threshold between LOS D and E for conventional transportation planning and provides a rational anchor for overlaying the rest of the LOS conceptual framework. Findings from this case study are being used at Acadia to guide management of its multimodal transportation system.

VISITOR CAPACITY AND TRANSPORTATION AT MUIR WOODS NATIONAL MONUMENT

Muir Woods National Monument, managed by the NPS as part of Golden Gate National Recreation Area (GGNRA), preserves the Redwood Creek canyon and its old growth coast redwood trees. With its proximity to San Francisco (10 miles), dramatic and locally rare natural features, and prominent role in conservation history, Muir Woods is a setting for meaningful visitor experiences. Primary among Muir Woods' management objectives is provision of an accessible setting for intimate experiences with primeval nature. Nearly one million people seek such experiences in Muir Woods annually. As GGNRA managers plan for the future, they are challenged to provide opportunities for high quality visitor experiences and protect natural, cultural, and experiential resources within the context of intensive, urban-proximate visitor use. This challenge has been approached with a management-by-objectives, indicators and standards of quality based framework that couples normative survey methods with monitoring and simulation modeling to inform the monument's carrying capacity management and transportation planning. This program of research can be described through a three phased approach. The first phase identified indicators and standards of quality for the visitor experience. The second phase monitored indicator conditions in the woods. The third phase simulates changes in indicators under alternative transportation scenarios. Through these three phases, monument managers have taken an informed and proactive approach to managing visitor carrying capacity.

Initial research in Muir Woods was directed at soliciting indicators of quality that are salient to visitor experiences. A survey posed open and closed ended questions to visitors upon completion of their trips to the woods. Visitors were asked to evaluate the severity of a range of potential problems. As defined in Chapter 3, indicators are measurable, manageable variables that are affected by visitor use or behavior and that have an important influence on the quality of experiences and resources. Using this definition, responses to the problem-evaluation questions can help researchers and managers identify indicators of quality. Among the most problematic items evaluated was too many people along trails (Manning, 2007). This variable, being related to use level and important to visitors, was chosen as an indicator of quality for the visitor experience in Muir Woods.

With selection of indicators informed by visitors to the monument, standards of quality need to be identified. Standards of quality are the minimum conditions possible while still realizing management objectives. Because of the high levels of use Muir Woods receives, visual simulation methods were used to identify crowding related standards for trails. In an on-site survey, visitors to Muir Woods were presented with a number of simulated views of representative sections of trails (Figure 19 and Figure 20). Survey respondents were asked to evaluate how acceptable it would be to experience each simulated level of crowding. Aggregating and charting these acceptability evaluations yields the norm curves presented in Figure 21 and Figure 22. The norm curve for main trails in Muir Woods suggests that the visitor experience may become unacceptable, in terms of crowding or visitor density, when 16 or more others are visible. The norm curve for Muir Woods' secondary trails, where visitors presumably have greater desire or expectation for solitude, suggests that experiences may become unacceptable when 7 or more others are in view. While these may be the minimum acceptable conditions from one perspective, the data suggest a range of other possible standards for the monument's main and secondary trails (Figure 21and Figure 22).

Figure 19: Study Photographs for people per view on the main trails at Muir Woods National Monument, CA

Figure 20: Study photographs for people per view on the secondary trails at Muir Woods National Monument, CA

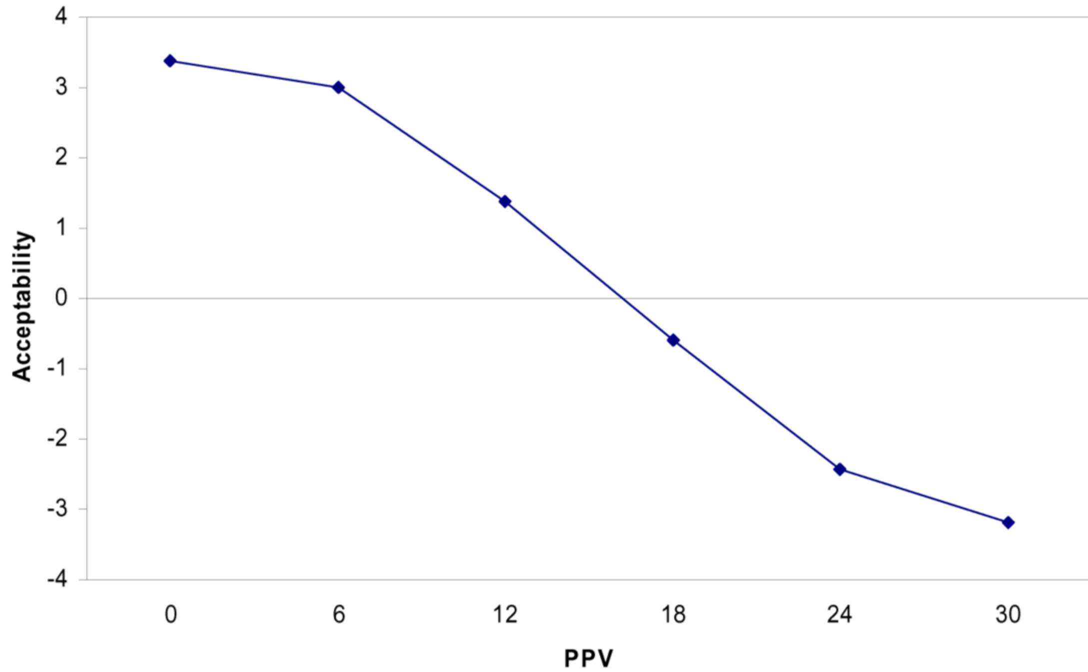


Figure 21: Social norm curve for people per view on the main trails at Muir Woods National Monument, CA

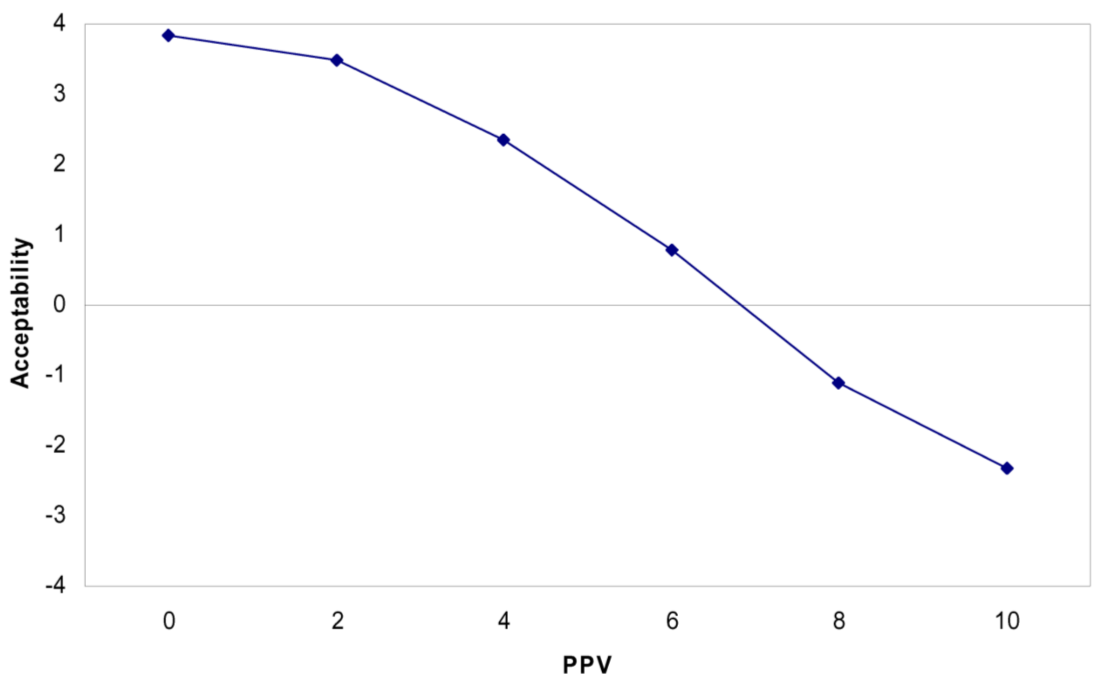


Figure 22: Social norm curve for people per view on the secondary trails at Muir Woods National Monument, CA

Table 5: Normative standards of people per view on the main trail at Muir Woods National Monument, CA

	Photo Number (Mean PPV)	Photo Number (Median PPV)
Acceptability	**16.2 (PPV)**	
Preference	2.1 (6.6)	**2.0 (6.0)**
Displacement	5.1 (24.6)	**5.0 (24.0)**
Management Action	4.1 (18.6)	**4.0 (18.0)**
Typically seen	**2.7 (10.2)**	**3.0 (12.0)**

Table 6: Normative standards for people per view on the secondary trails at Muir Woods National Monument, CA

	Photo Number (Mean PPV)	Photo Number (Median PPV)
Acceptability	**6.8 (PPV)**	
Preference	2.0 (2.0)	**2.0 (2.0)**
Displacement	5.2 (8.4)	**5.0 (8.0)**
Management Action	4.2 (6.4)	**4.0 (6.0)**
Typically seen	**2.4 (2.8)**	**2.0 (2.0)**

Monitoring is an important part of carrying capacity management for parks and recreation areas. Indicators and standards of quality allow managers and researchers to measure salient elements of visitor experiences and identify minimum conditions that are acceptable within management objectives. Monitoring indicator variables allows managers and researchers to assess existing conditions and, by comparing their observations to standards of quality, judge whether carrying capacities are being exceeded. Two methods of monitoring were employed in independent studies in Muir Woods. As part of the survey used to identify standards of quality for crowding along trails, visitors were asked to select the photographic simulation that depicted the level of use they typically saw during their visit. For both the main trails and the secondary trails, visitors indicated that they typically saw numbers of other visitors far lower than most of the potential standards (Table 5 and Table 6 Manning, 2007). In 2009, monitoring of trail crowding indicators for the main Muir Woods trails was repeated. This time, however, researchers directly observed the number of visitors in view along sections of trail similar to that depicted in the main trail visual simulation (Figure 19). These observations were collected at five minute intervals throughout 20 days. While the numbers of visitors observed were substantially higher than the number reported by visitors in the previous visual simulation research, the central tendencies of direct observations remained below most of the standards of quality. The result of this monitoring suggests that Muir Woods National Monument may indeed have unrealized capacity to accommodate visitor use without exceeding its carrying capacity. It should be noted that these capacity assessments are made from the visitor perspective with respect to crowding conditions along trails. There may indeed be other, more or less restrictive, criteria that contribute to the monument's ultimate visitor carrying capacity.

Trial crowding indicator monitoring was conducted in 2009 as part of transportation planning for Muir Woods and GGNRA. Transportation access and particularly private vehicle parking at Muir Woods is a perennial concern for monument managers and visitors alike (Manning, 2007). In the indicator survey discussed above, finding a parking place was rated by visitors as the most problematic aspect of their experience. In association with general management planning, GGNRA undertook a transportation planning effort that focused on both transportation system functioning and recreational experiences in the monument. To inform planning and implementation of transportation alternatives, a simulation model of visitor use in Muir Woods was developed. The model replicates patterns of use under various transportation scenarios, including some which alter the number of parking spaces and others that modify the capacity and frequency of shuttle bus arrivals. Specifically, the model estimates the conditions of indicator variables, including the number of visitors visible along sections of trails. By modeling indicators of quality and comparing the results to standards of quality, the potential effects of various transportation alternatives on visitor experiences in Muir Woods can be evaluated without the resource, economic and political costs of management trial and potential error. Figure 23 describes the transportation plan alternatives considered by GGNRA and modeled via simulation. Figure 24 presents the model's estimates of the number of visitors visible along a section of trail similar to the visual simulation evaluated by visitors (Figure 19) under existing conditions and the various transportation alternatives. All of the transportation alternatives are predicted to result in numbers of visitors along the trail similar to or less than existing use, suggesting that none of the transportation alternatives will have an adverse effect on the visitor experience.

	No Action	Alt 1	Alt 2	Alt 3
Parking capacity at MUWO	379	219	20	179
Parking capacity at intercept area	500	500	500	500
Bus capacity	35	35	35	35
Bus Headway		Min headway 10 min.	Min headway 10 min.	
Parking Conditions		First-come, first-serve, limit to number of buses they'll wait for	First-come, first-serve, limit to number of buses they'll wait for	Reservations and Paid Parking; Spread it evenly through the day
Meadow Linger (discussed with Mia)	Mean= 5 mins	Visitors' average linger times in the restored meadow will be similar to the average linger times observed in the café/gift shop during summer 2009.	Visitors' average linger times in the restored meadow will be similar to the average of linger times observed in Redwood Crosscut, Pinchot Tree, and Bohemian Grove during summer 2009.	Visitors' average linger times in the restored meadow will be similar to the average linger times observed in the potential restored meadow during summer 2009.

Figure 23: Alternative transportation scenarios for Muir Woods National Monument, CA (adapted from RSG, UVM, 2010)

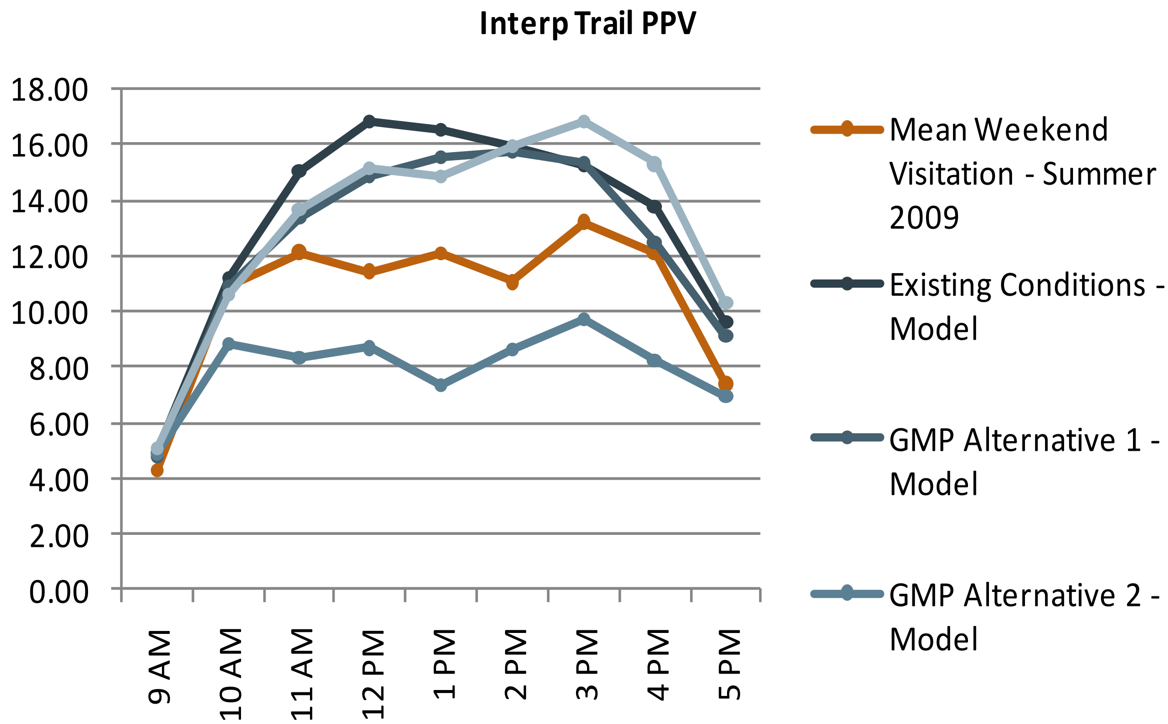


Figure 24: Simulation model estimates of people per view along main trails in Muir Woods National Monument, CA (adapted from RSG, UVM, 2010)

This three phased research approach employs an indicators and standards based framework to investigate the quality of visitor experiences and the effects of transportation planning in Muir Woods. First, indicators and standards of quality relevant and sensitive to visitor use were elicited via surveys. Second, the conditions of indicators were monitored to establish the existing condition of visitors' experiences. Third, the potential effects of transportation plan alternatives on visitors' experiences were examined. This research forms a basis not only for informed management decision making but for ongoing monitoring and evaluation of resource and experiential quality in Muir Woods National Monument.

MANAGING TRANSPORTATION FOR WILDLIFE VIEWING OPPORTUNITIES ON THE DENALI PARK ROAD

Denali National Park and Preserve offers its visitors unparalleled opportunities to view large concentrations of diverse wildlife, including grizzly and black bears, caribou, moose, wolves, and Dall's sheep. The 90-mile Denali Park Road provides access to these opportunities and accommodates over 400,000 visitors every year (Hallo & Manning, 2011). While cars are permitted on the first 15 miles of the road, motorized travel after that point is by shuttle bus. The National Park Service's initial decision to institute a mandatory bus system was in anticipation of a sharp increase in visitation due to the completion of the George Parks Highway in 1972. Today, park managers continue to use transportation as a tool for managing visitor use levels and associated impacts on wildlife and the quality of the visitor experience.

In 2006, Denali park managers commissioned a series of studies designed to integrate visitor experience and wildlife management. The focal point of these studies was the Denali Park Road and its role in providing world-class wildlife viewing opportunities to visitors. One component of the study used the VERP framework to develop indicators and standards of quality for the Denali Park Road experience, while another documented wildlife crossings of the park road.

To identify indicators and standards of quality for the visitor experience, the study used findings from two surveys of Denali Park Road visitors (Manning & Hallo, 2010). Qualitative interviews revealed 'wildlife' as what visitors enjoyed most about their experience along the park road (Table 7). Furthermore, responses to the questionnaires demonstrated that visitors perceived 'not seeing enough wildlife' and 'too few animals along the road' as the biggest problems along the park road (Table 8).

Table 7: Things enjoyed most by visitors on the Denali park road

Category/code	Frequency indicated
Wildlife	87
Scenery/mountains	83
Driver/information provided by the bus driver	49
Mount McKinley	14
Natural environment/landscape	8
Social experience with others	7
Solitude/not too much traffic on the road	6
Bus transportation	4
Hiking	3
Ride along the road	3
Wildflowers	2
Polychrome Pass	2
Driving on the road with a recreational vehicle	2
Rules on the bus intended to protect wildlife	1
Being able to get off the bus and walk around	1

Table 8: Visitor perceptions of problems on the Denali park road

Parameter	Percentage of respondents				N	Mean
	Not a problem	Small problem	Big problem	Don't know		
Too many buses on the Denali Park Road	43.3	45.7	9.8	1.2	685	**1.66**
Too many private cars/recreational vehicles on the Denali Park Road	64.5	23.0	9.3	3.2	668	**1.43**
Not seeing enough wildlife	49.5	33.2	16.7	0.6	683	**1.67**
Not seeing enough wildlife close to the road	39.6	37.4	22.0	1.0	690	**1.82**
Too few animals along the road	45.1	34.4	18.9	1.6	683	**1.73**
Wildlife being scared away from the road by buses	57.8	22.2	9.1	10.9	615	**1.45**
Other buses blocking views	62.4	30.4	5.4	1.7	675	**1.42**
Too many buses at "wildlife stops"	53.7	36.3	7.3	2.7	652	**1.52**
Visitors not following rules for observing wildlife while on the bus	67.3	23.3	6.3	3.2	666	**1.37**
Bus drivers not providing enough time at "wildlife stops"	87.0	10.4	1.6	1.0	686	**1.14**
Dust generated by buses	48.3	36.8	13.2	1.6	676	**1.64**
Uncomfortable seating on buses	55.0	34.9	9.8	0.3	689	**1.55**
Too many people on buses	61.4	29.0	9.1	0.4	689	**1.47**
Bus noise along the road	63.0	29.3	5.8	1.9	677	**1.42**
Noisy people on the bus	65.5	27.0	7.3	0.3	687	**1.42**
Too many buses at rest stops	65.3	27.0	6.4	1.3	677	**1.40**
Buses being poorly maintained	82.7	11.8	1.8	3.7	659	**1.16**
Windows on buses not working properly	68.5	24.0	6.7	0.9	682	**1.38**
Windows on buses are dirty	62.6	28.6	8.3	0.4	685	**1.45**
Bus drivers not stopping when asked	92.6	5.1	1.2	1.2	677	**1.08**
Lack of interpretive information provided on the bus	86.6	10.3	2.2	0.9	680	**1.15**
Lack of visitor facilities (e.g., restrooms)	90.6	8.3	0.6	0.6	686	**1.09**
Degradation of the quality of the Denali Park Road	64.4	26.2	5.0	4.4	656	**1.38**
Degradation of the wilderness character of the Denali Park Road (e.g., by buildings and human presence)	70.1	21.1	5.9	2.9	662	**1.34**
Not having binoculars	68.5	16.3	13.5	1.6	669	**1.44**
Poor weather	71.8	19.0	7.8	1.5	670	**1.35**
Smoke from wildfires	89.2	3.1	0.9	6.9	636	**1.05**
Feeling unsafe traveling along the road	85.7	11.5	2.0	0.7	682	**1.16**
Brush along the road obscured view of wildlife	**75.5**	**20.9**	**2.8**	**0.9**	**683**	1.27

These responses helped guide the use of normative methods in deriving social norm curves for a number of wildlife-related indicators, including the number of buses at informal wildlife stops, waiting time to see wildlife at informal wildlife stops, and the percentage chance of seeing a grizzly bear (Figure 25, Figure 26 and Figure 27).

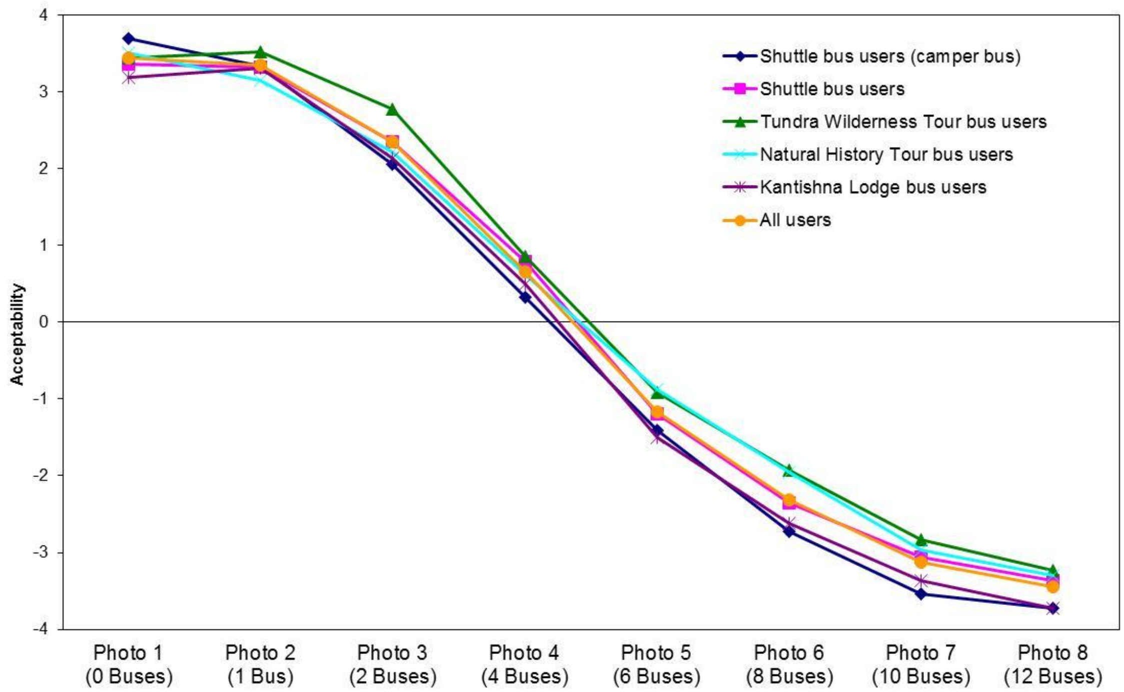


Figure 25: Social norm curve for numbers of buses at informal wildlife stops, Denali

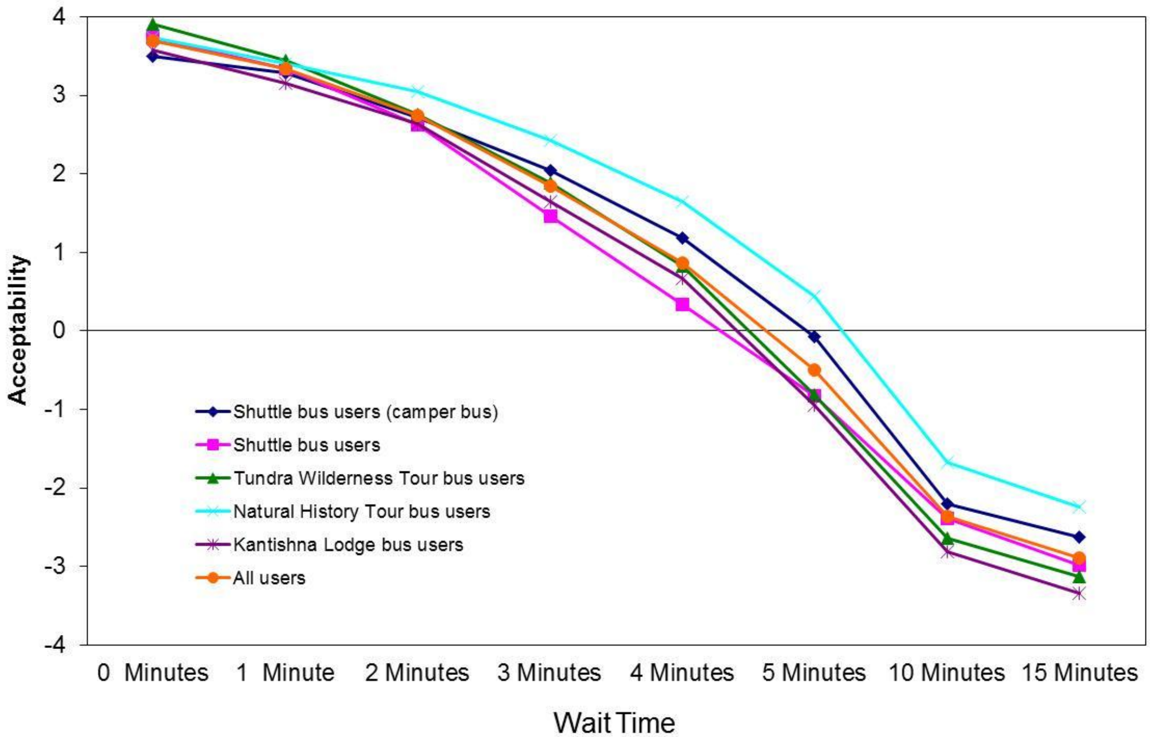


Figure 26: Social norm curves for waiting time to see wildlife at informal wildlife stops, Denali

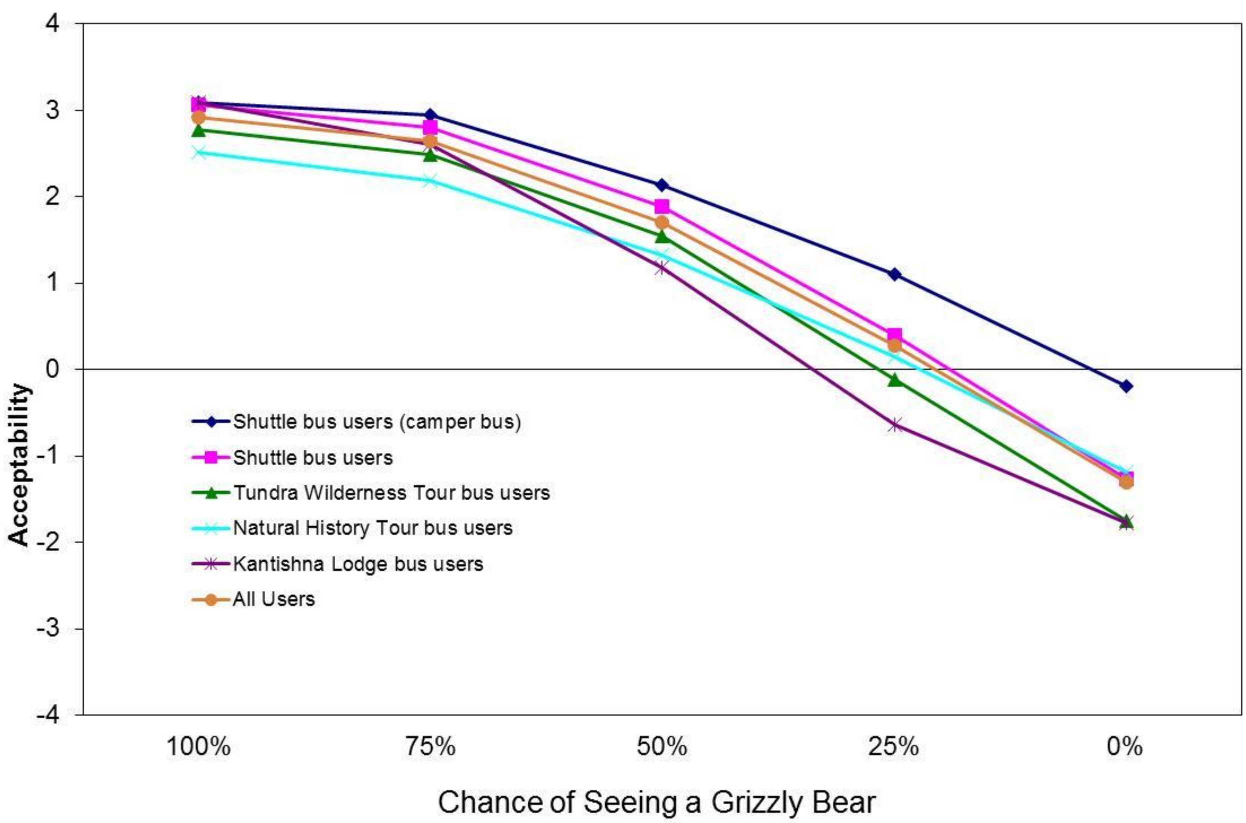


Figure 27: Social norm curves for the percentage chance of seeing a grizzly bear, Denali

The wildlife management component of the study was developed to examine potential impacts on wildlife from changes in traffic volumes or patterns along the park road. Eleven grizzly bears and seventeen Dall's sheep were radio-collared and monitored for the study. Global positioning system (GPS) technology was used to document their movement patterns along the park road, including road crossings. GPS technology was also used to track the movement of buses along the Denali Park Road. Study findings suggest that vehicle use levels and patterns have an impact on wildlife behavior, though these effects do not appear large (Morris et. al., 2010).

Ultimately, this interdisciplinary study exemplifies how transportation can be managed to provide high quality visitor experiences and minimize resource impacts such as wildlife disturbance. In fact, a backcountry management plan for Denali includes indicators and standards for wildlife. Wildlife are actively monitored and if statistically significant changes occur in the number, distributions, and demographics (e.g., age structure, gender ratios) of wildlife, and these changes can be correlated with changes in visitor use, the National Park Service will implement practices to manage the level and/or type of visitor use.

USING INDICATORS AND STANDARDS TO MANAGE MULTI-MODAL TRANSPORTATION AND VISITOR CAPACITY AT YOSEMITE NATIONAL PARK

In 1999, former Secretary of the Interior Bruce Babbitt stated that "our parks don't have too many people, but they can, and often do, have too many cars" (LA Times, 1997). Few other parks exemplify this issue as much as Yosemite, one of the "crown jewels" of the nation's public land system. With its towering granite domes and alpine meadows, the World Heritage Site is a popular destination for visitors from around the globe. During the summer months it receives up to 15,000 visitors per day. While the park is more than 700,000 acres in size, much visitation occurs in Yosemite Valley (an area comprising less than 1% of total park acreage). This concentration of visitor use is typical of Yosemite and other public lands, where most recreation use is concentrated at sites easily accessed by the park's multi-modal transportation network. Transportation is connected to recreation on public lands like Yosemite in two ways. First, transportation can be an important form of recreation. And second, transportation systems influence where, when and how many visitors recreate throughout the park. Two indicators and standards based research and planning efforts illustrate these connections between transportation and recreation and how they can be leveraged to support park and public land management.

MANAGING CONGESTION: STATED PREFERENCE FOR RECREATIONAL TRAVEL MODE

Within Yosemite Valley, one of the most popular attraction sites is Yosemite Falls. Comprised of three sections, it is 2,425 feet high making it the tallest waterfall in North America. Yosemite Falls is accessible by multiple modes of transportation. Roadside parking is available close to the site, the Yosemite Valley Shuttle arrives and departs from the Yosemite Falls stop, and a 12-mile paved bike path also provides access to cyclists. This multimodal network is in keeping with NPS objectives for managing congestion. As noted earlier, the CFR states that when developing a congestion management system "consideration shall be given to strategies that promote alternative transportation systems, reduce private automobile travel, and best integrate private automobile travel with other transportation modes" (CFR Title 23 970.214). While Yosemite Valley's transportation infrastructure has been developed to integrate alternative transportation modes, indicators and standards of quality provide insight into how park managers might promote shuttle bus and bicycle use to help manage congestion and improve both transportation system functioning and the recreational experience of traveling through the park.

A study conducted in Yosemite Valley in 2010, assessed the relative importance of transportation-related indicators and standards of quality. Stated preference analysis was used to compare the utility of crowding, convenience, corridor design, and cost in visitors' transportation choices among private automobiles, shuttle busses, and bicycles. Results offer insight into managing traffic congestion, and illustrate which management actions may be most effective in influencing visitors' travel behavior.

The stated preference experiment included a number of indicators that describe the quality of visitors' transportation choices. Furthermore, a range of standards (Table 9) depict a series of alternative scenarios within a stated preference questionnaire (Figure 28). The transportation-related indicators were chosen based upon results from 2009 travel surveys (described in the Acadia multimodal case study above) and were corroborated by other studies and consultation with outdoor recreation researchers and transportation planners. A representative sample of visitors were asked to complete the questionnaire by rank ordering how they would prefer to travel from most to least (1=least preferred and 3=least preferred). Each questionnaire included nine paired comparisons of travel scenarios, and data were aggregated and analyzed using a multinomial logit model.

Table 9: Transportation modes, indicators and standards for Acadia

	Car	Shuttle Bus	Bicycle
Crowding	**4 cars** per 125m length of road	There is **1 rider for each seat**	**6 bicycles** per 125m length of path.
Crowding	**8 cars** per 125m length of road	There are **5 riders for every 4 seats**	**15 bicycles** per 125m length of path.
Crowding	**12 cars** per 125m length of road	There are **3 riders for every 2 seats**	**24 bicycles** per 125m length of path.
Convenience	Parking is **always available** at attraction sites within the park.	Buses depart stops **every 15 minutes**.	Bicycles are **available at multiple locations in the park**.
Convenience	Parking is **sometimes available** at attraction sites within the park.	Buses depart stops **every 30 minutes**.	Bicycles are **available at a single location in the park**.
Convenience	Parking areas are **often full** at attraction sites within the park.	Buses depart stops **every 45 minutes**.	Bicycles are **available outside the park**.
Corridor Design	The travel corridor is designed as a two-lane highway with **no bike lane**.	The travel corridor is designed as a two-lane highway with **no bike lane**.	The travel corridor is designed as a two-lane highway with **no bike lane**.
Corridor Design	The travel corridor is designed as a two-lane highway with a **bike lane on the road shoulder**.	The travel corridor is designed as a two-lane highway with a **bike lane on the road shoulder**.	The travel corridor is designed as a two-lane highway with a **bike lane on the road shoulder**.
Corridor Design	The travel corridor is designed as a two-lane highway with a **bike lane separate from the highway**.	The travel corridor is designed as a two-lane highway with a **bike lane separate from the highway**.	The travel corridor is designed as a two-lane highway with a **bike lane separate from the highway**.
Cost	There is **no additional fee** to enter the park by car.	Shuttle bus is provided at **no cost** to visitors.	There is **no fee** to rent a bicycle.
Cost	There is an **additional fee of $10** to enter the park by car.	Shuttle bus costs **$1 per person per ride**.	There is a fee of **$15 per day** to rent a bicycle.
Cost	There is an **additional fee of $20** to enter the park by car.	Shuttle bus costs **$2 per person per ride**.	There is a fee of **$30 per day** to rent a bicycle.

1=Most preferred, 2=Second most preferred, and 3=Least preferred

Car

A. The number of cars you would typically see looks like the following picture:

B. Parking is **always available** at attraction sites within the park.

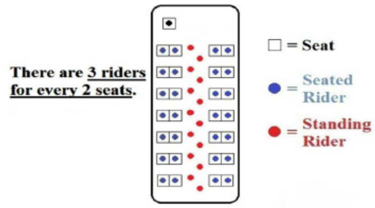
C. The travel corridor is designed as a two-lane highway with a **bike lane on the road shoulder**.

D. There is **no additional fee** to enter the park by car.

Preference:__________

Shuttle Bus

A. The number of riders on the shuttle bus would typically be as follows:



B. Buses depart stops **every 15 minutes**.

C. The travel corridor is designed as a two-lane highway with a **bike lane on the road shoulder**.

D. Shuttle bus service is provided at **no cost** to visitors.

Preference:__________

Bicycle

A. The number of bicycles you would typically see looks like the following picture:

B. Bicycles are **available outside the park** (for use inside the park).

C. The travel corridor is designed as a two-lane highway with a **bike lane separate from the highway**.

D. There is a fee of **$15 per day** to rent a bicycle.

Preference:__________

Figure 28: Example of a Mixed Visual and Narrative Choice Set for Acadia

Results illustrate that while each transportation-related indicator in the model was important to visitors travel choices, some were more influential than others in shaping visitor mode choice. For instance, convenience was ranked the most influential factor, while corridor design was ranked the least. Regardless of their relative influence on travel behavior, this research illustrates how indicators and standards of quality help inform park and public land management actions. These actions may be taken to ensure that transportation-related standards of quality are maintained. For instance, if park road congestion standards for scenic driving are being violated, managers may wish to promote alternative modes of transportation. This study illustrates that this could be done in a number of ways. First, alternative transportation could be made more convenient. For instance, the frequency of shuttle bus service could be increased or bicycles could be made available at more locations within the park. Second, if not already available, a dedicated bike path separate from the road could be designed to establish connectivity between sites. Third, cost could be used to promote alternative transportation. For example, shuttle buses and bicycles could be made free of charge to visitors. Of course, any number of these actions could to taken in conjunction with each other to further promote use of alternative transportation, reducing congestion and improving the quality of recreation experienced while traveling within the park.

Many visitors experience traffic congestion while traveling within public lands. As part of their recreational experience, this congestion demands management for both efficient transportation system performance and experiential quality. This case study illustrates how management actions may be used to disperse use across transportation modes and thereby reduce impacts of traffic congestion to visitor experience.

MANAGING CAPACITY: INTEGRATING TRANSPORTATION, VISITOR USE, AND EXPERIENTIAL QUALITY

Transportation is intimately related to national parks, particularly the large, remote western parks often thought of as the crown jewels of the national park system. From the early days when partnerships between the National Park Service and railroads built a constituency of park supporters and delivered visitors from far away cities to modern days of automobile travel and tourism, transportation has been both a means and end for national park recreation. In 2010 a program of integrated research was conducted in Yosemite to investigate the connections between recreation and transportation in the park. The goal of the research and planning project was to provide Yosemite National Park with tools to assess and manage visitor use on the parks road network and at recreation sites. Initially, data collection and analysis will inform park managers about both the levels of use on roads and at recreation sites and visitors' perceptions of experiential quality. Later, the models developed by this research will monitor recreation quality within the park based on counts of vehicles entering the park. Armed with this information, park managers will better be able to balance visitors' enthusiastic demands for use with maintenance of high quality park and recreation experiences (Meldrum & DeGroot, 2012).

The program of research is founded on the understanding that transportation helps shape demand for recreation. By delivering visitors to recreation settings, both in terms of public lands as whole entities and recreation destinations within these lands, transportation systems shape visitor use, influencing the places where people go and the times they go there. This understanding positions transportation systems as major influences on the capacity of recreation sites and the quality of visitors' experiences at these sites.

Indicators and standards of quality have helped structure this research and planning effort. The public and administrative objectives for parks and recreation areas are often broadly defined in narrative terms. To effectively measure, communicate and manage the quality of recreation experiences and transportation resources, such objectives must ultimately be expressed in more quantitative indicators and standards of quality. Indicators of quality are specific variables that serve as proxies for management objectives, capturing their essence in measurable and manageable terms. While indicators can communicate the quality of recreation and transportation, they cannot judge whether or not conditions are of a nature to satisfactorily achieve objectives. Standards of quality, informed by public norms, ecological constraints, and administrative capabilities provide gauges by which the conditions of indicators can be judged. If monitoring of recreation experiences and transportation systems indicates that conditions do not meet standards of quality, then management action may be required. Indicators and standards of quality allow researchers and managers to formulate specific variables and values to structure research and to manage transportation and recreation.

Along with indicators and standards of quality, integration of transportation and recreation in this program of research is enabled with simulation modeling. Simulation models replicate empirically observed patterns of recreation and transportation in virtual space. In this research, simulation models are used to mimic the movement and parking of vehicles on Yosemite's road network and the behavior of visitors along the parks trails and within its recreation destinations. With these models, various transportation delivery and visitor use scenarios can be played out in model space. From these scenarios, the effects of use, planning and management on the quality of transportation system performance and recreation experiences can be tested without the costs or constraints of "on the ground" trial and error.

The program of research and planning at Yosemite sets up a chain of methods and inferences. First the numbers of visitors arriving are counted. Second, the behavior of these visitors is simulated. Third, the conditions of indicators of quality are estimated. Fourth, indicator estimates are evaluated in comparisons to standards of quality. At Yosemite, this progression is pursued along two tracks (Figure 29).

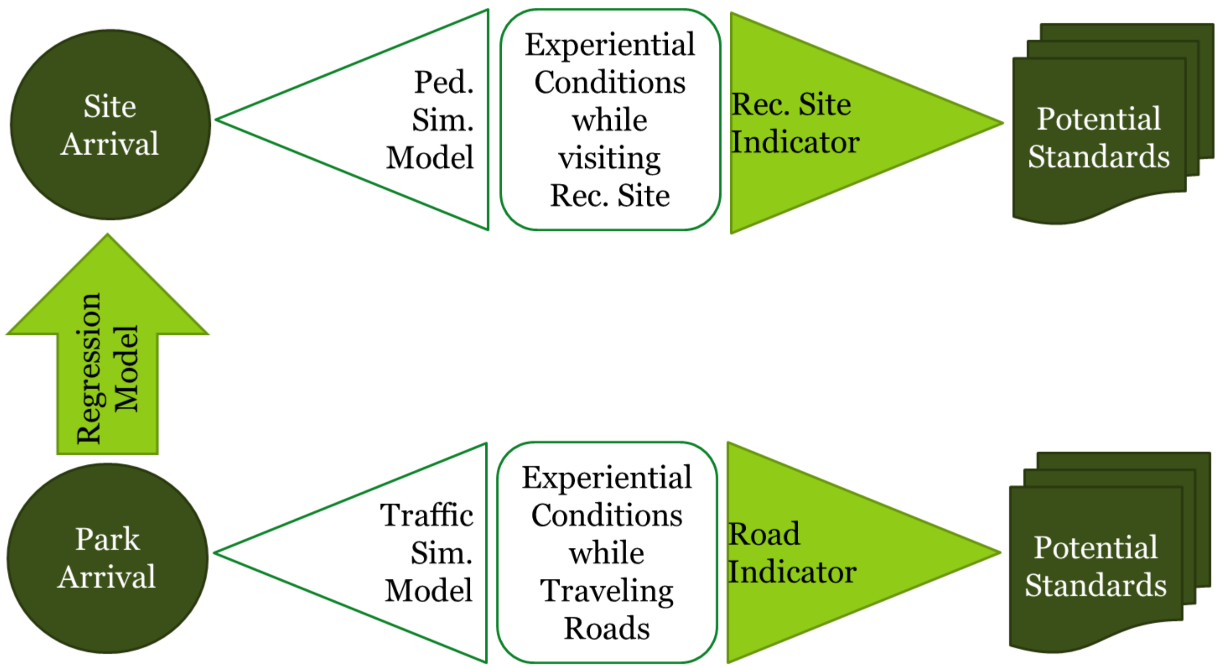


Figure 29: Integrated transportation and visitor capacity model for Yosemite

One track (as illustrated in the upper half of Figure 29) seeks to estimate and evaluate the quality of recreation experiences on trails and in pedestrian recreation sites based on counts of visitors arriving via the transportation network. Arrivals of visitors to the park and to specific recreation sites are counted and statistically modeled. The behaviors of visitors within recreation sites are simulated and indicators of the social conditions at recreation destinations are modeled. These indicators include the number of people at one time at beaches, overlooks and interpretive sites, the number of people in view along high-use trails, and the number of encounters with other hikers along sections of low-use trails (Figure 30). Normative evaluations of these indicators are elicited from visitors using on-site surveys and simulations, either visual or narrative, of a range of conditions of indicator variables (Figure 30). By following this methodological chain (arrival count, simulation model, indicator estimation, standards evaluation) the effects of transportation delivery of visitors on recreation experiences can be documented and experimentally managed (Reigner, et al., 2012).

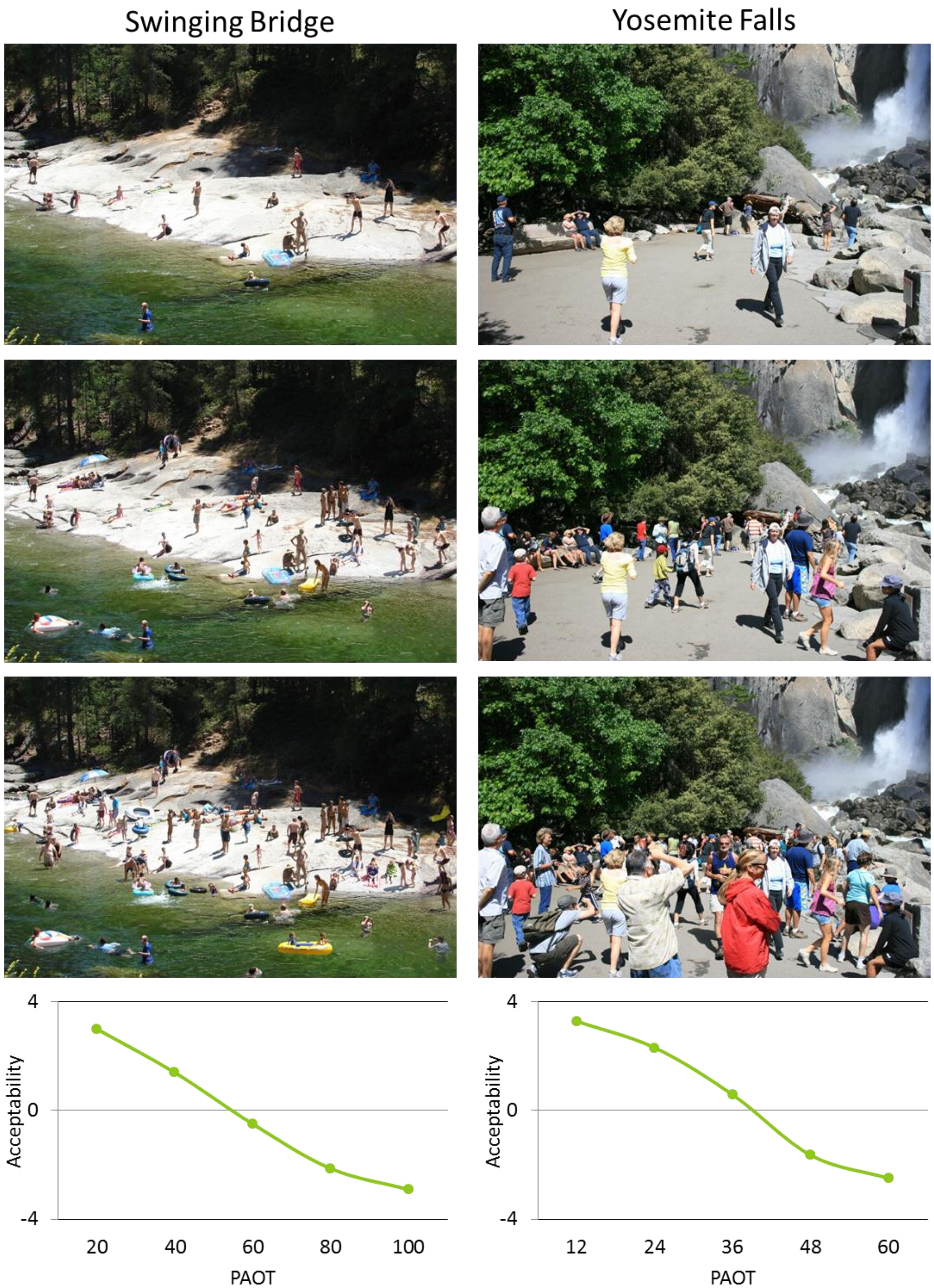


Figure 30: Indicators and standards of quality for visitor use in Yosemite

The second track of research (the lower half of Figure 29) uses a similar methodological progression to understand the quality of recreation experiences for visitors engaged in the conventional transportation activity of driving. Combining counts of vehicles driving along the park's road network with observation of vehicle travel patterns, a series of road-based simulation models estimate the travel conditions along park roads. These conditions are translated into indicators of quality of road-based recreation, including the number of vehicles in view and the travel time along road sections. Like recreation sites, evaluations of these road-based indicators are solicited from visitors via on-site surveys using visual and narrative representations (White, et al., 2012).

As public land managers research, plan, and manage visitor use and capacity, an integrated understanding of transportation and recreation can provide powerful leverage. Much recreation use is based upon transportation systems and many of the impacts of recreation can be traced, in some way, to visitor transportation. Making explicit and quantified connections between transportation and recreation allows park managers to better approach their basic charge – balancing public access and protection of park resources and experiences.

USING INDICATORS AND STANDARDS OF QUALITY TO INFORM TRANSPORTATION FOR TOURISM

During the summer of 2009, the University of Vermont's Parks Studies Laboratory, in conjunction with the University's Transportation Research Center, undertook a program of research to develop indicators and standards of quality to help inform transportation for tourism. Numerous sites were studied including a range of three types of roads located across northern New England. The Acadia Park Loop Road is located in Acadia National Park and provides visitors an opportunity to drive for pleasure and experience many of the iconic features of the park. It is part of the All-American Road referred to as the Acadia Byway. An All-American Road is the highest scenic designation a road may receive and the loop road was recognized for both its recreational and scenic qualities (National Scenic Byways Online, 2010). The Green Mountain Byway is a state scenic byway located between Stowe and Waterbury, Vermont and provides access to numerous outdoor recreation activities. This rural road also passes by historic homes, farmsteads, and villages (Vermont Byways Program, 2012). The third road selected for this study was a stretch of Interstate-89 near Burlington, Vermont. While the interstate highway system is designed for fast and efficient travel, this highway segment provides scenic backdrops across the green mountain state as well as access to its largest city. Whether designed for pleasure in the natural environs of a national park or planned for the effective transport of people and goods to urban centers, each of these highways provides recreational travel opportunities to many visitors.

A survey was administered to a representative sample of drivers on each of these roads. The survey was designed to measure normative standards of respondents for speed limits and the availability of commercial services at each site. Normative research methods were used for this purpose. Respondents were asked to evaluate the acceptability of varying speed limits and levels of commercial services on a scale bounded by -4 (very unacceptable) to +4 (very acceptable). Responses to these questions helped derive social norm curves for each of the indicator variables (Figure 31 & Figure 32).

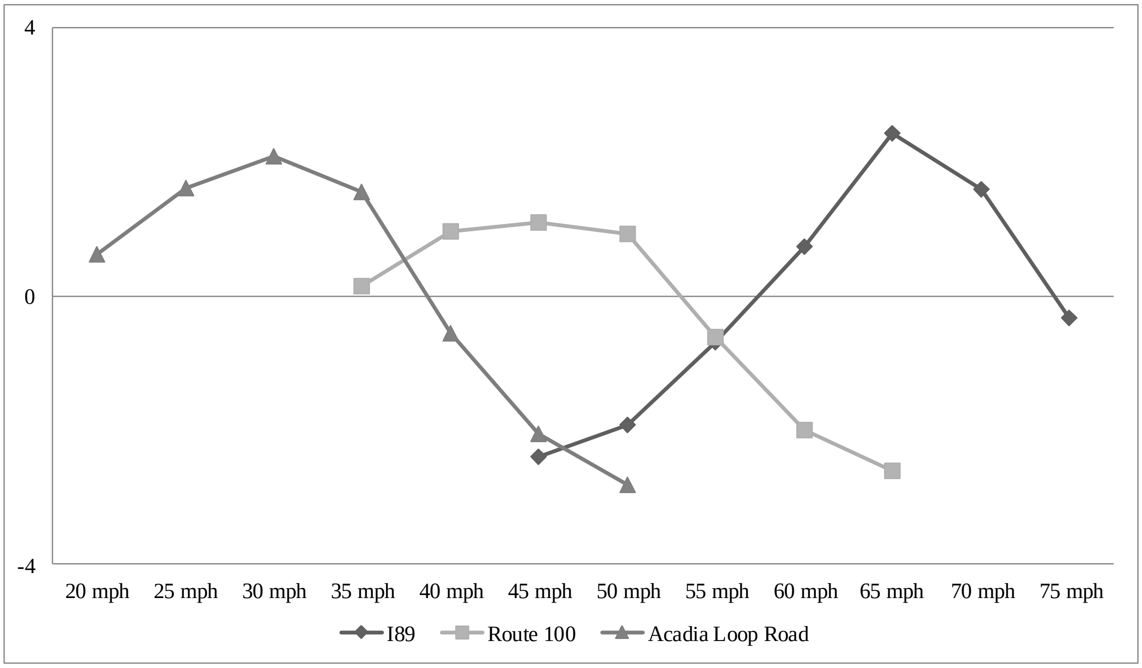


Figure 31: Social norms curve for speed limits along scenic roads in Northern New England

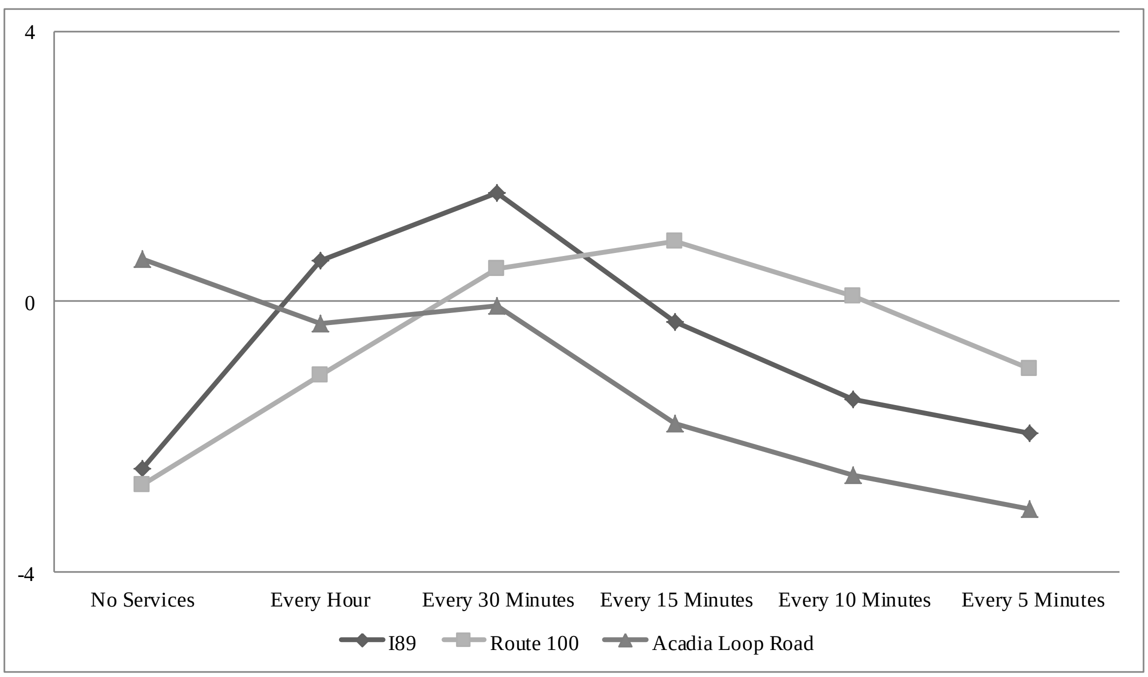


Figure 32: Social norm curves for the availability of commercial services along scenic roads in Northern New England

Ultimately, this study exemplifies how the desired conditions along scenic highways may vary across travel contexts. For instance, both desired speed limits and levels of commercial services differ for roads included in this study. While desired speed limits may be a function of road design and safety considerations, they may also illustrate that in some settings, such as national parks, it is more desirable to drive at a more leisurely pace and have the opportunity to enjoy scenic views. This is in keeping with past studies (Hallo and Manning, 2009). Furthermore, while commercial services may be desirable along some scenic roads, there may be less tolerance for them in settings such as national parks. This study helps document and quantify these standards of quality.

This program of research also considered transit as a component of tourism travel. A series of three transit systems across public land settings was chosen for the study. The Island Explorer is a shuttle bus system that delivers visitors to, from, and around Acadia National Park. The bus service utilizes intelligent transportation systems technology to provide real-time information to visitors and also incorporates the use of alternative fuels. Subsidized by the L.L. Bean Corporation, bus service is provided free of charge to visitors and has been in operation at the park since 1999. It was one of the National Park Service's first alternative transportation pilot projects and has reduced congestion and greenhouse gas emissions within the park (National Park Service, 1999). The Muir Woods shuttle was developed by Marin County, California and the National Park Service to help deliver visitors from the urban environs of the San Francisco Bay area to Muir Woods National Monument. Started as a three year pilot project in 2005, ridership increased 140% in a single year (Nelson, et al., 2008). Today the shuttle bus system continues to provide access to one of Golden Gate National Recreation Area's natural wonders. Another one of Golden Gate National Recreation Area's iconic sites is Alcatraz Island. In this case, access to the historic prison and island is provided by ferry. And while capacity studies linking ferry service to the attraction site have been conducted (Manning et al., 2002), ferry trips to Alcatraz as a recreation experience have yet to be considered. Regardless of transit mode, these shuttle buses and ferries provide recreational travel opportunities to visitors ranging from dense urban centers to rural seaside communities.

In this case, a study questionnaire was developed to measure indicators and standards of quality for each form of transit. The survey was specifically designed to measure normative standards of respondents for the frequency of transit service at each site. Normative research methods were used for this purpose. Respondents were asked to evaluate the acceptability of varying arrival and departure times on a scale bounded by -4 (very unacceptable) to +4 (very acceptable). Responses to these questions helped derive social norm curves for inter-arrival travel times (Figure 33).

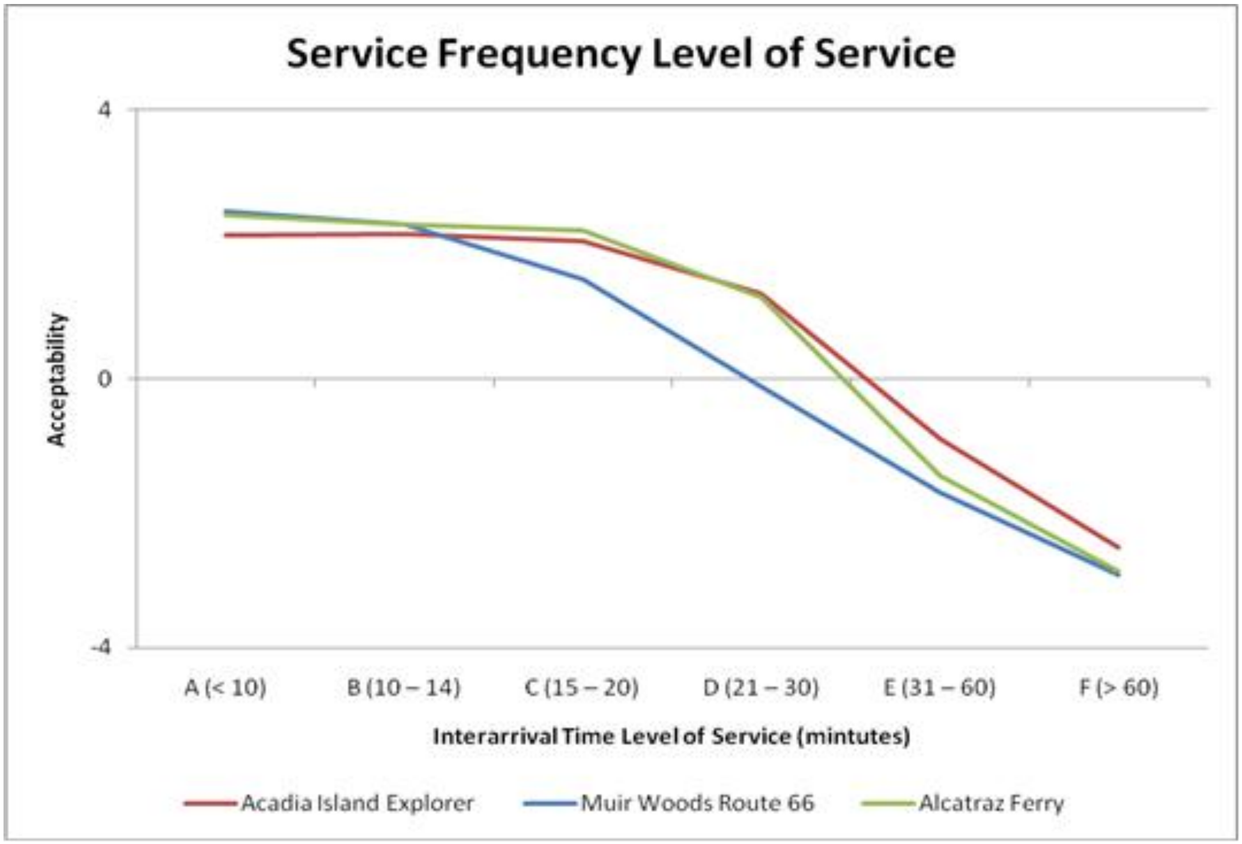


Figure 33: Social norm curves for transit frequency of service

Like findings from the scenic highways study, this study suggests that there may be some differences in the desirability for service frequency across travel contexts. However, it also suggests a critical threshold around 30 minutes where wait times become unacceptable. While further studies should continue to examine service frequency across a broader range of travel settings, these results illustrate that 30 minute wait times may be a minimum standard of quality for public transit for tourism in parks and public lands.

CHAPTER 7: STANDARDIZING TRANSPORTATION RELATED INDICATORS AND STANDARDS OF QUALITY

The research, management, and related materials presented in this Best Practices Manual document the importance of indicators and standards of quality to outdoor recreation and transportation management and suggest a broad array of transportation related indicators and standards of quality. But are there universal indicators and standards of quality that can be adopted and applied in outdoor recreation and transportation management?

Research is just beginning to address this question. There have not yet been enough studies to effectively test the degree to which indicators and standards of quality can be generalized from one context – type of recreation area, recreation activity, type of visitor – to another. Research designed to answer this question must be conducted using comparable methods. Several recent studies are suggestive of what these methods may include. For example, one study addressed crowding-related indicators of quality for the driving experience along two scenic roads (Park Studies Laboratory, 2010). While both roads are recognized for their recreational qualities, they are located in different settings. The Acadia Loop Road passes through a national park while the Scenic Route 100 Byway passes through the tourism-based community of Stowe, Vermont. Normative standards of quality were measured for the density of use for both roads using the same research methods. Drivers on both roads were asked to evaluate the acceptability of seeing visual simulations of 0, 4, 8, 12, 16 and 20 cars on 125 meter long lengths of road. The common denominator of 125 meters of road allows normative evaluations derived from these indicators to be directly compared and findings from these studies are shown in Figure 34.

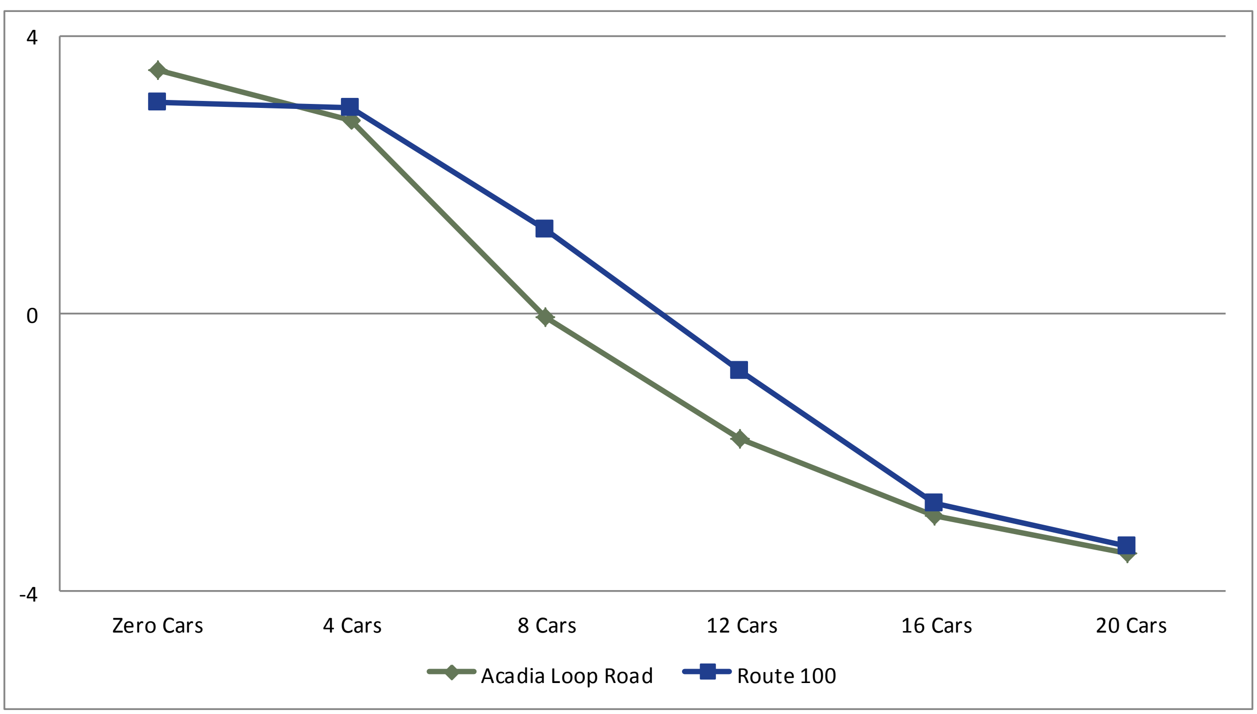


Figure 34: Social norm curves for congestion on Acadia Loop Road & Scenic Route 100 Byway

In keeping with research on crowding in parks and outdoor recreation, findings illustrated that the travel experience along each road was impacted by the number of other cars along the road. Furthermore, in accordance with the theoretical underpinnings of ROS, the standards of quality, or minimum acceptable conditions, for density of use along the roads varied across settings. Driver evaluations of the acceptability of 8 cars/125m road and 12 cars/125m road, the levels of use which straddle the minimum acceptable conditions, are significantly different. Because standards of quality were explicitly designed to measure use and quality in a comparable way (they share a common denominator), the difference in normative evaluation can be attributed to the contexts in which the measurements were taken. Moreover, the findings from this study are intuitively meaningful - visitors to a national park reported less tolerance for vehicle traffic congestion than did drivers on a state scenic byway.

While the findings of the scenic driving study suggest that visitors to different settings may have different standards of quality for traffic congestion, research addressing standards of quality for transit ridership in parks suggests that some crowding-based standards may be more generalized across settings. For instance, as discussed in the multimodal case study in Chapter 6 (Managing Multimodal Transportation at Acadia National Park) and the Highway Capacity Manual, congestion on buses and other forms of public transit may be described and measured in standardized terms of availability of the number of seats for each rider (Figure 15). While these shared modes of travel may carry visitors across public lands ranging from urban to primitive contexts, recent research has found that measures of quality for crowding on transit systems is relatively standard across settings.

For instance, a study in 2009 considered crowding as a component of travel on two shuttle bus systems and a ferry (Park Studies Laboratory, 2010). Travel settings included a national park, a national monument, and a national recreation area. These settings range from the urban environs of the San Francisco Bay Area (the ferry to Alcatraz Island – a unit of Golden Gate National Recreation Area), through suburban Marin County, CA (Muir Woods National Monument), to the woodlands of Bar Harbor, ME (Acadia National Park). Riders of the buses and ferry were presented with a range of riders per seat expressed as the ratio of riders/seat. From visitor evaluations of these indicators, normative standards were developed as shown in Figure 35.

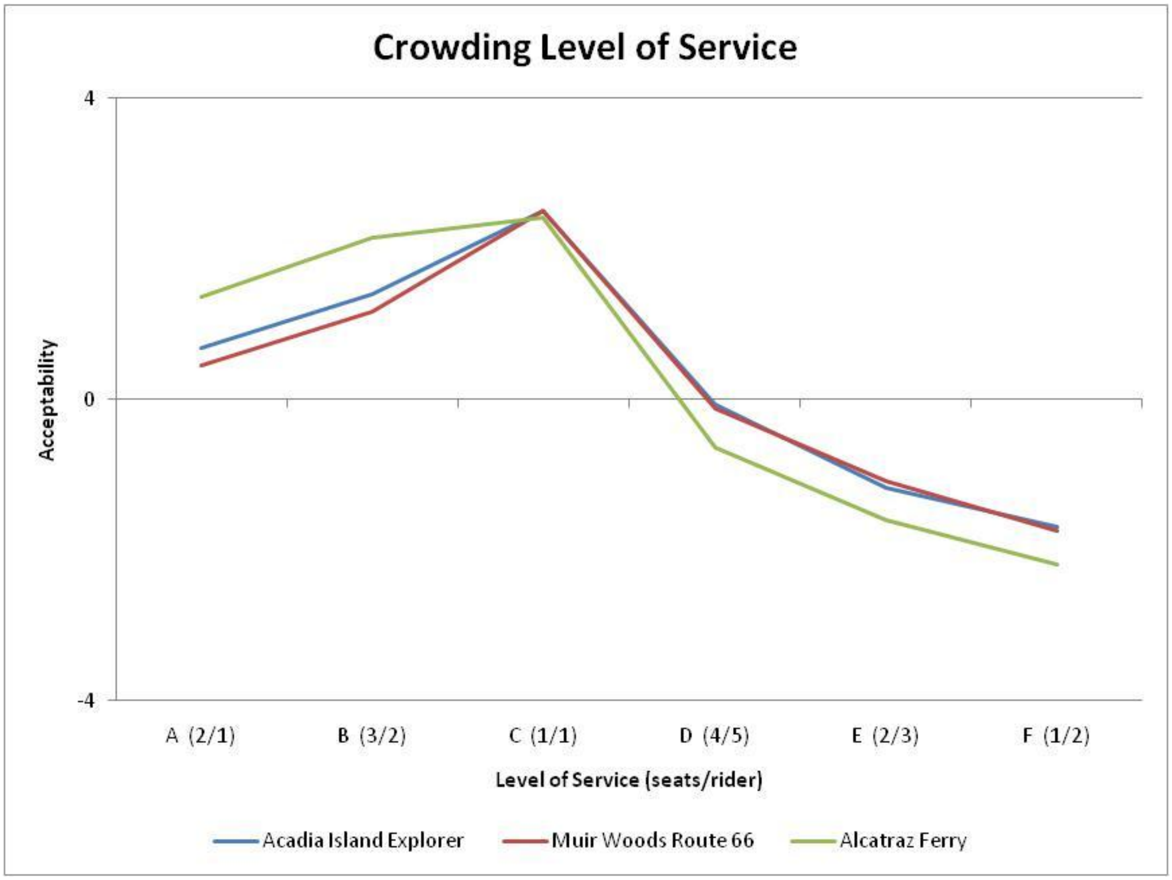


Figure 35: Social norm curves for congestion on the Island Explorer, Muir Woods Shuttle & Alcatraz Ferry

While the settings for transit service were highly diverse, the common units through which indicators were expressed facilitate direct comparison. The social norm curves suggest that having one seat available for each rider on either a shuttle bus or ferry is the optimum condition and that higher and lower densities of use are less acceptable. This is true regardless of the transportation mode (i.e., ferry or shuttle bus) and of the recreational travel setting (i.e., urban or natural). This measure of optimum condition suggests that there may be a "social" component to transit in parks and outdoor recreation; that is, visitors may wish to share the ride with similarly minded others, as long as all riders have a seat. Or, perhaps visitors perceive a half empty bus as inefficient and an environmentally ineffective mode of transport. Such a conclusion is in keeping with past studies that link the use of alternative transportation with pro-environmental attitudes (White, 2007). Regardless of the attitudes and expectations underlying normative evaluations, their convergence when elicited with standardized indicators may suggest a generalized standard of quality for transit systems across a spectrum of park, recreation and public land settings.

Using examples from two different travel modes, driving and transit ridership, the previous two studies illustrated how standardized indicators and standards of quality with common measures can differentiate and generalize normative standards among diverse settings. Another recent study of transportation and recreation quality on greenways combines both multiple modes of transportation and a diversity of settings. Bicycle and pedestrian travel illustrate this point. In 2009, on-site surveys of visitors across three greenways in northern New England were administered to solicit knowledge of how travelers use and perceive the quality of these facilities (Park Studies Laboratory, 2010). Not only do greenways represent a spectrum of travel settings ranging from natural to urban, but they are the setting for multiple recreation activities.

Walkers and bikers on the study greenways were presented with standardized measures of a range of potential standards of quality similar to those used in the above scenic road example. In this case, the same indicator is used to describe and measure quality for two different transportation and recreation activities: biking and walking. Each photograph developed for the study (Figure 36) presents standard variables, a number of visitors per 125m of greenway. As with the scenic roads study, and in keeping with the ROS, the minimum acceptable standard varied across settings in intuitively meaningful ways. With the knowledge that respondents at each study site were shown standardized indicators depicting use levels in common units, findings suggest differences in standards of quality are indeed the result of travel setting.

Figure 36: Minimum acceptable standards for walking and biking for Acadia, Stowe, and Burlington greenways

Furthermore, differences and similarities in perceptions of quality can be illustrated using these standardized standards. Results from the Acadia National Park carriage roads provide an example (Figure 37). When presented with a range of standards of quality, differences and similarities between recreationists engaged in different modes of transportation emerge. Both bicyclists and pedestrians have a higher tolerance for greater densities of pedestrians than bicyclists. Through the standardization of indicators using the common unit of number of individuals/125m of greenway, differences in the perception of quality across both settings and modes can be illustrated with the same set of indicators. Moreover, the findings from this research approach are intuitively meaningful in that pedestrians were more sensitive to the presence of bikers than other pedestrians; bikers were more sensitive to the number of other bikers as well.

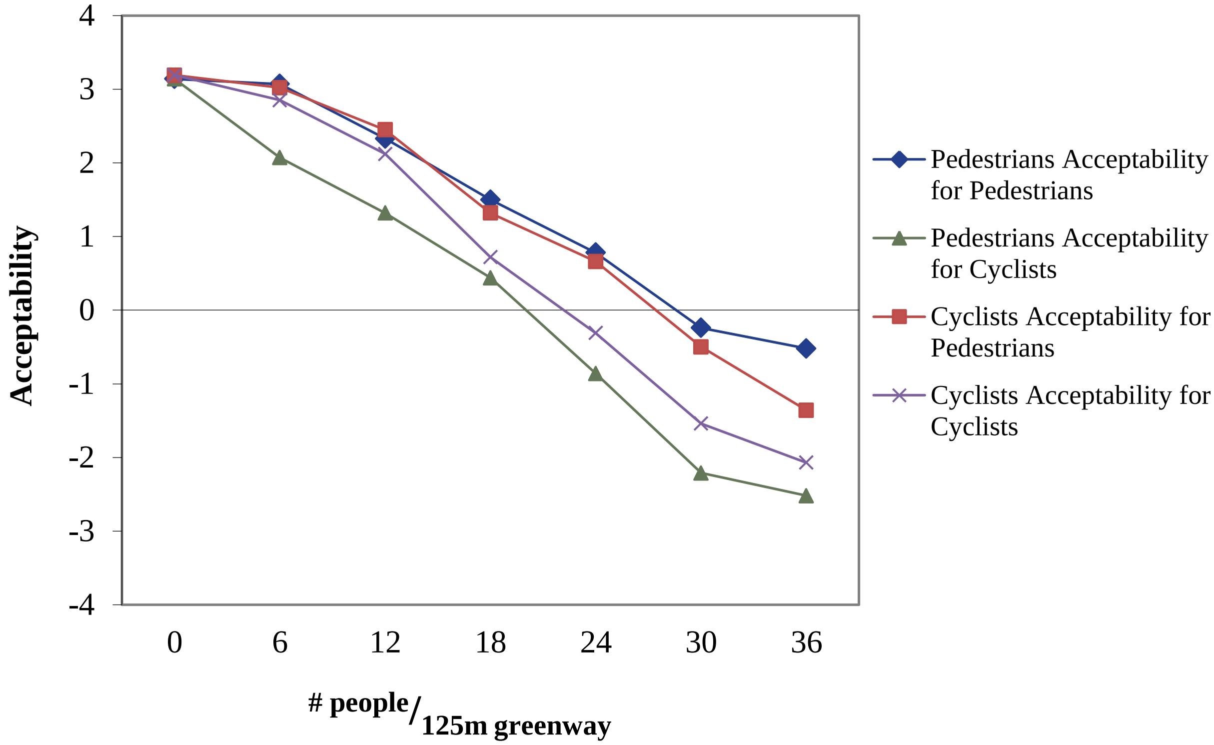


Figure 37: Standards of quality for pedestrians and cyclists in Acadia

The three examples presented in this chapter illustrate the potential value of efforts to standardize indicators and standards of quality. Findings from these initial studies are promising. There appears to be some generalizability with regard to crowding-related standards of quality across diverse forms and contexts of public transit in parks and public lands. Moreover, crowding-related standards of quality appear to range in intuitive ways across park and recreation contexts as defined by type of road and type of visitors.

The ROS framework (described in Chapter 4) may be helpful in thinking about standardizing indicators and standards of quality. For example, the research described above used the common indicator of cars/$_{\text{125m road}}$ to measure congestion-related standards of quality across a range of scenic road contexts. This research found that 8 cars/$_{\text{125m road}}$ and 12 cars/$_{\text{125m road}}$ were the minimum acceptable levels of use on a national park road and a state scenic byway, respectively. Given the characteristics of public land contexts and management objectives, public land managers may locate their roads and recreation sites within the ROS matrix and formulate indicators and standards accordingly. For example, a remote and relatively undeveloped road may be thought of as a more primitive recreation opportunity than the Acadia National Park Loop Road. Therefore, a congestion-related standard of quality that is more stringent than 8 cars/$_{\text{125m road}}$ found at Acadia may be warranted. Similarly, the ROS framework can be useful in formulating a set of indicators and standards that help ensure a diverse array of transportation and recreation experiences across a park, forest, or other unit of public land.

CHAPTER 8: CONCLUSIONS

This Best Practices Manual demonstrates the relationship between transportation and parks, outdoor recreation and public lands. The scientific and professional literature in transportation and parks and outdoor recreation have developed separately, but the material presented in this manual suggests that there are strong relationships between these professional areas of study and that integration between them can lead to important advances in understanding and managing transportation in the context of parks, outdoor recreation and public lands. The material presented in this manual can be summarized and highlighted in the following principles that can be used to help guide transportation in parks and outdoor recreation.

1. Transportation is an important component of the visitor experience in parks and outdoor recreation. Visitors rely on many modes of transportation to travel to, from, and through parks and related outdoor recreation areas and this travel is often a vital part of the ways in which most visitors experience and appreciate these public lands. Transportation in parks and related public lands should be planned and managed in ways that protect park resources and enhance the quality of the visitor experience.

2. Transportation is an important tool in managing parks and outdoor recreation. Parks and related public lands must be managed to protect important natural and cultural resources and the quality of the visitor experience. Transportation can be used to help manage parks and outdoor recreation by delivering the “right” number of visitors to the “right” places and the “right” times.

3. The relationship between transportation and parks and outdoor recreation has been emphasized in contemporary transportation and parks and outdoor recreation related legislation and policy. Important manifestations of these relationships include cooperative agreements and related programs between the Department of Transportation and the National Park Service, the Paul S. Sarbanes Transportation in Parks Technical Assistance Center (TRIPTAC), the need for a vehicle congestion management system in the national parks, and the Transportation Equity Act for the 21st Century (TEA-21, 1998) and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU, 2005).

4. Indicators and standards of quality represent an important framework for managing parks and outdoor recreation. Indicators and standards of quality are an important component of contemporary management-by-objectives frameworks that are used to manage parks and outdoor recreation. Indicators and standards of quality are used to quantify management objectives. Indicators of quality are measurable, manageable variables that are proxies for management objectives and standards of quality define the minimum acceptable condition of indicator variables. Once indicators and standards of quality are formulated, indicators are monitored and management actions taken to ensure that standards of quality are maintained.

5. Indicators and standards of quality are an integral part of several conceptual frameworks that can help guide management of parks and outdoor recreation, including transportation. For example, 1) quality in outdoor recreation can be defined as the degree to recreation opportunities meet the objectives for which are designed, 2) indicators and standards of

quality help define the relationship between park and outdoor recreation settings and associated visitor motivations and benefits, 3) indicators and standards of quality quantify management objectives and help define the limits of acceptable change and recreation carrying capacity, 4) indicators and standards of quality can be defined for each of the three basic components of parks and outdoor recreation: park resources, the quality of the visitor experience, and the type and extent of recreation management, and 5) indicators and standards of quality are used to help define a diverse system of park and outdoor recreation opportunities as represented in the Recreation Opportunity Spectrum (ROS).

6. Indicators and standards of quality are highly compatible with the management framework of levels of service conventionally used in the field of transportation. The concept of levels of service (LOS) is conventionally used to help guide transportation management. LOS defines a range of service levels (represented by "letter grades" from A to F) for a series of variables that are thought to be important in defining the quality of transportation facilities and services. These variables and the associated range of service levels are analogous to indicators and standards of quality as used in parks and outdoor recreation.

7. Levels of Service used in conventional transportation management should be extended and re-registered in the context of parks, outdoor recreation, and public lands. In keeping with conventional concerns in the field of transportation management, LOS is focused on issues of speed, safety, efficiency, and convenience. While these issues may be of importance to transportation in parks and outdoor recreation, other issues related to protection of park resources and enhancing the quality of the visitor experience are also important. Moreover, LOS guidelines on matters such as speed of travel and convenience may have to be re-registered in important ways to meet the demands of park and outdoor recreation visitors.

8. Indicators and standards of quality can be formulated and defined through a program of research. A number of research methods have been used to help define indicators and standards of quality in parks and outdoor recreation. These research methods include qualitative and quantitative surveys of visitors and other stakeholders, importance-performance analysis, a threats matrix, and normative theory and methods. These research approaches are beginning to be applied to transportation in parks, outdoor recreation, and public lands.

9. Research has identified a diverse range of indicators and standards of quality. Indicators and standards of quality have been identified for a diverse range of recreation settings. These indicators and standards of quality address park resources, the quality of the visitor experience, and the type and extent of management. A growing number of indicators and standards of quality have been identified for transportation in parks and outdoor recreation.

10. The case studies included in Chapter 6 of this manual suggest how indicators and standards of quality can be used in managing transportation in the context of parks and outdoor recreation. These case studies address 1) the issues of transportation as a form of recreation and transportation as a tool for managing outdoor recreation, 2) multiple modes of transportation including cars, public transit, biking, and hiking, and 3) a variety of park, recreation and transportation contexts including urban through rural settings.

11. Research has recently begun to address the topic of “standardizing” indicators and standards of quality. Research on indicators and standards of quality has conventionally been conducted at the site level and in isolation from other parks and public land units and this has made it difficult to test the degree to which indicators and standards of quality might be generalized across areas. Testing for the generalizability of indicators and standards of quality requires using comparable research methods. Several recent studies of transportation in parks and outdoor recreation have been designed to test the degree to which indicators and standards of quality can be “standardized.” Findings from these studies are promising, but more work is needed.

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