MANAGING RECREATION ON MOUNTAIN SUMMITS IN THE NORTHERN FOREST REGION OF MAINE, NEW HAMPSHIRE, NEW YORK, AND VERMONT

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Abstract.—Land managers in the Northern Forest region of Maine, New Hampshire, New York, and Vermont face the challenge of providing high-quality recreation opportunities and experiences while also protecting fragile summit resources. The goals of this study were to identify indicators and standards of quality for visitor experiences and summit resources for three mountains with a range of recreation opportunities. Crowding, trail condition, damage to summit soils and vegetation, and type and level of management were found to be important indicators of quality. A visitor survey identified the social, resource, and management conditions that visitors find minimally acceptable. An assessment of summit resources quantified relative cover of vegetation, exposed soil, lichens, and bedrock. Overall, visitors to the three summits reported having high-quality recreation experiences. However, resource conditions on two summits were below what visitors find minimally acceptable. The management implications related to using a monitoring system are discussed.

1.0 INTRODUCTION

Mountains are highly valued resources for recreation and tourism (Godde et al. 2000) and provide a wide range of recreation opportunities. However, mountains are also ecologically fragile and highly susceptible to recreation disturbance and adverse impacts (Hammitt and Cole 1998, Monz 2000, Slack and Bell 2006), including loss of vegetation cover, soil exposure, and soil erosion (Billings 1973, Ketchledge et al. 1985, Larson 2004). In addition to ecological impacts, high visitation rates at mountain summits can threaten the quality of the recreation experience. Crowding, conflict, and resource impacts can detract from the quality of the visitor experience (Manning et al. 2004, Manning 2007). The challenge facing managers of mountain summits is balancing recreation opportunities and resource protection.

The concept of carrying capacity and its related frameworks can prove useful in guiding management of recreation on Northern Forest mountain summits. Frameworks such as Limits of Acceptable Change (Stankey et al. 1985) and Visitor Experience and Resource Protection (National Park Service 1997) rely on formulating indicators and standards of quality for resource and social/experiential conditions that reflect management objectives. Management objectives are statements that define the desired resource and social conditions within a park or protected area. Indicators of quality are measurable variables that serve as proxies for management objectives. Standards of quality define the minimum acceptable condition of indicator variables. This study was designed to help guide the formulation of indicators and standards of quality for resource conditions and the recreation experience for a spectrum of mountain summits in the Northern Forest.

2.0 METHODS

2.1 Selection of Study Sites

We adapted and applied Clark and Stankey's (1979) Recreation Opportunity Spectrum (ROS) to mountain summits. We created a spectrum of four mountain recreation opportunity settings based on five criteria: access, use level, recreational uses, management presence, and level of development. The spectrum ranged from "primitive" summits to "developed" sites. We compiled a list of 153 summits in the Northern Forest region of Maine, New Hampshire, New York, and Vermont. Individuals from management agencies and user groups from the four states evaluated summits according to the mountain summit ROS. The final study sites represented

different points along the spectrum. Cadillac Mountain in Acadia National Park, Maine, was chosen to represent the "developed" end of the spectrum; Cascade in the Adirondack State Park, New York, was chosen to represent the "primitive" end of the spectrum; and Camel's Hump in Camel's Hump State Park, Vermont, represented the middle of the spectrum.

2.2 Visitor Survey

We surveyed a representative sample of visitors at each study site using an on-site questionnaire during the 2008 summer and fall hiking season (July - October). The first section of the questionnaire focused on identifying potential indicators of quality and included a series of open- and close-ended questions. Open-ended questions asked visitors what they enjoyed most and least about their experience at the summit, and what they would like managers to change. Close-ended questions asked visitors to rate the importance of several issues or problems at the summit they visited. The second section of the questionnaire focused on identifying standards of quality and asked visitors to rate the acceptability of a range of resource, social, and management conditions. These questions reflected normative theory and methods (Manning 1985, Vaske et al. 1986, Shelby and Vaske 1991,;; Vaske and Whittaker 2004), and used visual and long- and short-question formats (Manning et al. 1999, Manning and Freimund 2004). The following six indicator variables were addressed: 1) number of people on the trail, 2) number of people off the trail, 3) impact to the trail corridor, 4) impact to summit resources, 5) level of trail development, and 6) management tactics designed to discourage off-trail hiking. Visitors completed 476 questionnaires (Cascade n = 126; Camel's Hump n = 157; Cadillac Mountain n = 193) with an overall response rate of 83 percent. We conducted analysis of variance (ANOVA) tests to detect differences in the acceptability of impacts and intensity of management across the spectrum of summits.

2.3 Resource Assessment

We adapted and applied methods used in campsite impact assessments (Leung and Marion 2000) and range management (Booth and Cox 2008) to measure ground cover on mountain summits. We used a grid transect method to sample a representative area of each summit. We manually analyzed overhead digital photographs of 1-m^2 plots using SamplePoint (Booth et al. 2006) to quantify relative cover of vegetation, exposed soil, bare rock, and lichens. We ran ANOVAs to identify significant differences in resource condition among the three summits.

3.0 RESULTS

3.1 Indicators of Quality

Analysis of the visitor survey data identified trail condition, crowding, summit management techniques, and damage to vegetation and soils on and off the trail as important indicators of quality for recreation on mountain summits.

3.2 Standards of Quality

The survey asked respondents a series of questions to help identify standards of quality for the indicator variables discussed above. Visitors then viewed a series of six computer-generated photographs showing a range of social, resource, and management conditions and evaluated the acceptability of each condition. Acceptability was measured on a 9-point scale ranging from -4 ("Very Unacceptable") to +4 ("Very Acceptable"). Average acceptability ratings were calculated for each summit and plotted to form a social norm curve. Respondents also indicated which photographs most closely represented the conditions they encountered during their summit visit.

The first series of five photographs depicted increasing numbers of people along a section of the summit trail. See Table 1 for a summary of visitor responses to this battery of questions. Some significant differences emerged in how respondents viewed increasing levels of use. Overall, visitors to Cadillac Mountain were more tolerant of higher use levels than visitors to Cascade or Camel's Hump.

The second set of questions included five photographs showing increasing numbers of off-trail hikers. Visitors to Cadillac Mountain, Camel's Hump, and Cascade displayed strikingly similar norms regarding the acceptability of off-trail use (Fig. 1). There were no

Table 1.—Summary of respondents' assessments of on-trail use levels

Use Level	Cascade (n = 117-124)	Camel's Hump (n = 143-156)	Cadillac (n = 177-192)	ANOVA	
	Mean	Mean	Mean	F-value	p-value
0 people	3.56	3.67	3.38	1.722	.180
9 people	2.68[a]	2.14[a,b]	3.10[b]	13.474	< .001
18 people	1.08[c]	0.63[b]	1.85[b,c]	13.051	< .001
27 people	-0.73[c]	-0.93[b]	0.13[b,c]	9.479	< .001
36 people	-2.38[c]	-2.47[b]	-1.51[b,c]	8.918	< .001
Acceptability	23.37	21.63	27.71	-	-
Typically Seen	13.59[a,c]	10.71[a,b]	19.08[b,c]	43.367	< .001

Any two summits that share a superscript are significantly different ($p \leq .05$) according to Bonferroni's least significant difference test.

significant differences in the average acceptability of increasing off-trail use. Visitors to Cascade and Cadillac Mountain found a maximum of approximately 17 people off-trail to be acceptable, while at Camel's Hump the maximum was about 15. Respondents at Cadillac Mountain reported seeing significantly higher levels of off-trail use than did hikers on the other summits ($F = 9.593$; $p < .001$). Hikers at Cascade typically saw 11 people off-trail, hikers on Camel's Hump observed approximately 10, and hikers at Cadillac Mountain saw about 14 people off the designated trail.

Next, respondents viewed a series of five photographs showing increasing levels of impact to the trail corridor (e.g., trail widening, root exposure, soil erosion). Again, the norms displayed by visitors at the different summits were remarkably similar (Fig. 2). The amplitudes of the social norm curves are relatively low, indicating that trail impact was not highly salient to visitors.

However, this result contradicts responses from the open-ended questions that showed trail condition to be an important indicator of quality. It is possible that visitors were unable to recognize the subtle changes in trail condition depicted in study photos. It is also possible that visitors simply did not identify any negative impact to the trails in the photos. Previous research has suggested that visitors' perception of environmental impacts resulting from recreational use tends to be limited, especially when compared to those of managers and trained observers (Farrell et al. 2001, Park et al. 2008). However, other research has suggested that visitors have normative standards for the environmental conditions they encounter in parks and protected areas, and that these resource impacts can be an important factor in defining the quality of the recreation experience (Manning et al. 2004). There were no significant differences among the study sites in the acceptability ratings given to study photographs, the maximum amount of trail impact acceptable, or the level of impact visitors typically saw.

The fourth survey question dealt with impacts to the summit area (e.g., vegetation cover loss, root exposure, soil erosion). Visitors viewed five photographs showing 90 percent, 75 percent, 50 percent, 25 percent, and 10 percent of the summit area with green plant cover. Figure 3 shows the resulting social norm curves. Respondents indicated that the minimum amount of vegetation cover that was acceptable was between 43 percent and 47 percent, and reported seeing relatively high levels of cover (62 percent at Cascade, 67 percent at Cadillac Mountain, and 72 percent at Camel's Hump). There were no significant differences in the acceptability of study photos among the study sites.

The fifth battery of questions concerned type and level of trail management. Three photographs presented to respondents showed 1) a "natural" bedrock and soil trail, 2) a trail with stepping stones placed in areas of bare soil, and 3) a paved trail. None of these received an overall average negative (or "unacceptable") rating at Cadillac Mountain. The paved trail received the highest average acceptability rating and the "natural" trail the lowest, with ratings of 1.9 and 1.2, respectively. At both

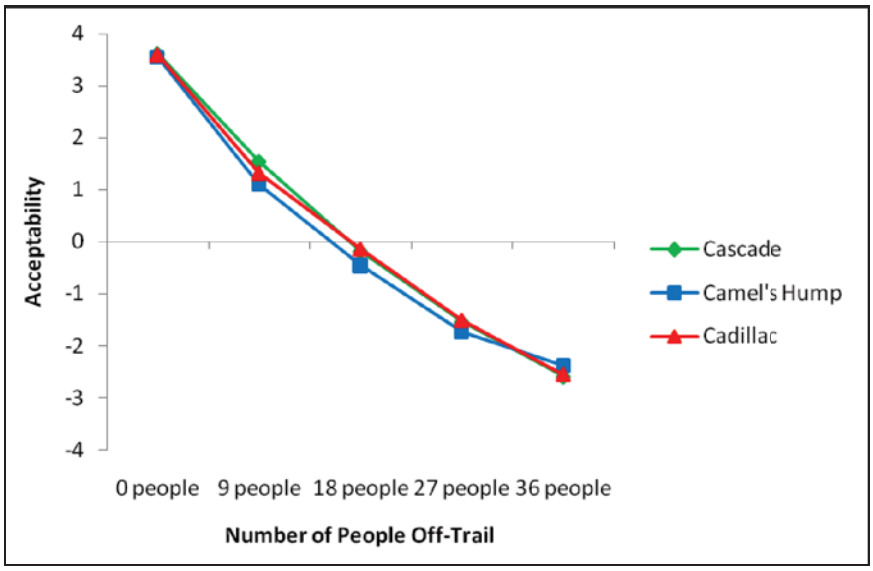

Figure 1.—Social norm curves for the acceptability of off-trail use levels.

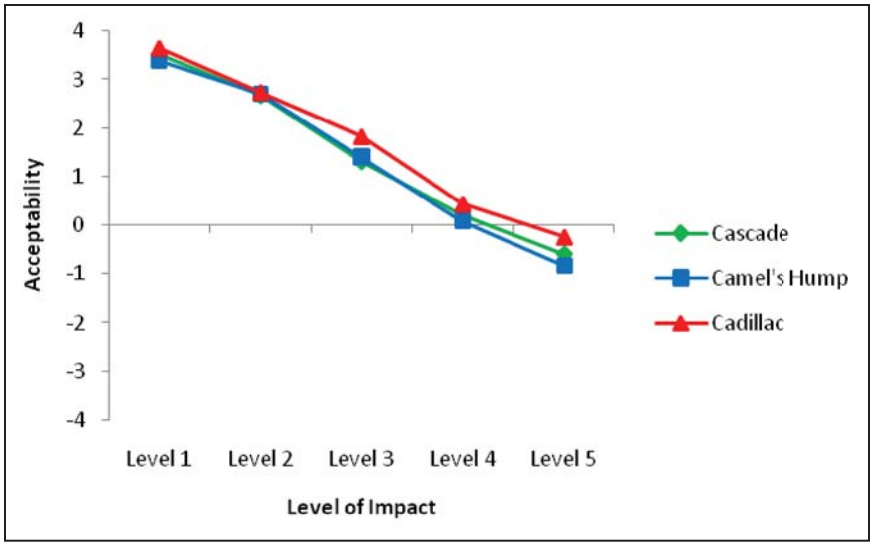

Figure 2.—Social norm curves for the acceptability of trail impacts.

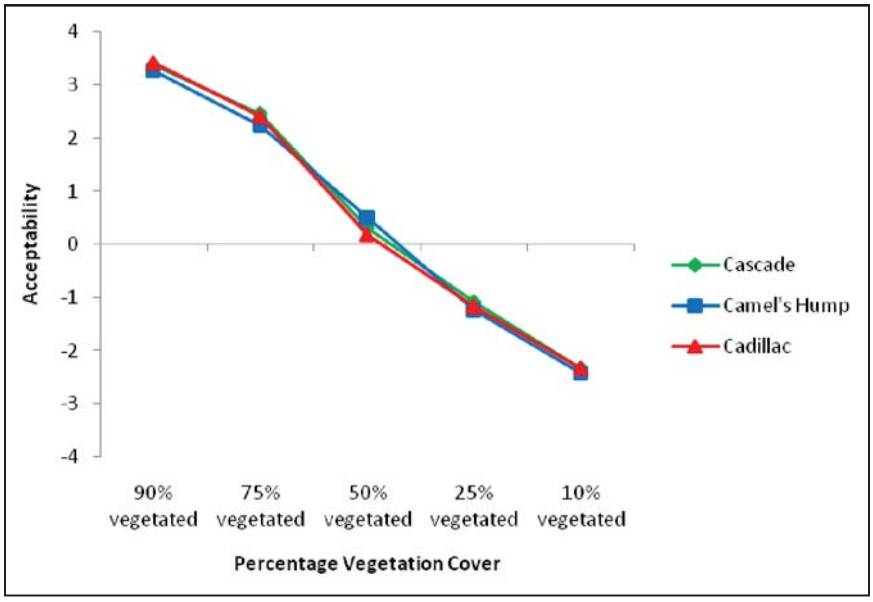

Figure 3.—Social norm curves for the acceptability of summit impacts.

Table 2.—Summary of respondents' assessments of visitor management tactics

Management Practice	Cascade (n = 117-124)	Camel's Hump (n = 143-156)	Cadillac (n = 177-192)	ANOVA	
	Mean	Mean	Mean	F-value	p-value
Cairns and Paint Blazes	3.11[c]	2.96[b]	1.55[b,c]	25.158	< .001
+ Sign	2.73	2.60	2.27	2.791	.062
+ Intermittent Scree Walls	1.77	1.74	1.63	.167	.846
+ Continuous Scree Wall	0.74	0.28[b]	1.19[b]	5.350	.005
+ Rope Fencing	-2.32[c]	-2.28[b]	-0.93[b,c]	14.196	< .001
Typically Seen	1.46[a,c]	2.17[a]	2.39[c]	23.708	< .001

Any two summits that share a superscript are significantly different (p ≤ .05) according to Bonferroni's least significant difference test.

Table 3.—Summary of land-cover analysis

Land Cover Class	Cascade	Camel's Hump	Cadillac	ANOVA F-value	ANOVA p-value
Vegetation	20.40[a,c]	44.25[a]	44.29[c]	32.879	< .001
Lichens	3.14[a,c]	32.70[a]	36.25[c]	116.557	< .001
Organic Soil	1.78[a,c]	0.52[a]	0.39[c]	11.047	< .001
Mineral Soil	4.72[a]	0.59[a,b]	6.73[b]	20.703	< .001
Bare Rock	68.45[a,c]	20.11[a,b]	11.27[b,c]	369.198	< .001
Vegetation	20.40[a,c]	44.25[a]	44.29[c]	32.879	< .001
Lichens	3.14[a,c]	32.70[a]	36.25[c]	116.557	< .001

Any two summits that share a superscript are significantly different (p ≤ .05) according to Bonferroni's least significant difference test.

Camel's Hump and Cascade, the "natural" trail received the highest overall acceptability rating (3.3 and 3.2, respectively), and the paved trail received a moderate negative rating (-2.3 and -2.2, respectively). Visitors to Cadillac Mountain rated the "natural" trail significantly less acceptable ($F = 52.107$; $p < .001$) and the paved trail significantly more acceptable ($F = 161.332$; $p < .001$) than visitors to Cascade and Camel's Hump. This response may be because the summit loop trail on Cadillac Mountain is paved.

Finally, visitors viewed a series of five photographs depicting increasingly intensive management practices designed to discourage off-trail hiking. Tactics shown in the study photographs were additive. The first photo showed rock cairns and paint blazes along the trail to guide hikers; the second photo added a sign asking hikers to stay on the trail; the third added intermittent scree (rock) walls lining areas of the trail adjacent to vegetation; the fourth added a continuous scree wall defining the margin of the trail; and the fifth photo added a rope fence to prevent visitors from leaving the trail. See Table 2 for a summary of respondent ratings for these photos. In general, as the intensity of the management actions increased, overall acceptability decreased. The one exception is Cadillac Mountain: visitors gave the highest rating to the photograph with the sign (photo #2 in the sequence). The rope fencing treatment was the only management strategy that received an overall negative acceptability rating. These results suggest that visitors to all three summits are willing to accept a variety of management practices that are designed to protect summit resources, so long as they are not overly obtrusive.

3.3 Current Ecological Conditions

The land cover analysis found a large amount of variation among the three summits. Table 3 presents a summary of the results. Significant differences occurred in the amount of vegetation cover, lichen cover, exposed soil, and bare rock across the spectrum of summits. Cascade had the lowest percent vegetation cover and the largest

amount of bare rock. Camel's Hump and Cadillac Mountain had similar relative vegetation cover on their summits, though Camel's Hump had significantly more bare rock. Camel's Hump had the lowest percent cover of exposed soil (1.1 percent of the summit area), while exposed soil accounted for 6.5 percent of the summit area on Cascade and 7.1 percent on Cadillac Mountain. Erosion is mostly to blame for the very high amount of exposed bedrock on Cascade. Although natural erosive forces are the main cause of soil loss, hiking also caused some of these impacts (Julia Goren, Adirondack High Peaks Summit Steward Program Coordinator, personal communication). Trampling of vegetation by hikers exposes the soil to wind and water, which quickly erode the thin soils (Ketchledge et al. 1985, Hammitt and Cole 1998). Hikers on Cascade continue to trample fragile vegetation and soils, and further losses are observable (Frank Kreuger, Adirondack High Peaks Summit steward, personal communication).

Cascade also differs dramatically from the other two summits with regard to its relative cover of lichens. The cause of the low lichen cover on Cascade is uncertain. Lichens are highly sensitive and vulnerable to sulfur dioxide and heavy metal concentrations associated with acid deposition (Larson 2004). The Adirondacks have suffered extensive damage from acid deposition (Driscoll et al. 2003), which may be the cause of Cascade's low lichen cover. Another possible explanation is the high rate of soil erosion that has occurred recently; lichens may not have not had the chance to recolonize the more recently exposed bedrock surfaces. However, there is also reason to suspect recreation as a factor. Examination of monitoring photo points on Cascade and observation of nearby mountains that have high lichen cover suggest that Cascade's lack of lichens may be due to hiking pressure (Julia Goren, personal communication), as hikers' boots and trekking poles can scuff lichens off the surface of the rock. Whatever the cause, the lack of lichen cover on the exposed bedrock at Cascade's summit is of great concern as lichens are critical to ecosystem functioning. Their ability to colonize exposed bedrock and to create and stabilize soils is important to the recovery of mountain ecosystems following disturbance (Larson 2004).

4.0 DISCUSSION AND CONCLUSIONS

Visitors to Cascade, Camel's Hump, and Cadillac mountains appear to be receiving high quality recreation experiences. Respondents reported encountering better than minimally acceptable conditions. They were also willing to tolerate a wide range of management tactics designed to protect summit resources. Highly intensive management was less acceptable than more subtle tactics, so managers should avoid using obtrusive practices unless absolutely necessary. Managers should also keep in mind that tactics that are acceptable at one site might not be acceptable in other contexts.

Some differences arose in the acceptability of certain conditions among summits located at different points along the mountain summit ROS. Specifically, there were differences in the acceptability of on-trail use levels, trail management techniques, and visitor management tactics. Visitors to all three summits exhibited very similar norms concerning off-trail use, trail conditions, and impacts to summit resources. There were some discrepancies between trail impact norms and responses to open-ended questions, suggesting that visitors may not have recognized impacts in the study photographs or did not consider these impacts unacceptable.

Interestingly, visitors reported seeing very high levels of vegetation cover and vastly overestimated actual summit conditions (Table 3). This result presents some interesting challenges for managers. On the one hand, summit resources at Camel's Hump are currently within the range of acceptable conditions identified by visitors; Cadillac Mountain's resource condition is slightly below the standard of acceptability; and current conditions on Cascade fall considerably short of the standard set by visitors. If managers at Cascade wish to provide conditions that are acceptable to visitors, they would need to exert considerable effort to restore the vegetation at the summit and work to bring conditions up to standard. The same is true at Cadillac Mountain, though a smaller improvement in the condition of summit resources would be needed. Likewise, managers at Camel's Hump must be mindful not to let conditions deteriorate.

On the other hand, respondents at all three sites reported seeing summit conditions that were much better than what they judged to be minimally acceptable. Laven et al. (2005) suggest that existing conditions at parks have little influence on the normative standards reported by visitors, and it appears that visitors derive their standards based on different factors. This observation seems to be true for visitors to the mountain summits in this study as well. Farrell et al. (2001) found that wilderness campers' perceptions of ecological impacts differed greatly from judgments made by trained field staff, and concluded: "Campers cannot, therefore, provide managers with accurate objective information about ecological impacts, as defined by recreation ecologists" (p. 247). Given the large differences between what visitors reported seeing during their visit and the extent of vegetation cover on the three summits as determined by digital image analysis, managers at Cadillac Mountain, Camel's Hump, and Cascade should be wary of giving too much weight to visitors' perceptions of the extent and severity of ecological impacts.

Monitoring is an increasingly important component of managing recreation and tourism on mountain summits in the Northern Forest. Indicators and standards of quality can be developed and employed to help define and manage high-quality recreation opportunities and experiences. The results of this study suggest that use levels, resource condition, and management practices are good indicators of quality for mountain recreation experiences. While the results presented in this paper represent a spectrum of mountain recreation opportunities found in the Northern Forest, the specific conclusions and management implications may not be directly transferable to other sites. Managers wishing to establish a recreation-monitoring program for mountain summits should conduct a program of research to develop appropriate and context-specific indicators and standards of quality.

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