Recreation Monitoring at Acadia National Park

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Introduction

Acadia National Park is one of the most intensively used national parks in the United States. While its annual visitation (2.2 million visits in 2004) does not rise to the levels of some of the "crown jewel" western national parks (Yellowstone National Park, for example, accommodated 2.9 million visits in 2004), visits to Acadia are concentrated on its comparatively small size of less than 50,000 acres. Yellowstone, by comparison, is spread across 2.2 million acres. Given the intensive character of visitor use at Acadia, it is vital to monitor recreational use and its associated impacts to help ensure protection of important park resources and the quality of the visitor experience.

Over the past decade, Acadia has undertaken an expanding program of recreation-related monitoring and associated activities. This program has been guided by the National Park Service (NPS) Visitor Experience and Resource Protection (VERP) framework (NPS 1997; Manning 2001). VERP was designed by the NPS to address carrying capacity and related recreation management issues. The underlying rationale of the VERP framework is to (1) define desired resource and social conditions in terms of empirically based indicators and standards, (2) monitor indicator variables, and (3) apply management actions to ensure that standards have been maintained. Thus, monitoring resource and social conditions at Acadia has become an important part of park planning and management.

This paper describes four aspects of the monitoring program applied to Acadia. First, a suite of indicators and associated standards was initially formulated to guide monitoring of the park's carriage road system. These indicators and standards give focus to the monitoring program, enhancing its efficiency and effectiveness. Second, computer-based simulation modeling has been used to help conduct the monitoring program. Simulation models can be used to estimate park conditions (as defined by indicator variables), reducing the need for on-the-ground monitoring, and can be used as a more "proactive" monitoring approach by estimating the maximum amount of visitor use that can be accommodated without violating standards. Third, several issues associated with monitoring on the carriage roads are described. These issues have arisen over several years of experience with this monitoring program. Finally, the recreation monitoring program at Acadia is expanding to address other areas of the park. A program of natural and social science research has been undertaken to help guide this monitoring. The final section of the paper briefly describes this program of research as it applies to resource-based impacts of recreation, including societal judgments about appropriate standards for such impacts.

Indicators and standards to guide monitoring

Parks are complex resource and social systems that can be characterized by a multitude of ecological and experiential variables. However, monitoring such variables can be time-consuming and expensive. Therefore, monitoring programs must be designed carefully to ensure that they focus on a relatively small number of indicator variables that best meet selected criteria or characteristics (Schomaker 1984; Stankey et al. 1985; Marion 1991; Merigliano 1990; Whittaker and Shelby 1992; National Park Service 1997; Manning 1999).

Moreover, within the context of the VERP framework, standards must be formulated for indicator variables. Standards are generally defined as the minimum acceptable condition of indicator variables (National Park Service 1997; Manning 1999). Standards provide vital reference points for monitoring programs. Within the VERP framework, standards are thresholds that define when and where management action is needed. Without such standards, findings from monitoring programs are difficult to interpret and provide little direct guidance to managers.

For these reasons, the recreation-related monitoring program at Acadia began with an effort to formulate a suite of indicators and standards. This work was initiated in the mid-1990s on the park's system of carriage roads (Manning et al. 1998; Jacobi and Manning 1999) and has expanded to include all major visitor use areas within the park. The initial application to the carriage roads will be used to illustrate this work.

The carriage roads, a system of more than 50 mi of unpaved roads constructed at the direction of John D. Rockefeller, Jr., in the early 1900s, represent one of the most significant resources in the park. Originally built for horse-drawn carriages, the carriage roads are now used primarily for hiking and biking and have become extremely popular. However, increased use has created concern for the quality of the recreation experience. In response to this concern, a program of research was initiated to help formulate indicators and standards for the carriage-road experience.

A first phase of research focused on identifying potential indicators. A survey of a representative sample of carriage road visitors was conducted. Using both open- and closed-ended questions, visitors were asked to report on what added to or detracted from the quality of their experience on the carriage roads. Two types of indicators were identified: one was crowding-related and concerned the number of visitors seen on the carriage roads; the other was conflict-related and addressed several "problem behaviors" experienced on the carriage roads, including bicycles passing from behind without warning, excessive bicycle speed, people obstructing the carriage roads by walking abreast or stopping in groups, and dogs being off leash.

The first phase of research also documented existing patterns of use on the carriage roads and visitor attitudes toward a variety of management alternatives. The carriage roads support a diversity of recreation opportunities defined both spatially and temporally. Some areas and times are relatively heavily used, while others accommodate relatively light levels of use. Despite the problem behaviors noted above, most visitors supported maintaining the current mix of carriage road users—hikers, bikers, and equestrians. Based on these findings, park management decided to maintain a diversity of carriage road experiences by establishing two types of recreation opportunity "zones" for the carriage roads as defined by location, time of day, and time of year. However, both of these zones would continue to accommodate all types of visitors. The two carriage road zones would be defined by the same indicators, but different standards would be set.

A second phase of research focused on formulating standards for indicator variables. This research also used a survey of a representative sample of carriage road visitors and adopted normative theory and related empirical techniques (Shelby and Heberlein 1986; Vaske et al. 1986; Manning 1999). As applied in outdoor recreation, norms are generally defined as standards that individuals and groups use to evaluate social and environmental conditions in parks and related areas (Shelby and Vaske 1991). If visitors have normative standards concerning relevant aspects of recreation experiences, then such norms can be studied and used as a basis for formulating standards.

Because of the relatively large number of visitors on the carriage roads, crowding was measured in terms of persons-per-viewscape (PPV), incorporating a visually based measurement approach (Manning et al. 1996; Manning and Freimund 2005). The viewscape for the carriage roads (the length of carriage road that can be seen at any one time) averages approximately 100 m. A series of photographs was prepared that showed a range of zero to 30 visitors on a typical 100-m section of the carriage roads. The photographs were prepared using digital photo-editing software. Sample photographs are shown in Figure 1.

Visitors were shown the photographs in random order and asked to rate their acceptability on a scale from –4 ("very unacceptable") to +4 ("very acceptable"). Study findings are shown in Figure 2. This figure is called a social norm curve (or impact acceptability curve) and represents the aggregate acceptability ratings for the sample of visitors. The norm curve documents the relationship between increasing use levels and the quality of the visitor experience.

Two other sources of information were developed to help formulate standards for crowding on the carriage roads. The survey using the photographs described above was administered to a representative sample of residents of communities surrounding the park, and a computer-based simulation model of visitor use on the carriage roads (described in the next section) was developed to provide more detailed information on the relationship between total daily use level of the carriage roads and PPV conditions. Based on all of this information, standards were formulated for the indicator variable of PPV conditions.

Standards were also formulated for the four problem behaviors described above. Visitors were asked to report the maximum number of times it would be acceptable to experience each of these behaviors during a trip on the carriage roads. The resulting norms were used as a basis of formulating standards.

After indicators and standards for the carriage road experience were formulated, a similar program of work has been conducted in all other major visitor use areas of the park; indicators and standards are now being formulated for these areas. Examples of the range of resource and social indicators being formulated at Acadia include trail

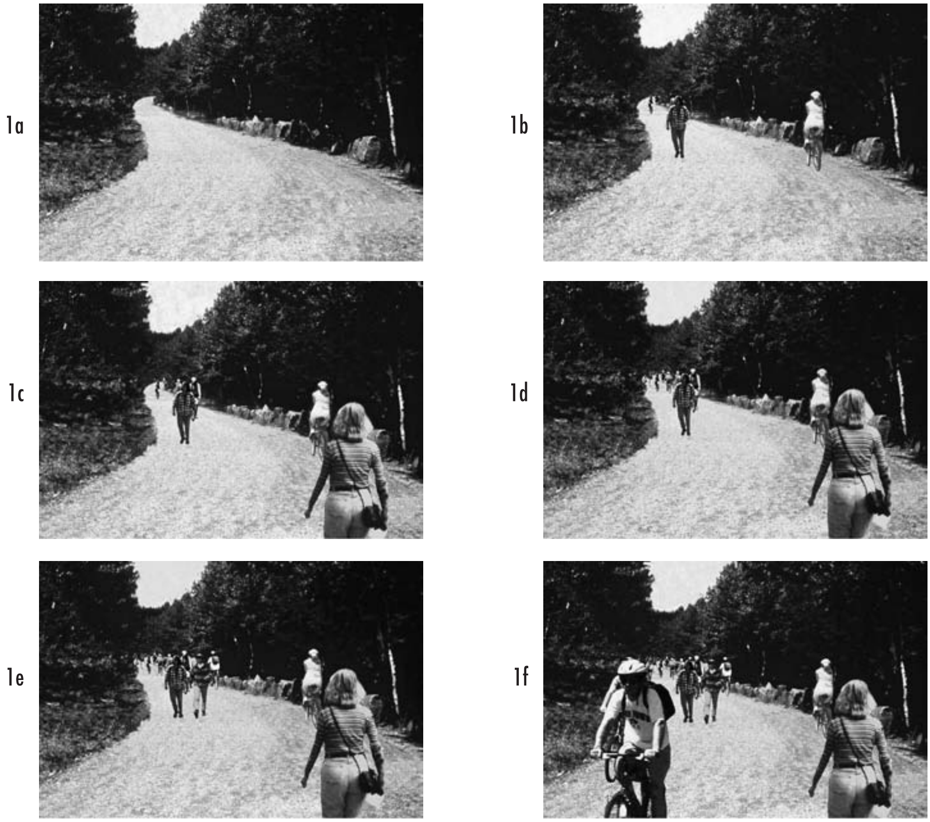

Figure 1. Sample study photographs showing a range of visitor use on the carriage roads.

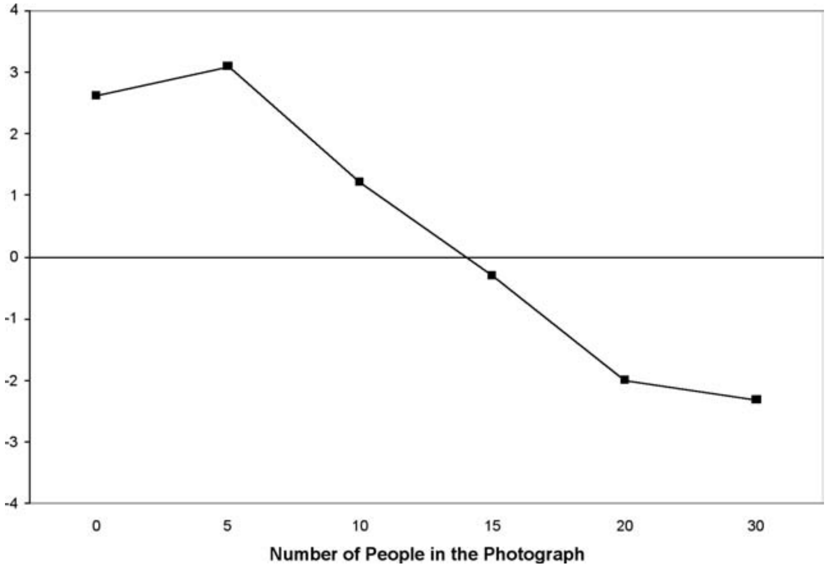

Figure 2. Social norm curve for PPV on the carriage roads.

width and erosion, visitor encounters along trails, number of visitors at one time at attraction areas, and number of cars on park roads.

Computer simulation modeling as a monitoring tool

As noted earlier, monitoring indicator variables can be time consuming and costly. Moreover, some indicators, like PPV conditions along the carriage roads, can be inherently difficult to observe. Simulation models offer a potentially attractive alternative to on-the-ground monitoring. Once a simulation model is developed, it can be used to estimate the condition of indicator variables.

A simulation model of carriage road use was developed in the 1990s (Manning et al. 1998; Wang and Manning 1999; Jacobi and Manning 1999; Manning and Wang 2005). The model was constructed using diary reports by visitors of their travel routes and times along the carriage roads and counts of the number of visitors entering each of the 11 major access points to the carriage roads. These and related data were processed using the general purpose simulation software, Extend. The model was designed to estimate PPV levels along the carriage roads and can be run at any daily use level of the carriage road system. The park's monitoring program measures daily use of the carriage roads through an electronic trail counter and uses the simulation model to estimate PPV levels (the crowding-related indicator variable) to ensure that crowding-related standards are not violated. Moreover, the model has been used in a more "proactive monitoring" approach (Lawson et al. 2003). The model was run at increasing levels of daily carriage road use to estimate the maximum daily use level that can be accommodated on the carriage roads without violating crowding-related (PPV) standards. Finally, the model can also be used to facilitate a program of adaptive management (Lee 1993; Stankey et al. 2005) by estimating ("monitoring") the effects on PPV levels of alternative management practices, such as redistributing use over time and space and altering the mix of carriage roads users (Lawson et al. 2003).

Monitoring recreation on Acadia's carriage roads

Based on the research described above, several indicators were established for the quality of the carriage road experience, including PPV levels and problem behaviors. Standards were then formulated for these indicator variables. For PPV levels, the simulation model of carriage road use estimated that the carriage roads could accommodate up to 3,000 visitors per day without violating the PPV standards that were formulated. Because total daily use of the carriage roads was potentially easier to monitor than PPV levels, this became a focus of the recreation monitoring program. Total daily use of the carriage roads is monitored by means of an electronic trail counter. Over a period of several years, a series of one-day censuses of carriage road use were conducted by stationing volunteer observers at each of the 11 major carriage road entrances. Resulting counts of total daily carriage road use were correlated with simultaneous trail counter readings, and a strong correlation was found. Based on this analysis, PPV levels are monitored on an annual basis using trail counter readings. Trail counter readings from 1997 through 2004 suggest that carriage road use has remained relatively stable and that PPV-related standards have not been violated.

In addition to the monitoring described above, actual PPV counts are conducted every three years at selected locations and times. An observer records the number of visitors on 100-m viewscapes at 15-second intervals. These counts help "ground truth" and validate the PPV estimates derived from the trail counter and computer simulation model.

Monitoring of problem behaviors on the carriage roads is conducted by means of a short visitor survey conducted every three years. Respondents are asked to report how many of the four problem behaviors they have experienced. Resulting data suggest that standards are being violated for two problem behaviors despite enactment of several management practices (promulgation of "rules-of-the-road" for the carriage roads, "courtesy" patrols of the carriage roads, and production of an educational video shown at local bicycle rental shops) designed to address this issue. If data from the next monitoring cycle in 2006 suggest that standards are still being violated, a decision will be made to either take additional management actions to reduce the incidences of problem behaviors (e.g., educate visitors, adopt behavioral regulations, limit carriage road use) or formulate revised, more realistic standards.

Monitoring resource impacts

Acadia National Park visitors participate in a variety of recreation activities, including driving, boating, hiking, horse riding, and biking, and these activities have an array of effects or "impacts" on natural resources, including vegetation, soils, water, and wildlife. To date, resource-related monitoring and associated research has focused on hiking and camping impacts to vegetation and soils, including assessments of undesignated (visitor-created) trails on Little Moose Island (LMI) and designated trails on Isle au Haut (IAH). Research has been directed at selecting appropriate indicators of resource impacts and developing protocols for monitoring these indicators. This work has integrated natural and social science studies to yield indicators and associated standards that are both ecologically and experientially meaningful. This work will be extended to undesignated and designated trails on Mount Desert Island in 2007.

The creation and proliferation of undesignated trails is a common problem in parks that can directly affect sensitive plant communities, rare flora and fauna, and wildlife habitats (Leung and Marion 2000). Visitors seeking to access scenic overlooks, water resources, or merely to explore, often trample vegetation sufficiently to create extensive informal trail systems. Resource degradation on these trails is often severe due to lack of professional trail design, construction, and maintenance. Such unplanned trail networks generally receive no environmental reviews, yet they cause direct trampling and resource degradation, habitat fragmentation, and can further spread invasive species. While some degree of visitor impact is unavoidable, excessive trail impacts threaten natural resource values, visitor safety, and the quality of recreation experiences.

On LMI four types of monitoring procedures have been experimentally applied: (1) global positioning system (GPS) surveys of the location and extent of visitor-created trails, (2) trail condition class assessments based on vegetation and soil loss, (3) photographic monitoring from permanent GPS-mapped photopoints, and (4) a point sampling method with a systematic sampling interval of 300 ft following a randomized start. LMI is a very small, pristine island located off the Schoodic Peninsula and is only accessible to hikers during low tide.

The GPS and condition class surveys revealed a surprisingly large network of visitor-created trails, totaling 15,618 ft (2.96 mi) (Figure 3 & Table 1). While 8,552 ft (54.8% of the total) were classified as having impacts that were barely distinguishable or being in a lightly impacted condition (Class 0 or 1), 2,864 ft (18.3%) were assessed as being heavily impacted with eroded treads (Class 5) (Table 1). These procedures and data illustrate the most efficient methods for tracking the proliferation

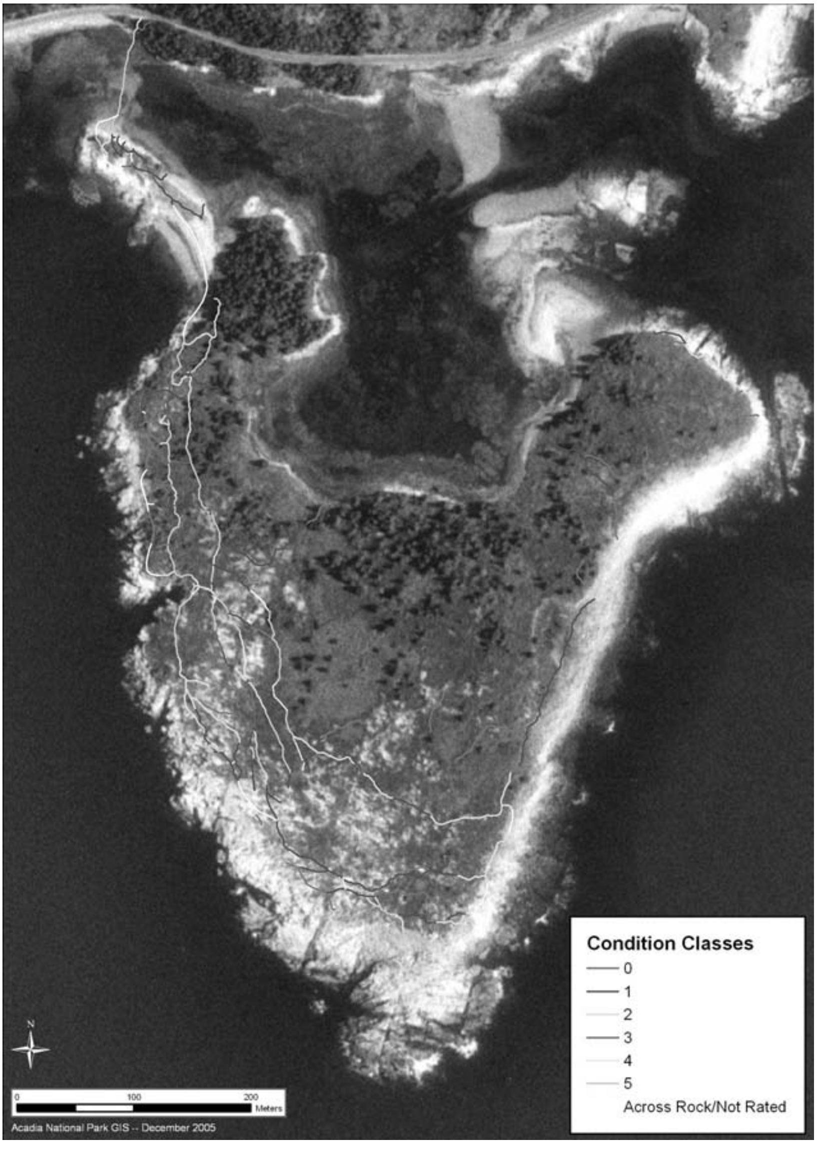

Figure 3. Trails on Little Moose Island.

Condition class	Length (percent)	Condition class description
0	3,469 ft (22.2)	Trail barely distinguishable; no or minimal disturbance of vegetation and/or organic litter.
1	5,083 ft (32.6)	Trail distinguishable; slight loss of vegetation cover and/or minimal disturbance of organic litter.
2	2,988 ft (19.1)	Trail obvious; vegetation cover lost or disturbed.
3	583 ft (3.7)	Vegetation cover lost and organic litter lost in nearly all places, but little or no erosion.
4	631 ft (4.0)	Soil erosion or compaction in tread is beginning in some places.
5	2,864 ft (18.3)	Soil erosion or compaction is common; tread is obviously below ground surface.

Table 1. Condition class and length of visitor-created trails on Little Moose Island in 1996.

and degradation of undesignated trails. Park staff analyzed and employed these data to define a limited subset of 1.09 mi of designated trails, a 63% reduction, that retain access to the island's principal destination sites. These trails received subtle maintenance work to facilitate their use, while 1.86 mi of trail were closed to use with brush and small trail closure/revegetation signs. A trailhead sign with a Leave No Trace message was installed asking visitors to protect sensitive vegetation by staying on the main trails or rock ledges.

Photopoint monitoring can be easily added to GPS surveys to provide a visual documentation of changing trail conditions. Park staff purposely identified and took photos at 24 photopoints in 2001 and 2003, including points along the newly designated trail system and along the trails identified for closure. Few changes in vegetation cover were detectable along the designated trails but photos revealed substantial recovery beginning along the closed trails. Finally, the point sampling survey provided additional quantitative transect data on indicators such as tread width, soil loss, and tread substrates (e.g., percent cover of vegetation, organic litter, exposed soil, rock, and roots). This type of data is presented for illustration purposes in the next section on IAH.

On IAH two trail condition assessment methodologies, the point sampling and problem census methods, were integrated to provide quantitative data describing conditions for several impact indicators. A point sampling method with a systematic sampling interval of 500 ft, following a randomized start, was the primary method (Leung and Marion 1999b; Marion and Leung 2001). Data assessed for a subset of the indicators are reported here, including tread width, maximum tread incision, and a new, more efficient variable interval method for determining cross-sectional area (CSA) of soil loss (see Figure 4). While more time-consuming than maximum incision, CSA provides an accurate measure of trail soil erosion that can be extrapolated to provide an estimate of total soil loss from each trail.

A problem census method integrated into the monitoring procedures provided census information on three specific trail impact problems: excessive erosion (>5 in), excessive muddiness, and number of infor-

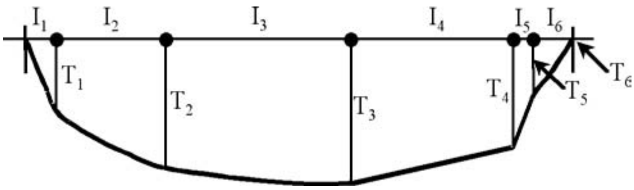

Figure 4. Diagram of the cross-sectional area method (variable intervals) for assessing soil erosion on trails.

mal trails branching from the formal trail since the last sample point (Leung and Marion 1999a). As they hiked, field staff looked for and recorded the beginning and ending distances from the starting point for all occurrences of these problems. In contrast to point sampling, this method provides census data on the extent and location of specific pre-defined problems, facilitating management efforts to rectify such impacts. Both methods can be applied concurrently at an assessment rate of approximately one mile/hour by two surveyors.

All 12 NPS trails on IAH were assessed; trail length ranged from 0.16 to 3.99 mi, with a mean of 1.56 mi and a total of 20.1 mi. Use data were developed for each trail based on trail use monitoring and development of a simulation model of visitor use (Manning et al. 2004). Based on natural breaks in the use data, IAH trails were classified as low-use (0.3–1.0 encounters/mi), moderate-use (4.0–6.0 encounters/mi), and high use (10.0–11.0 encounters/mi).

Table 2 presents point sampling data for each trail with summaries by level of trail use and for the entire island. Results reveal increasing degradation with use level, though conditions on even the high-use trails are good—which we attribute to relatively low use, good design, and durable substrates. However, even with a mean maximum incision value of 1.4 in, estimated soil loss for the entire trail system totals 553 yd^3, which equates to a loss of about 55 truckloads of soil. Problem assessment data (Table 3) also reveal very few occurrences of excessive soil erosion and muddiness, with a lineal extent of only 368 and 292 ft/mi, respectively. These data illustrate the capability of more measurement-based trail assessment protocols that provide quantitative data for tracking degradation. Preliminary standards of quality have been selected for tread width and maximum incision, and monitoring will be replicated to evaluate these approximately every five years.

An associated program of social science research was also conducted on trail-related impacts at IAH. Trail widening and erosion, visitor-created trails, and vegetation loss affect park resources, but these impacts can also degrade the quality of the visitor experience. At what point do such impacts become unacceptable from an experiential perspective? To help answer this question, two series of photographs were prepared illustrating a range of recreation-related trail impacts on IAH, including trail erosion and proliferation of visitor-created trails (Manning et al. 2004). Preparation of these photographs was guided by the assessment of trail conditions described above. The photographs for visitor-created trails are shown in Figure 5. As with the photographs of visitor use on the carriage roads described earlier, these photographs of resource impacts were incorpo-

Trail name	Tread condition characteristics[1]			
	Tread width (in)	Maximum incision (in)	Cross-sectional area (in^2)	(yd^3)
Low-use trails	***20.9***	***1.1***	***9.5***	***106***
Bowditch	20.0	1.1	10.2	27
Long Pond	20.2	0.9	7.9	35
Median Ridge	21.4	1.2	8.9	23
Nat Merchant	24.1	1.5	13.6	21
Moderate-use trails	***24.3***	***1.4***	***15.4***	***116***
Deep Cove	20.1	1.5	31.7	8
Duck Harbor Mtn	29.2	1.7	13.6	22
Eben's Head	29.9	1.6	17.1	19
Goat	23.2	1.3	9.6	53
Thunder Gulch	18.9	1.3	10.3	14
High-use trails	***35.4***	***2.3***	***34.7***	***331***
Cliff	31.1	2.2	32.0	28
Duck Harbor	25.4	1.4	14.0	214
Western Head	39.5	2.6	40.5	89
All IAH trails	***24.5***	***1.4***	***14.9***	***553***

[1] Mean values reported, except cross-sectional area (yd^3), where sum values are reported.

Table 2. Point sampling data for tread width and soil loss.

rated into a survey of visitors to IAH. The resulting social norm curve for visitor-created trails is shown in Figure 6. These and related data are also being used to help formulate standards for recreation-caused resource impacts.

Conclusion

Recreation monitoring is an expanding, evolving, and increasingly important element of park management at Acadia. This monitoring program is conducted within the context of the NPS VERP framework, which requires identification of indicators and formulation of associated standards. Indicators provide a focus for the monitoring program and standards provide reference points that inform interpretation of resulting monitoring data and ultimately guide management action. Identification of indicators and formulation of standards is informed by a continuing program of natural and social science research.

Monitoring of recreation at Acadia includes both resource and experiential variables. The monitoring program, and the research upon which it is based, explicitly recognize the interrelationships that can characterize the resource and social dimensions of park and recreation management.

Use level & indicator	Occurrences		Lineal distance		
	#	*#/mi*	*ft*	*ft/mi*	*%*
Low-use trails					
Excessive soil erosion	1	0.12	74	9	0.002
Excessive muddiness	7	0.83	200	24	0.005
Moderate-use trails					
Excessive soil erosion	7	1.33	141	27	0.005
Excessive muddiness	3	0.57	92	17	0.003
High-use trails					
Excessive soil erosion	4	0.63	153	24	0.005
Excessive muddiness	0	0	0	0	0
All IAH trails					
Excessive soil erosion	12	0.60	368	18	0.003
Excessive muddiness	10	0.50	292	15	0.003

Table 3. Problem assessment data for number of occurrences and lineal distance of excessive soil erosion and muddiness.

For example, natural science research helps document the ecological impacts of recreation and how these impacts progress over time, while social science research helps understand the degree to which these impacts degrade the quality of the visitor experience. An integrated program of natural and social science research can help develop a more comprehensive and coordinated suite of recreation-related indicators and standards.

Recreation monitoring at Acadia is conducted through a combination of field-based measurements (e.g., measures of trail width and erosion, direct observation of PPV levels, visitor surveys), remote sensing (trail counters), and computer simulation modeling. This combination of methods is designed to maximize efficiency and provide measures of cross-validation where possible.

Recreation monitoring began at Acadia nearly 10 years ago, but was relatively narrowly focused on the quality of the visitor experience on the carriage roads. Monitoring has since been extended to other areas of the park and to both experiential and resource-related visitor impacts. Ultimately, a suite of resource and experiential indicators and standards will be formulated for all major areas of the park, and management of recreation use and related impacts will be guided by data derived from the park's program of recreation monitoring.

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5d


Figure 5. Study photographs showing increasing levels of visitor-created trails.

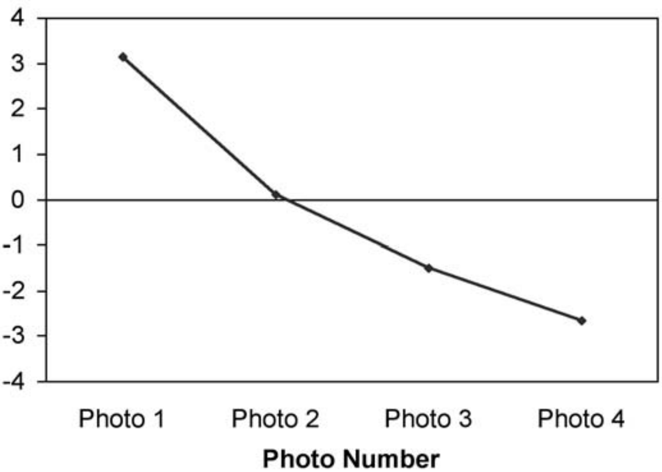

Figure 6. Social norm curve for visitor-created trails.

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