Journal of Park and Recreation Administration
Spring 2008
Volume 26, Number 1
pp. 97-121

Managing Visitor Impacts in Parks: A Multi-Method Study of the Effectiveness of Alternative Management Practices

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EXECUTIVE SUMMARY: How can recreation use be managed to control associated environmental impacts? What management practices are most effective and why? This study explored these and related questions through a series of experimental "treatments" and associated "controls" at the summit of Cadillac Mountain in Acadia National Park, a heavily used and environmentally fragile area. The treatments included five management practices designed to keep visitors on maintained trails, and these practices ranged from "indirect" (information/education) to "direct" (a fence bordering the trail). Research methods included unobtrusive observation of visitors to determine the percentage of visitors who walked off-trail and a follow-up visitor survey to explore why management practices did or didn't work. All of the management practices reduced the percentage of visitors who walked off-trail. More aggressive applications of indirect practices were more effective than less aggressive applications, and the direct management practice of fencing was the most effective of all. None of the indirect management practices reduced walking off-trail to a degree that is likely to control damage to soil and vegetation at the study site. Study findings suggest that an integrated suite of direct and indirect management practices be implemented on Cadillac Mountain (and other, similar sites) that includes a) a regulation requiring visitors to stay on the maintained trail, b) enforcement of this regulation as needed, c) unobtrusive fencing along the margins of the trail, d) redesign of the trail to extend it, widen it in key places, and provide short spur trails to key "photo points", and e) an aggressive information/education program to inform visitors of the regulation to stay on the trail and the reasons for it. These recommendations are a manifestation of what may be an emerging principle of park and outdoor recreation management: intensive use requires intensive management.

Keywords: Visitor impacts; management practices; observation; visitor survey; Acadia National Park

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Concern over the environmental impacts of visitor use in parks and related areas is a perennial and increasingly important issue. An accumulating body of research dating back several decades has documented the variety and severity of impacts that visitors can have on parks, including trampling of fragile vegetation, soil compaction and erosion, water pollution, and disturbance of wildlife (Hammitt & Cole, 1998; Marion & Leung, 2001). A common finding of this research is that such impacts can occur even under relatively low levels of use. For example, an early study in the Boundary Waters Canoe Area Wilderness found that an average of 80% of ground cover was lost at campsites in a single season, even under use conditions that were described as "light" (Frissell & Duncan, 1965). The urgency of this issue has been magnified over time as annual use levels of popular parks and related areas are now measured in the hundreds of thousands and even millions.

The importance of this issue is derived from the fundamental, two-fold mission of most parks and related areas: parks are to be enjoyed, but also protected. The 1916 Organic Act of the U.S. National Park Service (NPS) is the classic manifestation of this inherent tension. This legislation requires that national parks be managed "to conserve the scenery and the natural and historic objects and the wildlife 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" (The National Park Service Organic Act, § 1, 1916).

How can parks be managed to limit the environmental impacts of visitor use? How effective are these management practices? Why are some management practices more effective than others? How acceptable are alternative management practices to visitors? To help answer these and related questions, a multimethod study was conducted at Acadia National Park, Maine. The study applied a range of management practices ("treatments") along with associated "controls" and employed observational and survey methods to measure the effectiveness of the experimental management practices. The first component of the study used unobtrusive observation to determine the percentage of visitors who walked off an official trail (and therefore damaged surrounding soils and vegetation) under control and treatment conditions. The second component of the study used a series of surveys of visitors exposed to control and treatment conditions to understand how these management practices affected visitor behavior and how acceptable these management practices were to visitors. The combination of research design (experimentation and associated controls) and methods

(observation and visitor surveys) used in this study makes it distinctive in the scientific and professional literature on parks and outdoor recreation, and provides multiple and complementary perspectives on the important issue of protecting park resources from the impacts of visitor use.

In 2004 Acadia National Park was among the ten most-visited U.S. national parks (nps.gov, September 2007). Moreover, its nearly 2.5 million visits per year are concentrated on less than 50 thousand acres of park land, making Acadia what may be the most intensively used U.S. national park. Much of this visitor use is further concentrated at several popular "icon" sites, including the summit of Cadillac Mountain. Cadillac Mountain offers sweeping views of the park and surrounding areas and is readily accessible by road and trails. Consequently, up to 5,500 visitors are drawn to the summit area on peak summer days (Turner & LaPage, 2001; Baldwin & LaPage, 2003). A 0.3 mile paved summit loop trail (along with a large parking lot and gift shop) is designed to accommodate this use. However, many visitors choose to walk off this formal trail, and off-trail walking has resulted in extensive and severe trampling impacts to surrounding soil and vegetation (Turner & LaPage, 2001; Evans, 2002). These impacts are exacerbated by the fragile character of the summit, which is comprised of low-lying sub-alpine vegetation and thin soils, and by the short, high latitude growing season. The presence of rare plant species, and concerns about visitor-caused impacts have prompted the State of Maine to designate the summit as a Critical Environmental Area (Turner & LaPage, 2001).

Managing Visitor Use

The literature in parks and outdoor recreation suggests that there is a variety of management alternatives that might be applied to guide visitor use and minimize resulting impacts (Cole, Petersen, & Lucas, 1987; Anderson, Steward, Yates, and Yerba, 1998; Manning, 1999). For example, visitor use and impacts might be subject to four basic management strategies: limiting the amount of use, increasing the supply of recreation areas/opportunities, altering visitor behavior to reduce impacts, and hardening the resource to visitor use (Manning, 1979). There are a number of sub-strategies within each of these alternatives.

Another way to conceptualize management alternatives focuses on tactics or actual management practices. Management practices are actions or tools applied by managers to accomplish the strategic objectives outlined above. For example, restrictions on length of stay, differential fees, and mandatory use permits are all management practices designed to implement the strategy of limiting recreation use. Management practices may be classified along a spectrum according to the directness with which they act on visitor behavior (Lime, 1977; Peterson & Lime, 1979; Chavez, 1996). As the term suggests, direct management practices act directly on visitor behavior, leaving little or no freedom of choice. Indirect management practices attempt to influence the decision factors upon which visitors base their behavior. As an example, a direct management practice for reducing campfire-related impacts would be a regulation to prohibit campfires. An indirect management practice would be an education program informing visitors of the undesirable ecological and aesthetic impacts of campfires and encouraging them to carry and use portable stoves instead.

The relative advantages and disadvantages of direct and indirect recreation management practices have received substantial attention in the professional literature. Generally, indirect management practices are favored when and where they are believed to be effective (Peterson & Lime, 1979; McCool & Christensen, 1996). Emphasis on indirect management practices, however, has not been uniformly endorsed (McAvoy & Dustin, 1983; Shindler & Shelby, 1993). It has been argued that indirect management practices may be insufficiently effective. Some visitors, for example, may ignore management efforts to influence the decision factors that guide behavior. The actions of a few, therefore, hamper attainment of management objectives. This problem may be especially germane to the issues of resource impacts because, as noted earlier, these impacts can be caused by low levels of use.

Since information/education programs are an indirect management practice, they are commonly applied to help manage visitor use (Marion, Roggenbuck, Manning, 1993; Abbe & Manning, 2007). However, information/education can be seen as having varying degrees of application to a variety of recreation management problems (Roggenbuck, 1992; Vander Stoep & Roggenbuck, 1996; Hendee & Dawson, 2003). Problem behaviors of visitors can be classed into five basic types along a spectrum. At the two ends of the spectrum, problem behaviors can be seen as either deliberately illegal (e.g., theft of Native American artifacts) or unavoidable (e.g., disposal of human waste). In these instances, information may have limited effectiveness. However, the other three types of problem behaviors—careless actions (e.g., littering), unskilled actions (e.g., selecting an inappropriate campsite), and uninformed actions (e.g., using dead snags for firewood)—may be considerably more amenable to information/education programs.

Information/education can also be considered in relation to theories of moral development (Christensen & Dustin, 1989). This approach builds on two prominent theories of moral development as suggested by Kohlberg (1976) and Gilligan (1982). Both theories suggest that people tend to evolve through a series of stages of moral development ranging from those that are very self-centered and are based on issues of immediate rewards and punishments to those that are highly altruistic and are based on principles of justice, fairness, and self-respect. Individual visitors to parks and recreation areas may be found at any of the stages of moral development. Management implications of this conceptual approach suggest that information/education programs (and perhaps management programs in general) should be designed to reach visitors at each of these stages of moral development. For example, to reach visitors at lower levels of moral development, managers might emphasize extrinsic rewards and punishments for selected types of behavior. However, communicating with visitors at higher levels of moral development might be more effective by means of emphasizing the rationale for selected behaviors and appealing to one's sense of altruism, justice, and fairness.

Method

While there are a variety of practices that might be used to manage visitor use and its associated impacts, there is uncertainty about the effectiveness of these alternatives (Manning, 1999). A number of studies have explored this issue (see, for example,

Roggenbuck & Berrier, 1982; Harmon, 1992; Alpert & Herrington, 1998), but resulting knowledge is spotty. Most research has focused on only a few management practices such as information/education and use limitation. Moreover, much of this research has been hypothetical and attitudinal, not experimental and behavioral. This study was designed to test the effectiveness of alternative management practices that ranged from indirect to direct, and to conduct this test in an experimental context. Moreover, multiple research methods (observation and visitor surveys) were used to capitalize on the strengths of each and to validate findings from each methodological approach. Management practices included in the study were designed to encourage visitors to the summit of Cadillac Mountain to stay on the paved summit loop trail in order to limit their impacts on surrounding soil and vegetation. The following range of controls and treatments were tested in this study. A summary of management actions by controls and treatments is shown in Table 1.

Table 1. Summary of Management Actions for Study Controls and Treatments

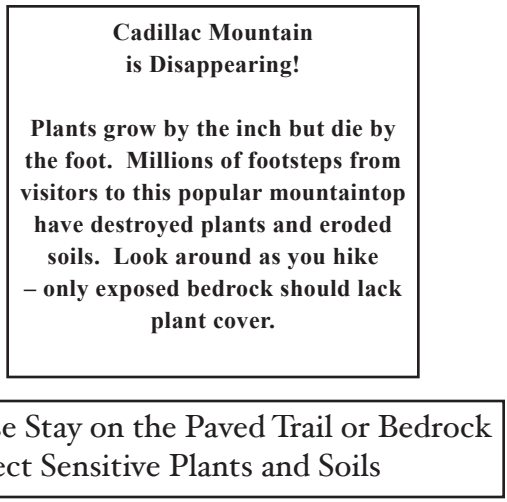
Controls/Treatments	Educational Signs	Appeal to Remain on Trail or Bedrock	Appeal to Remain on Trail	Personal Educational Message	Prompter Signs	Trailside Fencing
Control 1 (control for treatments 1-4)	No	No	No	No	No	No
Treatment 1 (educational signage I)	Yes	Yes	No	No	No	No
Treatment 2 (educational signage II)	Yes	No	Yes	No	No	No
Treatment 3 (educational signage III)	Yes	No	Yes	No	Yes	No
Treatment 4 (fencing)	Yes	No	Yes	No	No	Yes
Control 2 (control for treatment 5)	Yes	No	Yes	No	No	No
Treatment 5 (personal message to tour bus passengers)	Yes	No	Yes	Yes	No	No

1-Pre-existing management actions were held constant for all controls and treatments: paved trail with some coping stones, site map signs, and exclosures around several patches of vegetation.

Control 1 (control for treatments 1 through 4). Simple site maps of the summit loop trail were posted at both entrances/exits to the summit loop trail. Existing split-rail fence exclosures around some large patches of remaining vegetation on the summit and large coping stones defining the trail margin in selected locations were kept in place for this control and all treatments. Moreover, the existence of the paved trail itself could be considered a "treatment" designed to encourage visitors to confine their use to the developed, formal trail.

Treatment 1 (educational signage I paved trail and rocks). Signs were posted at the site maps at the entrances/exits to the summit loop trail and at two intervals along the trail. These signs briefly described the damage caused by walking off the trail and asked visitors to walk only on the paved trail or on rock surfaces (Figure 1). This treatment was designed to test the effectiveness of the indirect management practice of information/education delivered through signs. As described above, it encouraged visitors to stay on the paved trail but also allowed them to walk off the trail if they stayed on rock surfaces.

Figure 1. Trailhead Educational Signage Messages



Treatment 2 (educational signage II paved trail only). This treatment was the same as treatment 1, but the second set of signs asked visitors to remain on the paved trail only.

Treatment 3 (educational signage III paved trail only plus prompter signs). This treatment was the same as treatment 2. However, ground-level "prompter" signs (Figure 2) constructed of 4x4 inch wooden blocks with a "no walking" graphic were installed at the 24 most prominent informal (visitor-created) trails branching off the paved summit loop trail.

Treatment 4 (site management.) This treatment was the same as treatment 2 but added a low symbolic rope fence lining the first 150 feet of the paved trail. The fence was designed to keep visitors on the paved trail. This treatment was designed to test the effectiveness of a direct management practice.

Control 2 (control for treatment 5.) This control was the same as treatment 2. However, in this control, only visitors arriving at the summit by bus were selected for observation. This control (and its companion treatment 5) was administered only on days when cruise ship passengers were driven to the summit on charter busses

Treatment 5 (personal message to tour bus passengers.) This treatment was the same as control 2. However, concessioner tour bus drivers delivered a brief oral educational message and request to visitors to stay on the paved trail. This message was delivered verbally as passengers were en route to the summit. This treatment tested information delivered in person.

Figure 2. Prompter Signage Installed at Most Prominent Informal Trailheads

Each of the above controls and treatments was applied for up to three randomly selected days over a two week period in August, 2005. On each of these days, trained research staff unobtrusively observed a systematic random sample of visitors (every nth visitor) and recorded whether or not visitors walked off the paved trail and related information. Field staff consisted of 16 trained observers. On a given day, up to ten observers worked singly or in pairs to collect data on individual visitors throughout a full observation. Interobserver reliability was checked during training exercises on-site at the study outset, and exceptional situations were clarified daily at start- and break-times. Observers dressed and behaved in a manner generally consistent with park visitors to conceal their identity (Burrus-Bammel & Bammel, 1984; Turner & LaPage, 2001). Observations were conducted only during peak use hours and fair weather when use levels were sufficient to ensure that observers would not be obvious. Visitors were followed at a discrete distance of approximately 50 feet. Sample sizes for treatments and controls ranged from 137 to 210, and totaled 1,135. Observers recorded relevant behavioral information, including time spent reading information signs, occurrence of walking off-trail, apparent reasons for walking off-trail, surfaces visitors walked on when off-trail, and whether or not visitors crossed trailside coping stones that marked the margin of the trail in some sections and the symbolic rope fencing when and where applicable. In addition, observers conducted rapid spot counts of other visitors visible and off-trail nearby (within 50m). A short list of common "apparent reasons for walking off-trail" was supplied to observers based on pretrial Delphi study observations, with additional space to record other reasons as observers saw fit. General demographic data of visitors were also recorded as observed, including gender, apparent age, and apparent group type. Observations continued for the length of the subjects' visit to the summit as long as the subject remained on the paved trail. If the subject walked off the paved trail, observation continued for a maximum of one minute or until the visitor's feet were no longer visible (at which point the observers could no longer see the surfaces on which visitors were walking).

A survey of representative samples of visitors was also administered in conjunction with the observational study. The survey was administered on the same days that control 1 and associated treatments 1 through 4 were applied. Control 2 and treatment 5 applied to tour bus passengers could not be included in the survey component of the study because the short period of time spent on the summit by these visitors did not allow them to participate. Visitors who were finishing their walk in the area of the paved summit loop trail were randomly selected (every *n*th visitor) and asked to complete a self-administered questionnaire. It should be noted that visitors who participated in the survey were not necessarily the same visitors who were observed in the observational component of the study. The response rate to the survey was 71.7%. Sample sizes for the control and treatments 1 – 4 ranged from 100 to 161, for a total of 596 completed questionnaires. The questionnaire addressed several issues, including a) whether or not visitors reported walking off the paved trail, b) why they did or didn't walk off-trail, c) whether or not they noticed 1) the study treatments (i.e., the management practices that were applied) and 2) the environmental impacts caused by visitors walking off-trail, d) how the management practices included in the treatments affected their decision to walk off-trail or not, and e) the degree to which they supported or opposed a range of management practices designed to keep visitors on the paved

trail. Questions addressing why visitors did or didn't walk off-trail were guided by the conceptual frameworks outlined earlier. Statements were developed representing the five basic types of problem behaviors (illegal, unavoidable, careless, unskilled, uninformed) and respondents who reported walking off-trail were asked to indicate which of these statements applied to them (see Table 4). Similarly, statements representing a range of moral development were presented and respondents who reported that they had not walked off-trail were asked to indicate which of these statements applied to them (see Table 5).

Observation Results

Effectiveness of Treatments

The percentage of visitors walking off trail for all treatments and controls is shown in Table 2. A substantial majority of visitors (73.7%) walked off-trail under control 1 (control for treatments 1 through 4) conditions. Treatment 2 (educational signage II) reduced walking off-trail to 63.0% of visitors, but this reduction from the control was not statistically significant: x^2 (1, N = 290) = 3.803, p = .051. Treatment 1 (educational signage I) reduced walking off-trail to 59.1% of visitors, and this reduction from control 1 was statistically significant, with x^2 (1, N = 328) = 7.724, p = 0.005. The more aggressive treatment 3 (educational signage III) reduced walking off-trail to 24.3% of visitors, and this reduction from the control was also statistically significant at x^2 (1, N = 362) = 86.928, p < .001. Treatment 4 (site management) reduced walking off-trail to 1.2% of visitors within the fenced portion of the trail, x^2 (1, N = 317) = 77.490, p < .001, and to 24.2% of visitors beyond the fencing, and both of these reductions were highly statistically significant from control 1.

Table 2. Percentage of Visitors Walking Off-Trail By Controls and Treatments

Controls/Treatments	Observation	Self-report
Control 1 (control for treatments 1-4)	73.7	67.7
Treatment 1 (educational signage I)	59.1*	39.4
Treatment 2 (educational signage II)	63.0	36.9
Treatment 3 (educational signage III)	24.3**	17.2
Treatment 4 (fencing)	1.2 (within and beyond fence: 24.2†)	25.2
Control 2 (control for treatment 5)	36.9	
Treatment 5 (personal message to tour bus passengers)	40.7††	

* significantly different than control 1 at x^2 (1, N = 328) = 7.7, p < 0.001
** significantly different than control 1 at x^2 (1, N = 362) = 7.724, p = 0.005
† significantly different than control 1 at x^2 (1, N = 317) = 77.490, p < 0.001
†† significantly different than control 1 at x^2 (1, N = 301) = 35.631, p < 0.001

Control 2 (control for treatment 5) found that 36.9% of bus passengers walked off-trail, and this reduction from the control 1 was statistically significant: x^2 (1, N = 301) = 35.631, $p < .001$, underscoring the importance of properly controlling for different types of users (i.e., tour bus passengers vs. other visitors). As noted earlier and in Table 1, control 2 included the educational signage of treatment 1. This effect may be due in part to the tightly controlled schedule of tour bus operations that allow passengers only a short time at the summit. Treatment 5 (personal message to tour bus passengers) resulted in 40.7% of tour bus passengers walking off-trail, and did not differ to a statistically significant degree from control 2, with x^2 (1, N = 294) = 0.036, $p = .051$.

Attention to Signage

One reason for the limited effectiveness of the text-based educational management practices (treatments 1 through 3) may be due to the lack of attention to signs by most visitors (Table 3). In no treatment did mean time spent reading signs exceed eight seconds. For the first sign encountered, a majority of visitors either ignored or only glanced at the sign regardless of the treatment. The second sign encountered contained less information (it did not include the site map or the educational message, but only asked visitors to remain on the trail or rock surfaces). This distinction may be why visitors spent even less time reading this sign (only about a third of the time spent on the first sign). The lack of attention to signs may be at least partly a function of crowding at the summit. When some visitors stopped to read the signs, they may have inadvertently blocked the view of other visitors. Visitors obstructing the signs would obviously reduce the potential effectiveness of this management practice.

Table 3. Mean Time Spent Reading Signage

Controls/Treatments	Time at Sign 1 (sec / SD)	Time at Sign 2 (sec / SD)	N	Sign 1: Percentage of visitors who:		
				Ignored (%)	Noticed (%)	Read (%)
Control 1 (control for treatments 1-4)	4.11*/4.21	--*	124	42.6	28.4	29.0
Treatment 1 (educational signage I)	5.92 / 5.05	1.58 / 0.86	111	19.0	41.6	39.4
Treatment 2 (educational signage II)	5.88 / 5.06	1.99 / 1.04	133	24.0	29.9	46.1
Treatment 3 (educational signage III)	6.39 / 7.15	2.29 / 0.96	170	25.2	30.4	44.4
Treatment 4 (fencing)	7.13 / 6.43	2.39 / 1.16	142	19.0	41.6	39.4
Control 2 (control for treatment 5)	4.66 / 4.53	1.59 / 0.99	123	31.2	36.2	32.6
Treatment 5 (personal message to tour bus passengers)	5.60 / 7.58	1.88 / 0.96	112	35.2	33.6	30.2

* For control conditions, the first sign was only a map, the second sign was removed.

Off-Trail Behavior

Why did visitors walk off-trail, and what did they do off-trail? Research staff recorded notes on their observations about these issues (using a short list of potential reasons as described earlier), though these questions cannot be fully answered by observation alone. (These issues are addressed more fully in findings from the visitor survey component of the study.) The vast majority of visitors who walked off-trail (78.6%) simply seemed to be "exploring" the area. The next most common reason (13.0%) was to take photographs. Photographers seemed to be searching for a better vantage point and trying to take pictures that did not include large numbers of other visitors.

Once visitors walked off the trail, the vast majority (72.5%) did not evidence any visible effort to avoid stepping on vegetation or bare soil (i.e., by remaining on rock surfaces). The treatment in place had no statistically significant effect on this behavior: x^2 (1, N = 469) = 23.694, $p > .005$.

Predictors of Walking Off-Trail

Several characteristics of respondents and other variables were tested to see if they were associated with walking off-trail (i.e., could these variables be used to help predict what type of visitors are mostly likely to walk off-trail?). Demographic and socioeconomic characteristics of respondents, including age and gender, were generally not strongly associated with walking off-trail or other off-trail behavior for any of the controls or treatments. However, group type was highly significant as a predictor of visitors going off-trail: x^2 (1, N = 1094) = 25.824, $p < .001$. Family and friendship groups were significantly more likely to walk off-trail than couples were x^2 (2, N = 936) = 22.416, $p < .001$. The other variable that was strongly associated with walking off-trail was the presence of other visitors off-trail. Cross tabulation showed that up to 20 other visitors were observed to be off-trail in nearby areas in over 80% of cases when subject visitors walked off-trail.

Visitor Survey Results

Sample

Respondents were nearly evenly split between males (51.8%) and females (48.2%). They tended to be very well educated, with 69.9% reporting having earned a college or graduate degree. The vast majority (94.5%) were white and 96.3% did not consider themselves Hispanic or Latino. Most respondents (59.2%) were between 40 and 60 years old. Visitors resided in 39 states and nine foreign countries. No significant differences were found in these characteristics across the days of the week, suggesting that the days of the week on which controls and treatments were applied did not affect resulting visitor behavior and responses to the survey questionnaire.

Walking Off-trail

Visitors were asked to report whether or not they had walked off the paved trail. Data for the applicable control and treatments are shown in Table 2 (along with comparable findings from the observational component of the study as discussed above).

During control 1, about two-thirds of respondents (67.7%) reported walking off-trail

compared to 73.7% who were observed to walk off-trail. These proportions were significantly different x^2 (1, N = 251) = 41.936, $p < .001$. It should be remembered, as noted above, that even though the observational and survey components of the study were conducted simultaneously, survey participants were not necessarily—and most probably were not—visitors who were actually observed. To the extent that visitors observed and surveyed were representative of all visitors (both samples were randomly selected), survey respondents underestimated the extent to which they walked off-trail for the control and four of the five treatments. There is little reason to think that the observational data are not the most accurate measure of walking off-trail. There are several reasons why respondents may have underreported walking off-trail. First, there may be some degree of "social desirability bias" as respondents may have been hesitant to report that they engaged in a behavior that is officially discouraged (Godbey, 1984). Second, there may have been some confusion about what constitutes "walking off-trail". The questionnaire was quite specific about defining this behavior, but there are many visitor-created trails that diverge from the paved trail, and it is possible that some respondents considered at least some of these trails as part of the officially designated and maintained summit loop trail. Finally, some respondents may have had difficulty recalling the specific nature of their activities, including exactly where they walked over the duration of their visit to the mountain summit.

Why Visitors Walked Off-Trail

As noted above, many visitors reported walking off-trail. These respondents were asked two follow-up questions to explore why they walked off-trail. The first question addressed the purpose of walking off-trail, much like research staff tried to note in the observational component of this study. Respondents were asked to indicate which of seven purposes of walking off-trail applied to them, and respondents were allowed to indicate as many of these purposes as applied. Large percentages of respondents reported the relatively generic purposes of "to get a better view" (62.3%) and "to explore" (43.2%). Seeking out a better point to take a picture was also reported by a relatively large percentage of respondents (61.8%). These findings are generally in keeping with data derived from the observational component of the study. A total of 18% of respondents reported that they walked off-trail "to move past others on the trail" and "to get away from crowds on the trail." This raises the potential connections between the ecological and social dimensions of carrying capacity and recreation management more broadly; crowding/congestion along the trail can lead to some visitors walking off the trail, and this leads to increasing environmental impacts. Relatively few respondents walked off-trail to participate in other recreation activities, including picnicking (7%) and picking blueberries (5%).

The second question was based on the conceptual framework of "types" of recreation management problems as described earlier. Respondents were asked to report whether or not each of five basic reasons for walking off-trail applied to them. Results are suggestive of the extent to which information/education programs (and perhaps indirect management practices in general) might be effective in addressing the issue of walking off-trail (Table 4). Relatively large percentages of respondents (from 27.8% to 66.7%, depending on the control/treatment in place) reported that they walked off-trail because they felt visitors should be allowed to do so. This response generally

corresponds to the "illegal" type of recreation management problem (especially when considered in the context of the treatments that admonished visitors to stay on the paved trail). Strikingly, 55.6% of respondents reported this reason for walking off-trail even for the treatment of fencing. The literature suggests that information/education may not be very effective in keeping these visitors on the paved trail (Roggenbuck, 1992). All of the treatments in the survey component of the study asked visitors to stay on the paved trail (or rock surfaces in the case of treatment 1) and explained the reasons for this desired behavior. Yet, many visitors walked off-trail, apparently because they disagreed with the information/education that was presented or thought

Table 4. Type of Problem Behavior Associated with Walking Off-Trail

Type of Problem	Control 1	Treatment 1	Treatment 2	Treatment 3	Treatment 4
I needed to walk off the paved summit loop trail (e.g., I had to get around other visitors)	23.3	23.3	30.4	23.5	20.7
I didn't know that walking off the paved summit loop trail might damage soils and vegetation	42.9	33.3	18.8	22.2	32.1
I didn't know that I was supposed to stay on the paved summit loop trail	70.7	43.6	19.1	31.6	55.2
I didn't mean to walk off the paved summit loop trail (i.e., I walked off the paved summit loop trail accidentally)	10.2	25.6	22.2	27.8	11.1
I feel visitors should be allowed to walk off the paved summit loop trail	66.7	54.1	35.6	27.8	55.6

Note. Data are percentage of respondents who agreed with each statement.

that the problem of impacts to soil and vegetation was not important enough to warrant restrictions on freedom of movement by visitors.

Substantial but smaller percentages of respondents (from 20.7% to 30.4%, depending on the control/treatment in place) reported that they walked off trail because they "needed to" (e.g., they had to pass other visitors who were blocking the trail). This generally corresponds to the "unavoidable" type of problem described earlier. Information/education may not be very effective in keeping these visitors on the paved trail.

Substantial percentages of respondents also reported that they walked off-trail for all of the other three reasons included in Table 4 – because respondents were careless, unskilled, or uninformed. As described earlier, the literature suggests that these reasons for problem behaviors may be more amenable to management through information/education programs. The findings reported in Table 4 are mixed with regard to this hypothesis. Relatively large percentages of respondents fell into the uninformed (18.8% to 42.9%) and unskilled (19.1% to 55.2%) categories even though they were subject to one of the educational signage treatments. On the other hand, the percentage of respondents in these categories was consistently lower than the percentages in control 1 (in which no information/education on walking off-trail was provided).

Why Visitors Didn't Walk Off-trail

A substantial percentage of visitors (ranging from 32.8% for the control to 82.8% for treatment 3) reported that they did not walk off-trail. Why not? Insights into this question were derived from the survey question based on the conceptual framework of moral development described earlier. Respondents were asked to indicate why they did not walk off-trail by indicating which of five reasons (corresponding to five stages of moral development) applied to them. Findings are presented in Table 5. The first statement illustrates the concept of "preconventional morality" and is highly oriented to fear of punishment and/or minimizing pain/maximizing pleasure. The second two statements illustrate the concept of "conventional morality" and are oriented to what others think. The last two statements illustrate the concept of "postconventional morality" and are inwardly oriented toward issues of justice, fairness, and self-respect. It is clear from the findings that the majority of respondents who did not walk off-trail were influenced in their decision making by matters of postconventional morality. Fear of punishment and concern with what others (inside or outside the respondent's social group) think influenced only a small minority of this subset of respondents. This suggests that information/education messages about walking off-trail on the summit of Cadillac Mountain should probably emphasize how walking off-trail affects this area's vegetation and soil, why it is important to protect this area, and why it is everyone's duty to help ensure this. At least, this is the case for respondents who did not walk off-trail. Recall that many visitors did walk off-trail, even when efforts were made to inform them of the impacts of such behavior. It appears that the population of visitors to the summit of Cadillac Mountain is diverse in their levels of moral development, and that a program of management directed at keeping visitors on the paved trail will probably have to address multiple levels of moral development to reach this broad audience.

Visitor Awareness

Respondents were asked several questions regarding their awareness of the management practices that were in effect when they visited the summit and the degree to

Table 5. Reasons for Not Walking Off-Trail

Statement	Percentage who replied "applies to me"
I was afraid I would be reprimanded or fined	14.8
I was afraid that other members of my group would think poorly of me.	11.4
I was afraid that other visitors in general would think poorly of me.	20.1
It is not fair for me to walk off the paved summit loop trail when many other visitors don't.	49.1
I feel better about myself by not walking off the paved summit loop trail.	76.8

which they noticed the environmental impacts of walking off-trail. Respondents were asked if they had noticed trailhead and trailside signage and if so, to briefly describe the major messages presented by the signs. The vast majority of respondents for all of the treatments reported seeing the trailhead signs. Only about half of respondents reported seeing trailside signs except for treatment 3 that used prompter signs at visitor-created trails, for which 87.4% of visitors reported seeing trailside signs. However, most respondents could not accurately recall important and relevant themes of the content of the messages provided. Less than 30% of respondents for all treatments recalled that signage described the fragile character of the summit environment, the need to protect this environment, and management guidelines for visitors to remain on the paved trail (or rock surfaces).

Respondents were also asked if they noticed any damage to soils and/or vegetation on the summit and, if so, how severe would they rate this damage (Table 6). In the control, only 20.4 % of respondents reported that they noticed any damage and most (81.4%) of the minority who did rated this damage as "minor." However, even under the treatments (where signage informed visitors of the environmental damage of walking off-trail and the resulting ecological impacts occurring on Cadillac Mountain), substantially less than half of respondents reported that they noticed any damage, and most of those who did rated this damage as minor. The treatment in place had a strong effect on the reported degree of perceived damage. Specifically, as treatments became more aggressive and direct, visitors tended to rate the damage as more severe.

Table 6. Visitor Awareness and Assessment of Damage to Soil and Vegetation

	Percent of Respondents				
Variable	Control 1	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Aware	20.4	40.0	34.0	36.4	36.7
Assessment of severity:					
Minor	81.4	54.0	52.3	47.2	34.6
Moderate	18.6	42.0	39.5	45.3	48.1
Severe	0.0	4.0	8.1	7.5	17.3

Support for Management Actions

A final battery of questions asked respondents to report whether or not they would find a range of management practices acceptable for preventing damage to soils and vegetation on the summit of Cadillac Mountain (Table 7). These management practices were designed to present a full spectrum of approaches that ranged from indirect to direct, and this is the general order of these management practices as shown in Table 7 and in the questionnaire. For all respondents (regardless of whether they experienced control or treatment conditions) indirect management practices received the highest acceptability ratings and direct management practices received the lowest acceptability

Table 7. Acceptability of Management Practices

Management Practice	Percentage of respondents who support management practice
Educational signs about the damage that can be caused by walking on soils and vegetation	96.5
Signs asking visitors to stay on the paved summit loop trail or bare rock surfaces	94.2
Require visitors to not cross fenced boundaries	94.1
Signs asking visitors to stay on the paved summit loop trail	91.2
Require visitors to stay on the paved summit loop trail or bare rock surfaces	88.7
Pave the summit loop trail	87.6
Prohibit picking blueberries (to discourage visitors from walking off the paved summit loop trail)	85.9
Require visitors to stay on the paved summit loop trail	80.4
Prohibit picnicking (to discourage visitors from walking off the paved summit loop trail)	74.3
Station rangers on the summit to keep visitors on the paved summit loop trail	73.6
Fine visitors for walking off the paved summit loop trail	37.6
Allow walking on the summit only in ranger-led groups	26.1
Require visitors to travel to the summit in busses on which visitors would be told the importance of staying on the paved summit loop trail	23.9
Limit the number of visitors to the summit	21.5
Prohibit all visitors from walking anywhere on the summit (but allow visitors to drive to the summit)	8.2
Completely prohibit all visitor access to the summit	5.5

ratings. For example, informational/educational signage was judged as acceptable by over 90% of all respondents, whereas more restrictive management approaches (e.g., fining visitors for walking off-trail, limiting visitor use) were not acceptable to the majority of respondents. It is interesting to note that the percentage of respondents that found nearly all of these management practices acceptable tended to increase as they experienced some of these management practices in the study treatments.

Discussion

Most of the management practices (in the form of experimental treatments) applied in this study were effective in reducing the percentage of visitors who walk off-trail on the summit of Cadillac Mountain (as measured by direct observation and visitor self-reports). Without any of these management practices in place, nearly three-quarters (73.7%) of visitors were observed to walk off the paved trail. It is important

to emphasize that even the controls included several management treatments designed to encourage visitors to limit the areal extent of their walking and associated impacts. A paved trail was provided, coping stones had been placed along the margin of the trail in strategic places, and fenced exclosures were placed around several large patches of remaining vegetation. Most of the indirect and direct management practices applied in this study reduced the percentage of visitors who walked off-trail to a statistically significant degree.

The direct management practice of fencing the trail was substantially more effective than the indirect management practices. This finding tends to be generally corroborated in the literature (Hammitt & Cole, 1998; Cole, et al., 1987; McAvoy & Dustin, 1983). Moreover, the most aggressive application of indirect management practices (treatment 3) was found to be more effective than less aggressive applications (treatments 1 and 2).

Based on study findings, it is unlikely that indirect management practices will substantially reduce the environmental impacts of visitor use on the summit of Cadillac Mountain. The most effective indirect management practice applied in this study (treatment 3 – a relatively aggressive information/education signage program) reduced the observed percentage of visitors walking off-trail to 24.3. However, given the visitor use levels on the summit of Cadillac Mountain (as many as 5,500 visitors per day), reducing the percentage of visitors who walk off-trail to 24.3 would still result in well over a thousand visitors walking off-trail per day. Given the fragile environment of this area, and the findings from the recreation ecology literature that many ecological impacts caused by visitor use tend to occur quickly even under relatively light levels of use, damage to soils and vegetation at the study area will likely continue to grow in extent and severity under a management regime based on indirect practices.

These findings are important because the information/education treatments applied in the study were designed in concert with several principles for their application that have emerged from the professional literature (Manning, 2003). For example, the reasons why visitors should not walk off-trail in this area were included in the messages delivered to visitors, the messages were delivered multiple times, the messages were delivered in both writing (on signs) and in person (by tour bus drivers), and the messages were delivered before visitors arrived on site (on tour busses).

With regard to personal delivery of messages by tour bus drivers, it's possible that this source of information was not considered sufficiently authoritative by visitors. Communication theory suggests that non-substantive elements of information and education messages, such as message source and medium, can be important in determining effectiveness (Roggenbuck, 1992). These types of considerations are sometimes referred to as "the peripheral route to persuasion." If the message about walking off-trail had been delivered by a more authoritative source, such as a uniformed park ranger, it might have been more effective.

Study findings may be suggestive of other issues that might lead to more effective management practices. For example, visitors spent little time reading signs. As noted earlier, this might be exacerbated by visitor crowding around signs. This issue might be factored in as part of the process of considering appropriate use levels (i.e., carrying capacities) of parks and recreation areas. There was also evidence from both the observational and survey components of the study that some visitors walked off-trail

to pass large numbers of other visitors who had stopped on the trail or were moving very slowly. That is, trail width becomes important relative to allowed use levels. This might be another reason to link the conventional social and ecological dimensions of carrying capacity and park management more broadly (Manning, 1999).

Limited attention of visitors to signs might also be related to the fact that most visitors allocate only a short time to spend at sites like the summit of Cadillac Mountain, and they prefer to spend this time seeing the area rather than reading signs. This suggests that information/education might be delivered with more effect before visitors arrive on site. The park's visitor center, interpretive programs, brochures delivered at the park entrance gate, and announcements on the park's shuttle bus system offer some possible alternatives.

Compared to the observational data, visitors tended to under-report instances of walking off-trail, especially during the study treatments. There may be several reasons to explain this under-reporting, including social desirability bias and honest confusion over what constitutes "walking off-trail." However, these results suggest that it may be wise to at least spot-check self-reports of visitor behavior through observation.

Both observational and survey data suggest that many visitors who walk off-trail are not highly directed in this activity and are simply "exploring" and "searching for better views." This suggests that walking off-trail might be addressed by providing more maintained trails in the summit area to help satisfy the urge of many visitors to "roam." These additional trails would, of course, impact existing soil and vegetation, but might ultimately result in less impact than the current situation. Visitors might also be told more explicitly that there are other areas in the park that are more appropriate (i.e., more ecologically resistant and resilient, less heavily used) for informal exploration.

Some visitors walked off-trail to find a preferred site to take a picture. This suggests that it may be useful to incorporate short spurs along the paved summit loop trail that are posted as "photo points." This would offer visitors opportunities to take good pictures (and pictures without other visitors in the field of view if these photo points are well located and designed) while lessening their need to walk off the paved trail.

Messages concerning appropriate visitor behavior might be targeted more directly at individuals and groups that are more likely to be problematic. In this study, it was found that family and friendship groups (as opposed to couples) were more likely to walk off-trail. Previous research at this site found that children, while making up only 14% of all visitors, are responsible for "a higher relative level of off-trail behaviors" (Baldwin & LaPage, 2003). Park staff stationed at the summit could focus their personal contacts on these groups.

Study findings suggest that there can be a synergy of management practices. For example, adding "prompter" signs at key locations along the trail (treatment 3) to signs at the trailhead (treatment 2) reduced walking off-trail significantly: x^2 (1, N = 362) = 86.928, $p < 0.001$. Moreover, fencing at the beginning of the trail (treatment 4) dramatically reduced the percentage of visitors who stepped over the coping stones that defined the margin of the trail. When the fencing treatment was applied (treatment 4), only 4.8% of visitors were observed stepping over coping stones beyond the fencing to leave the trail. However, when treatments 1 and 2 were applied, over 20% of visitors stepped over the coping stones. Furthermore, the management practices applied in this study (and management practices more broadly considered) can (and probably should)

be used in a complementary manner. For example, fencing was found to be highly effective in reducing walking off-trail, but the educational signage employed in other treatments explains to visitors why it is important to remain on the trail, and these two management approaches can be seen to work in a complementary manner, leading to a greater level of effectiveness than either practice could attain independently. More generally, these findings suggest that a unity of management messages—a variety of management practices that offer a consistent message—may maximize effectiveness.

A potentially important finding from the observational component of the study concerns the positive relationship between walking off-trail and the number of visitors off-trail. Seeing visitors off-trail may offer license to other visitors to walk off-trail. To the extent this is true, it suggests the possibility of a downward spiral in visitor behavior and associated impacts. It also reinforces the importance of keeping visitors on the trail.

As described earlier in this paper, it has been suggested in the literature that the type of recreation management problem can influence the potential effectiveness of information/ education as a management practice. Very high percentages of survey respondents reported that the reasons they walked off-trail generally corresponded to illegal and unavoidable types of problem behaviors as described in the literature. This suggests that information/education (and perhaps other types of indirect management practices) are unlikely to fully address these problems. Moreover, even a majority of respondents reported illegal types of problem behaviors under the management practice of fencing (treatment 4)—a very direct management practice. This suggests that more aggressive management practices, perhaps in the form of enforcement, may ultimately be required. Many respondents also reported that their reasons for walking off-trail fell into the "careless", "unskilled", or "uninformed" categories of problem behaviors, and these may be more amenable to information/education (and other indirect approaches). However, all of these respondents who were surveyed during all of the management treatments had been exposed to information/education practices of varying intensity. Yet many of them walked off-trail.

It has also been suggested in the literature that visitors may operate at a variety of stages of moral development, and that this might help guide the application of information/education programs and other management practices. Visitors who did not walk off-trail (as defined by their self-reports) reported that their behavior in this regard was guided most strongly by reasons of postconventional morality (i.e., issues of altruism, fairness, and justice). This suggests that information/education programs should be designed to emphasize this type of rationale. However, it is also important to note that many visitors walked off-trail despite the information/education program that was applied. This may suggest that many visitors do not necessarily operate (at least in this context) at such high levels of moral development, and that, therefore, informational/ educational messages should be designed and delivered on a variety of moral planes.

Most visitors who were exposed to the management treatments reported remembering trailhead signs (but not trailside signs). However, most could not recall the relevant content of these signs. These findings suggest potentially important limitations to the effectiveness of information/education-based management practices. Moreover, most respondents were generally unaware of the environmental impacts that have occurred on the summit of Cadillac Mountain, and, if they are aware, judge these impacts

as minor. Exposure to management treatments increased the percentage of respondents who noticed visitor-caused damage to soil and vegetation. However, only a minority of respondents perceived these impacts even under treatment conditions. This lack of visitor awareness of impacts is in stark contrast to more objective, informed descriptions of the environmental conditions on the summit of Cadillac Mountain in which such impacts are considered serious (Turner & LaPage, 2001).
Moreover, it suggests that managers have a great deal of work to do to educate visitors about this issue, and/or that managers will have to take more direct management actions to address this problem even though visitors are generally unaware of this problem and may therefore not support such actions. Both of these tasks are likely to be challenging.

As might have been expected, respondents to the survey tended to support management actions to address walking off-trail that were indirect in nature, and tended to oppose actions that were more direct. However, respondents who had been exposed to the range of indirect and direct management practices included in the experimental treatments tended to be more supportive of the full range of management actions. This suggests that visitors might initially be reluctant to support management practices they have not experienced, but that these management actions are less objectionable when they are applied and actually experienced.

Implications for Managers

Findings from the observational and survey components of this study support several conclusions. It is unlikely that indirect management practices such as information/ education will satisfactorily solve the problem of visitors walking off-trail at the summit of Cadillac Mountain (and similar sites with relatively fragile natural environments and relatively high visitor use). Information/education-based management practices of increasing intensity, designed on the basis of principles derived from communication theory and the related professional literature, did not reduce the percentage of visitors walking off-trail to a sufficient degree that they are likely to reverse the trend of increasing resource degradation. This is because visitor use levels are so high at this site, soil and vegetation are so fragile, and the types of resource impacts experienced tend to occur relatively quickly even under light levels of use. This problem is exacerbated by the fact that the reasons many visitors walk off-trail can be classified as illegal or unavoidable and information/education programs (or other indirect management practices) may not be well suited to addressing these behaviors. Even the direct management practice of fencing the paved trail had limited effectiveness beyond its immediate extent (the first 150 feet of trail). Moreover, even though all of the treatments involved information/education about the impacts that are occurring on Cadillac Mountain, the fragile character of the environment, the need to protect this environment, and the impacts of visitors walking off-trail, most visitors could not remember these messages and noticed little or no visitor-caused impacts. And, of course, many visitors continued to walk off-trail.

Based on these and related study findings, we recommend that an integrated suite of direct and indirect management practices be implemented on the summit of Cadillac Mountain. The NPS should require that visitors remain on the paved summit loop trail. Moreover, the summit loop trail could be fenced, though this fencing might be of the symbolic type (i.e., low-lying, as unobtrusive as possible).

Further, uniformed rangers should be used to enforce (as needed) the regulation to stay on the paved trail. Consideration should also be given to redesigning the paved summit loop trail to extend it, to widen it in key places (e.g., where information/education signs are posted, where visitors tend to congregate), and to include a system of short spur trails to key photo points. This program of direct management practices should be complemented with a program of aggressive indirect management practices designed to inform visitors of the regulation to stay on the paved trail and the reasons for this regulation. Included in these messages should be identification of opportunities in the park where more informal exploration is allowed or even encouraged. This suite of management practices draws from the broad spectrum of management strategies and tactics outlined earlier in this paper, and is directly supported by the array of study findings.

Of course, such a program of management should be tested for its effectiveness with a program of research much like the study described in this paper. Off-trail walking and its environmental impacts should be monitored and management adjusted and refined as resulting data indicate. Surveys to explore how visitors react to these management practices should be included in this program of research. This approach is in keeping with the emerging concept of adaptive management that is increasingly being applied in multiple applications of contemporary environmental management (Lee, 1993; Stankey, Clark, & Bormann, 2005).

We also recommend that the management approaches described above be implemented as part of a larger analysis of the carrying capacity of Cadillac Mountain. Moreover, this analysis should include both resource and social components, and the potential interrelationships between these components. In particular, there are some indications that visitor use levels may be contributing to the problem of visitors walking off-trail. Specific examples include large number of visitors blocking park signage (designed to help address the issue of visitors walking off-trail) and some visitors having to walk off-trail because of congestion along the paved trail. The latter issue is especially important as study findings suggest that seeing visitors off-trail may "give license" to visitors to do the same. These types of issues should be considered when analyzing the maximum acceptable level of visitor use on the summit of the mountain.

The NPS, like most park and outdoor recreation management agencies, is charged with a) protecting significant environmental resources, and b) providing opportunities for public enjoyment and appreciation. Where public demand for parks is high, there can be tension between these two objectives. The summit of Cadillac Mountain is a quintessential manifestation of this tension. Under ideal conditions, visitor-caused impacts to park resources could be satisfactorily addressed through indirect management practices that maintain high levels of visitor freedom. However, research in general, and this study in particular, suggests that this may not be possible. In such cases—and we believe the summit of Cadillac Mountain is one of these cases—some degree of visitor freedom will have to be sacrificed to ensure protection of important park resources. Without a strong program of management that includes forceful, direct practices in combination with complementary indirect practices, large numbers of visitors will continue to walk off-trail on the summit of Cadillac Mountain and associated environmental impacts will continue to expand in extent and severity. As suggested in this study, visitors who walk off-trail will give license to other visitors to walk off-trail,

and this will lead to a downward spiral in which park resources will continue to be degraded. Ultimately, the quality of the visitor experience may also be compromised as a function of the aesthetic implications of these resource impacts. We are persuaded that an emerging principle of park and outdoor recreation management—intensive use of parks and outdoor recreation areas requires intensive management—will need wider application as visitor use levels and associated impacts continue to increase in national parks and related outdoor recreation areas.

We believe the combination of research approaches used in this study—a series of experiments with complementary controls, direct observation of visitor behavior, and follow-up surveys of visitors—was effective in exploring multiple dimensions of the issue of visitors walking off-trail and resulting environmental degradation. The observational component of the study made direct measurements of visitor behavior under control conditions and as visitors reacted to experimental management treatments. The survey component of the study explored how and why management treatments affected visitor decision making and associated behavior, including the acceptability of a range of management practices to visitors. In these ways, the research methods used in the study were complementary by drawing on their respective strengths.

Findings from the multiple methods were also reinforcing, and in this way they offer a check on the validity of study findings. For example, both observation and visitor surveys illustrate the magnitude of the problem of visitors walking off-trail, though visitors tended to underreport this activity. Visitors tended to spend little time reading information/education signage, and this was reflected in their general lack of knowledge of the issue of walking off-trail and the resource-related problems it causes. Both observation and the visitor surveys suggest that many visitors walk off the trail to explore, to find better photo points, and to avoid other groups, and these findings are suggestive of related management practices, including expanding the trail system, identifying other areas in the park that are more appropriate for exploration, adding key photo points to the trail system, and widening the trail in strategic locations.

We should also note some potential limitations of the study and implications for future research. First, the professional literature in parks and outdoor recreation suggests that there is a range of management practices available as defined by both strategies and tactics. However, this study employed only five management practices, four of which were oriented primarily toward information/education. More study is clearly warranted to test the effectiveness of a fuller range of management practices. Second, the two methodological components of the study (observation and the visitor surveys) did not necessarily (and probably in most cases did not) study the same visitors. Because the samples of visitors included in both components of the study were randomly selected (and were therefore representative of all visitors), we do not feel this affected study findings. However, surveying the visitors who were observed may have been a more powerful research design. Unfortunately, the logistics of doing this would have been considerably more time consuming and expensive. Finally, the observational component of the study required a relatively large staff and was time consuming (a staff member was needed to observe each visitor included in the study and the period of observation sometimes extended to a half hour or more). Moreover, using large numbers of observers

presents potential problems of reliability which were not fully addressed in this study. Future research of this nature should explore the feasibility of using technology such as global positioning system (GPS) units to track and record visitor behavior.

References

Abbe, J. D., & Manning, R. E. (2007). Wilderness day use: Patterns, impacts, and management. *International Journal of Wilderness. 13*(2), 21-25, 38.

Alpert, L., & Herrington, L. (1998). An interactive information kiosk for the Adirondack Park visitor interpretive center, *Proceedings of the 1997 North eastern Recreation Research Symposium*. USDA Forest Service General Technical Report NE-241, 265-267.

Anderson, M. A., Stewart, M. H., Yates, M. V., & Gerba, C. P. (1998). Modeling the impact of body-contact recreation on pathogen concentrations in a source drinking water reservoir. *Water Research, 32*(11), 3293-3306.

Baldwin, E., & LaPage, W. (2003). Visitor behaviors and resource impacts at Cadillac Mountain Acadia National Park, part II: Sign comparison study summer 2002. Technical report for Acadia National Park Natural Resources Division.

Burrus-Bammel, L. L., & Bammel, G. (1984). Applications of unobtrusive methods. In J. D. Peine (Ed.), *Proceedings of a workshop on unobtrusive techniques to study social behavior in parks*. National Park Service Southeast Regional Office, Natural Science and Research Division.

Chavez, D. J. (1996). *Mountain biking: Issues and actions for USDA Forest Service managers.* Research Paper PSW-RP-226. Albany, California: Pacific Southwest Research Station, USDA Forest Service.

Christensen, H., & Dustin, D. (1989). Reaching recreationists at different levels of moral development. *Journal of Park and Recreation Administration, 7*, 72-80.

Cole, D., Petersen, M., & Lucas, R. (1987). Managing wilderness recreation use: Common problems and potential solutions. USDA Forest Service Gen. Tech. Rpt. INT-230. 60 pp.

Evans, C. B. (2002). *Summit steward 2002 season report.* Acadia National Park.

Frissell, S. S., & Duncan, D. P. (1965). Campsite preference and deterioration in the Quetico-Superior canoe country. *Journal of Forestry, 65*, 256-260.

Gilligan, C. (1982). *In a different voice.* Cambridge, MA: Harvard University Press.

Godbey, G. (1984). Some reactions to nonreactive research in park and recreation settings. *Proceedings of a Workshop on Unobtrusive Techniques to Study Social Behavior in Parks*. U.S. Department of the Interior, National Park Service, Southeast Regional Office, Natural Science and Research Division.

Gramann, J.H., & Vander Stoep, G.A. (1987). Prosocial behavior theory and natural resource protection: a conceptual synthesis. *Journal of Environmental Management. 24*, 247.

Hammitt, W. E., & Cole, D. N. (1998). *Wildland recreation: Ecology and management* (2nd ed.). New York: Wiley and Sons, Inc.

Harmon, D. (1992). Using an interactive computer program to communicate with the wilderness visitor. *Proceedings of the Symposium on Social Aspects and Recreation Research*. USDA Forest Service General Technical Report PSW-132, 60.

Hendee J.C., & Dawson C.P. (2003). *Wilderness management: Stewardship and protection of resources and values* (3rd ed.). Golden: Fulcrum Publishing.

Kohlberg, L. (1976). Moral stages and moral development. *Moral development and behavior: Theory research and social issues*. New York: Holt, Rinehart, and Winston.

Lee, K.N. (1993). *Compass and gyroscope: Integrating science and politics for the environmen*t. Washington, D.C.: Island Press.

Lime, D. W. (1977). Research for river recreation planning and management. In *Proceedings: River Recreation Management and Research Symposium January 24-27*. Gen. Tech. Rpt. NC-28. Minneapolis: USDA Forest Service North Central Experiment Station.

Manning, R. E. (1979). Impacts of recreation on riparian soils and vegetation. *Water Resources Bulletin, 15*(1), 30-43.

Manning, R. E. (1999). *Studies in outdoor recreation: Search and research for satisfaction* (2nd ed.). Corvallis, OR: Oregon State University Press.

Manning, R. E. (2003). Emerging principles for using information/education in wilderness management. In *Reconstructing conservation: Finding common ground* (pp. 335-349). Washington, D. C.: Island Press.

Marion, J.L., & Leung, Y.F. (2001). Trail resource impacts and an examination of alternative assessment. *Journal of Park and Recreation Administration, 19*(3), 17-37.

Marion, J. L., Roggenbuck, J.W., & Manning, R.E. (1993). *Problems and practices in backcountry recreation management: a survey of National Park Service managers*. U.S. Department of the Interior, National Park Service, Natural Resources Report NPS/NRVT/NRR-93/12.

McAvoy, L.H., & Dustin, D.L. (1983). Indirect versus direct regulation of recreation behavior. *Journal of Park and Recreation Administration, 1*(4), 12–17.

McCool, S.F., & Christensen, N.A. (1996). Alleviating congestion in parks and recreation areas through direct management of visitor behavior. In D.W. Lime (Ed.), *Congestion and crowding in the National Park System: Guidelines for management and research.* (MAES Misc. Pub. 86-1996). St. Paul, MN: Department of Forest Resources and Minnesota Agricultural Experiment Station, University of Minnesota.

National Park Service. (2007). NPS visitation database – park report. Retrieved September 25, 2007 from http://www2.nature.nps.gov/NPstats/select_reportcfm?by=parktype

The National Park Service Organic Act. § 1, 16 U.S.C. § l-4 (1916).

Peterson, G., & Lime, D. (1979). People and their behavior: A hallenge for recreation management. *Journal of Forestry, 77*, 343–346.

Roggenbuck, J. W. (1992). Use of persuasion to reduce resource impacts and visitor conflicts. In M. Manfredo, (Ed.), Influencing human behavior. Champaign,IL: Sagamore.

Roggenbuck, J., & Berrier, D. (1982). A comparison of the effectiveness of two communication strategies in dispersing wildlife campers. *Journal of Leisure Research, 14*, 77-89.

Shindler, B., & Shelby, B. (1993). Regulating wilderness use: an Investigation of user group support. *Journal of Forestry, 91*(22), 41-44.

Stankey, G. H., Clark, R. N., & Bormann, B. T. (2005). *Adaptive management of natural resources: Theory, concepts, and management institutions.* General Technical Report PNW-GTR-654. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Swearingen, T. C., & Johnson, D. R. (1995). Visitors' responses to uniformed park employees. *Journal of Park and Recreation Administration, 13*(1), 73– 85.

Turner, R., & LaPage, W. (2001). *Visitor behaviors and resource impacts at Cadillac Mountain, Acadia National Park.* United States Department of the Interior. Cooperative Agreement 1443CA4520-A-0015.

Vander Stoep, G., & Roggenbuck, J. W. (1996). Is your park being "loved to death?": Using communication and other indirect techniques to battle the park "lovebug." *Crowding and Congestion in the National Park System: Guidelines for Research and Management*. St. Paul, MN: University of Minnesota Agricultural Experiment Station Publication 86-1996, 85-132.