Meaningful Measures: Developing Indicators of Visitor Impact in the National Park Service Inventory and Monitoring Program

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Introduction

THE CONSEQUENCES OF VISITOR USE FOR NATURAL RESOURCES is a common management concern in parks and protected areas. Managers are often charged with maintaining park resources in perpetuity while simultaneously allowing for an unconfined visitor experience. In order to meet this challenge, there is widespread agreement that monitoring trends in visitor use and resource condition is essential to inform the best management decisions. Designing, conducting, and processing information from monitoring programs is often a difficult charge, however, and all too often managers need to make decisions without adequate monitoring data. The problem is often exacerbated by an incomplete understanding of visitor impact issues that invariably include ecological and human dimensions.

In this paper we explore the process by which two National Park Service (NPS) networks—the Northeast Coastal and Barrier Island Network (NCBN) and the Southwest Alaska National Parks Network (SWAN)—developed the initial components of visitor use and impact monitoring programs. This discussion is useful to managers and researchers interested in developing visitor use and impact monitoring projects because it constitutes an initial effort to improve the methodology of the determination of appropriate measurement indicators. We suggest that, to date, this crucial process has not been considered with sufficient rigor to satisfy either scientific scrutiny or managers' needs, and intend this work to be contributory in these regards.

Visitor impact issues received agency-wide attention in NPS in the mid-1990s as the agency embarked on using the Visitor Experience and Resource Protection (VERP) framework in general management planning on the one hand, and launched the nationwide Inventory and Monitoring (I&M) program on the other. Established under the Natural Resource Challenge initiative, the NPS I&M program is designed to strengthen natural resource stewardship through science and long-term monitoring (NPS 2005a). On the monitoring side, the Vital Signs program was created to support the overall I&M effort by identifying important "vital signs"—measurable attributes indicative of ecological health. The program is composed of 32 networks of parks throughout the country, each of which includes parks that share similar geographic and natural resource characteristics (NPS 2005a). NPS I&M program recognizes visitor use as a potential threat to park resource quality. The amount, type, and distribution of visitor use can result in undesirable resource impacts that ultimately can influence ecological health from the site to the landscape scale. Accordingly, visitor use and impacts were included as an integral part of the general Vital Signs monitoring framework (NPS 2005b) and were selected as candidate vital signs for measurement protocol development by several NPS networks (Stevens et al. 2005).

For clarity, we use the term *measurement* to refer to the attribute of the environment to be monitored. Some park monitoring and planning frameworks call these attributes *indicators*. The use of the term *measurement* is in accord with the NPS I&M program, which has identified visitor and recreation use as a primary national vital sign. Individual networks (such as the NCBN) have developed more specific vital signs (e.g., park usage, habitat alteration, and wildlife disturbance). The projects discussed here identified meaningful and feasible measurements for each network vital sign. As an example, the number of unofficial recreation sites has been identified as a measurement of the NCBN "habitat alteration" vital sign (Table 1).

Visitor use and impact monitoring in the I&M program

Context and goals. During the period 2002–2005, two projects monitoring visitor use and impact were initiated as part of the Vital Signs program in the NCBN and SWAN networks, involving a total of 12 parks (Table 2). NCBN and SWAN developed these projects to (1) determine which of the NPS units required visitor impact monitoring programs; (2) develop clear, ecologically based conceptual models of visitor threats to resources; and (3) select and rank by importance relevant measures of resource condition. A fourth goal, to develop and test accurate monitoring and sampling protocols of the selected meas-

Table 1. Vital signs and associated measurements in the NCBN. Source: Stevens et al. 2005.

	National Vital Signs			Northeast Coastal and Barrier Island Network	
	Level 1	*Level 2*	*Level 3*	*Vital Signs*	*Measurements*
Visitor Impacts	Human Use	Visitor & recreation use	Visitor usage	Park usage	Park use type, park use density, park use distribution
	Human Use	Non-point source human effects	Non-point source human effects	Habitat alteration	Number and distribution of social trails and unofficial recreation sites, amount of newly exposed soil, amount of damage to bottom communities from anchoring and mooring
	Human Use	Non-point source human effects	Non-point source human effects	Wildlife disturbance	Disturbance type, disturbance time, attraction behavior

NPS network/ park	Park type	Primary visitor activities	Number of annual visitors[1]
SWAN			
Alagnak Wild River	wildland	fishing, wildlife viewing	thousands
Aniakchak	wildland	river running, wilderness backpacking	hundreds (300)
Kenai Fjords	wildland/ frontcountry	sea kayaking, day use	hundred thousands (244,000)
Katmai	wildland	wildlife viewing, backpacking	tens of thousands (57,000)
Lake Clark	wildland	backpacking, river running, wildlife viewing	thousands (4,900)
NCBN			
Assateague Island (MD)		beach recreation, camping, wildlife viewing	millions (2,000,000)
Thomas Stone (MD)			thousands (6,000)
Fire Island (NY)		beach recreation, wilderness camping	hundred thousands (800,000)
Gateway (NY)	developed/urban	beach recreation, wildlife viewing	millions (8,200,000)
Sagamore Hill (NY)	historic	museum activities	tens of thousands (41,000)
George Washington Birthplace (VA)	historic	museum activities	tens of thousands (75,000)
Colonial (VA)			millions (3,300,000)

[1] The order of magnitude is indicated, followed in parentheses by 2004 recreation visitor use estimates where available.

Table 2. Parks included in I&M visitor monitoring studies. Source: NPS Public Use Statistics Office.

ures, has not been accomplished to date. Further details on the specific components of scoping, site visits, and specific vital signs selected have been previously reported (Monz et al. 2004; Monz et al. 2005; Monz and D'Luhosch 2005).

NCBN parks generally consist of coastal areas in the eastern U.S. with a long history of visitor use. These areas provide outstanding opportunities for beach recreation and nature appreciation. Given their proximity to major population centers, visitation levels are generally very high. In scoping sessions, managers consistently reported concerns with minimizing visitor impacts to these unique and dynamic ecosystems, particularly in areas where visitor use overlapped spatially with sensitive species. Major network-wide commonalities include trampling impacts on vegetation and soils, wildlife impacts, impacts related to off-road vehicle use, and trash (Monz and Leung 2003).

In contrast, SWAN parks consist of geographically large areas far from most major population centers with low to moderate use. With the exception of Kenai Fjords National Park, most visitors access these areas by small fixed-wing aircraft or by boat. Development and facilities are generally at a minimum, as most visitors seek a wilderness-based experience on an Alaskan scale. Managers in these parks consistently reported challenges with determining visitor use levels, locations, and activity types given the possibility of innumerable entry points. This, combined with numerous outfitter camps in and near park boundaries and visitors seeking opportunities to view wildlife, make visitor management in these parks a unique challenge. Scoping revealed several visitor impact issues across SWAN parks, namely impacts on soil and vegetation, wildlife disturbance, and noise associated with aircraft and motorboat use (Monz and D'Luhosch 2005).

Process component 1: Scoping. The process of scoping and public involvement has been applied in most land use planning processes and in the vast majority of public lands agencies (e.g., McCool and Ashor 1984; McCoy et. al. 1995). In terms of visitor monitoring programs, understanding, analyzing, and documenting the fundamental concerns of managers provides an initial view of the potential location and extent of visitor impacts to resources and some indication of the trends in park use. A full scoping process also avoids the potential pitfalls of "expert opinion," in that scoping relies on multiple individuals, workshop approaches, and consensus. In each of these projects we relied on an initial scoping process to become familiar with the park units and to document managers' concerns. A second scoping phase involved site visits to each park, often accompanied by managers, and a photographic documentation of observable impacts in the field to clarify the nature and type of impacts to be addressed by monitoring.

Process component 2: Conceptual modeling. Conceptual models of important system components and interactions have a long history of application in the ecological sciences and have recently been applied to the selection of ecological indicators (Crabtree and Bayfield 1998; Jackson et al. 2000; Dale and Beleyer 2001). NPS has adopted this approach in the I&M program (Gross 2003), and both visitor monitoring projects described here utilized this approach. Despite the generalizations in conceptual models, their ability to illustrate complex interactions and the connections between measurements and ecological processes makes them a key component of monitoring programs (Gross 2003).

For the visitor use projects, we chose to develop *stressor* models designed to illustrate the relationships between important system components, effects, and potential measurements (e.g., Figure 1). These models were developed based on known ecological relationships between recreation use and ecosystem components well established in the recreation ecology literature (e.g., Hammitt and Cole 1998). The models were the first step in the measurement selection process. The intent of these models is to illustrate specific sources of stress to the ecosystem (in this case the varous components of recreation use) and resultant consequences to particular ecosystem attributes of interest. Other efforts in the I&M program have also used stressor models to guide their monitoring efforts (Gross 2003).

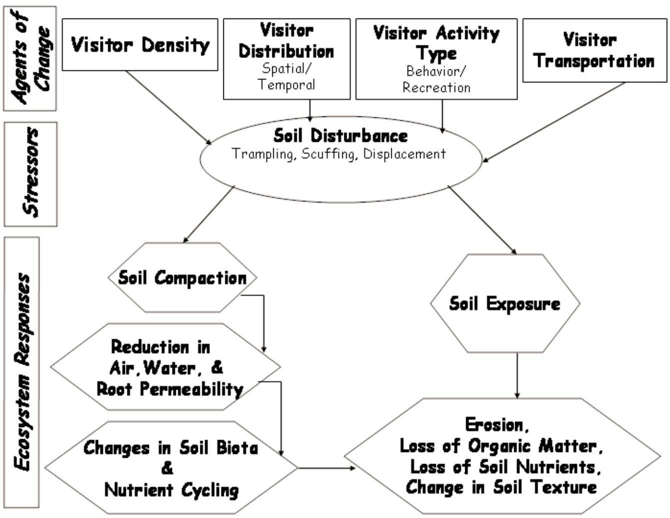

Figure 1. A soil disturbance stressor model for visitor monitoring.

A soil disturbance model (Figure 1) provides an example of this process. Four *agents of change* (in this case the components of recreation use) can lead to soil disturbance: visitor density, visitor distribution, visitor activity type, and visitor transportation (i.e., mode of transport). These agents can lead to soil disturbance through different stressors such as trampling, scuffing, displacement of soil, vehicle tracks, etc. The ecosystem responds to these stressors by exhibiting soil compaction, soil exposure, and reduction in air, water, and root permeability. The exposure of soil results in erosion, loss of organic matter, loss of soil nutrients, and changes in soil texture. Changes in soil biota and nutrient cycling occur when there is a reduction in air, water, and root permeability and results in erosion, loss of organic matter, loss of soil nutrients, and changes in the soil texture. The model clearly illustrates the role of two potential measurements of soil disturbance—soil compaction and soil exposure (vegetation loss)—in the selected system processes.

Process component 3: Vital Signs measure selection and ranking. At the beginning of the visitor monitoring projects, numerous sources were consulted to identify candidates for applicable measures. These sources included the scientific literature, I&M Network program guidelines, findings from the scoping process, and the conceptual models developed for visitor impacts (e.g., Figure 1). The vital sign measures that were selected are derived from the three major components of visitor impact conceptual models; namely, agents of change, stressors, and ecosystem responses. An example of some of the candidate vital signs measures for visitor use and soil and vegetation disturbance is provided in Table 3, along with associated monitoring approaches.

Criteria for ranking vital signs

Not all of the candidate vital sign measures identified can or should be implemented in a monitoring program. With all monitoring efforts, practical considerations, such as the monetary cost, staff time, measurement protocol complexity, and importance to park management should play a role in determining a feasible approach. A process for ranking and selecting candidate vital sign indicators for protocol development is therefore an essential next step.

Several recent studies have suggested approaches for the selection of general ecological indicators (CAC 1995; Jackson et al. 2000) and visitor impact indicators (Belnap 1998; GYWVU 1999; Manning et al. 2005). For these studies we modified the

Table 3. Examples of candidate vital signs, monitoring approaches, and specific measures identified in both the NCBN and SWAN visitor use and impact projects.

Candidate Vital Sign measure	Monitoring approach	Unit of analysis
Visitor activity type	Outfitter survey Direct field observation Entry point visitor survey	Dominant activity type Composition of different activity types
Distribution of visitor use	Outfitter survey Direct observation Automated counters	Location and extent of recreational use
Vegetation loss / soil exposure	Direct on-site measurement at recreation sites and along trails Digital photo image analysis	Relative cover loss (%) Changes in soil exposure (%)
Vegetation compositional change	Direct on-site measurement at recreation sites and along trails	Individual species cover (%) Presence / absence of invasive plant species
Social trail formation	Direct on-site assessment and mapping Digital photo image analysis	Location, extent, and mapping of visitor-created trails
Unofficial site formation	Direct on-site assessment and mapping Digital photo image analysis	Location, extent, and mapping of visitor-created sites
Shoreline disturbance	Direct on-site assessment and mapping in sensitive areas	Location, extent, and mapping of shoreline disturbance sites

existing approaches and developed a set of fourteen selection criteria to evaluate the candidate vital signs (Table 4). The first four are required criteria that must be fulfilled by any candidate indicator to be considered for selection; the remaining ten are optional criteria that are used for evaluating the desirability of candidate indicators that have met the required criteria.

For example, the SWAN project utilized a criteria-based selection process that yielded a ranked list of vital signs measures (Table 5). All sixteen candidate measures identified for consideration were evaluated based on a plus/minus scale for the fourteen criteria described in Table 4. Tallies of these ratings resulted in an overall score for each measure and resulted in a ranked list of candidate vital signs for adoption by the network and for further protocol development. High-priority indicators are those recommended for adoption in the network's Vital

Table 4. Evaluation criteria for candidate vital sign indicators. The first four criteria are required, while the remaining ten are desirable (see text). Criteria based on Belnap 1998, CAC 1995, GYWVU 1999, and Manning et al. 2005.

Criteria	Description
Low measurement impacts	The indicator can be measured with no or minimal level of ground disturbance
Reliable/repeatable	The measurements of indicator by different field staff would show reasonable agreement
Correlation with use	The indicator is directly related to visitor use with a good level of correlation
Ecologically relevant	The indicator must have conceptual relevance to concerns about ecological condition, i.e., it must be a component of the appropriate conceptual model, reflecting an important change of resource condition that would lead to significant ecological or social consequences
Respond to impacts	Change of resource condition can occur promptly after impacts are introduced
Respond to management	Resource conditions can be manipulated by management actions
Feasible to measure	Field measurements are relatively straightforward to perform with minimal level of equipment needed
Low natural variability	Indicator has a limited level of spatial and temporal variability
Large sampling window	Field measurements can take place in most seasons
Cost-effective	Measurements of indicator are inexpensive, with little additional cost to management; data gathered benefit management
Easy to train for monitoring	Field staff with no prior knowledge of field procedures can be easily trained to perform such procedures
Baseline data	There are existing data on the indicator, preferably with the nature of the use–impact link established
Measures multiple indicators	Possible to measure another indicator directly by assessment of primary indicator
Response over different conditions	Impacts can be measured while still relatively slight

Priority for protocol development	Candidate Vital Sign measures
High	Distribution of visitor use Vegetation loss / soil exposure Social trail formation Unofficial site formation Aircraft noise Aircraft landings / take-offs
Medium	Visitor activity type Visitor density Vegetation composition change Shoreline disturbance Turbidity
Low	Wildlife disturbance type Wildlife disturbance time Attraction behavior Fecal coliform

Table 5. A prioritized list of candidate vital signs.

Signs monitoring program, while the low- and medium-priority indicators require additional discussion by the network as to whether these should be examined further.

Conclusions and future challenges

Integrating visitor use and impact measures into the NPS I&M program is an on-going process. The experience gained from these projects will allow future efforts in visitor monitoring in I&M to be developed more easily, and can help managers working in other contexts to improve their programs. In addition to the preceding suggested process components, several overall conclusions are evident based on our experience with the projects.

First, most managers surveyed in the two projects were concerned about visitor impacts on natural resources. Through independent field scoping of observable impacts, we concluded that the information gathered in the managers' scoping was a sound representation of visitor use and impact patterns. Moreover, scoping was an important step in familiarizing park staff with the goals of the monitoring project and for external researchers to learn about the parks. Essentially, our experience suggests that a thorough scoping process and continued involvement of managers during the measurement selection phase is an essential component in a successful program.

Throughout the scoping and measurement selection process of both projects it became clear that the visitor element is an integral part of natural resource stewardship for most managers. Despite this consensus, there were strong and sometimes conflicting opinions on the importance and components of a monitoring program. Building a consensus among all parties, including managers, NPS scientists and network coordinators, and external researchers is a critical first step needed to facilitate the remainder of the process.

One of the most essential measurements in visitor monitoring is the measure of visitor use and distribution. This information often is of the highest priority to managers, but must be interpreted with caution because use information is much more relevant to natural resource stewardship if it is combined with some measure of resource condition. Past research on visitor impacts has found that the use–impact relationship is generally curvilinear ,with the majority of impact occurring with initial use. The degree of impact also depends on the type of activities, actual behavior, and the resistance and resilience of the ecosystem. A complete monitoring protocol for the visitor element should include a concerted effort involving recreation ecologists and social scientists on use and impact components that would yield meaningful data on both.

From a technical perspective, achieving the balance between precision, accuracy, and efficiency is as important for monitoring visitor use and impacts as for other monitoring efforts. Visitor use and impacts are dispersed and complex, and as such are very challenging to monitor at large geographic scales. Given the perennial constraints on human resources to perform actual monitoring, field efficiency is critical and more research at optimizing protocols needs to take place (see the article by Newman et al. in this issue). The selection of vital signs and measures should pay attention to this limitation early on and throughout the steps of protocol development. Routinely collected geospatial data may offer an efficient means to complement field-based monitoring. The potential of this kind of integration is still yet to be fully realized and represents an opportunity for continued methodological research.

Despite its dispersed nature, visitor use and its associated impacts do have some predictable patterns. The number of recreation sites is often finite and can be evaluated in its entirety to provide the full picture of impact patterns. While sampling is the common language and appears to be the only scientific approach to monitoring in the I&M documents, censuses may be possible and even more effective for some visitor use and impact indicators, unlike other types of natural resource vital signs. The value of censusing should be explored in visitor monitoring programs, along with a careful evaluation of the benefits and costs.

Arguably the most significant challenge we encountered in these projects was the lack of recognition of standards development as an important component of a monitoring effort. The use of "indicator and standards" approaches has gained nearly universal support in the recreation management field and has been adopted by NPS in the context of the VERP planning framework (NPS 1997). We see this as a great limitation to this work and other similar efforts, because monitoring without associated standards often results in confusion as to when a management action is appropriate. We hope that future visitor monitoring efforts in the I&M program will make allowances for standards development.

As visitor use and impacts become a greater threat to natural resources, and as research attention to this issue increases, there is reason to hope that more and better thinking on monitoring approaches and designs will lead to a strong set of scientifically valid protocols that exemplify a truly integrated, adaptive, and multidisciplinary approach.

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