**Guidance on Developing Recreation Impact Monitoring Programs for Wilderness**

*Dr. Jeffrey L. Marion, Recreation Ecologist, U.S. Geological Survey*[[1]](#footnote-1)

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This guidance is provided to federal agency wilderness managers and volunteers seeking to develop monitoring programs for recreation sites (including campsites) and formal or informal (visitor-created) trails. In particular, this guidance supplements that provided by the Interagency Visitor Use Management Council’s (IVUMC) publication: “[Monitoring Guidebook: Evaluating Effectiveness of Visitor Use Management](https://visitorusemanagement.nps.gov/Content/documents/highres_final_Monitoring_Guidebook_Edition_One_IVUMC.pdf)” (IVUMC 2019). More specifically it provides supporting information relative to laws and agency policies regarding the need for monitoring, monitoring objectives and capabilities, the selection of indicators, standards, and measurement protocols, and suggestions for training monitoring staff, conducting the field work, and data analyses. Some of this guidance is borrowed or further developed from earlier guidance provided in Marion (1991).

The Legal Mandate: Preservation and Use of Wilderness

The U.S. Wilderness Act of 1964 (P.L. 88-577) created a National Wilderness Preservation System that has grown to include 803 units of 111.4 million acres of undeveloped federal land across 44 states and Puerto Rico (as of July 2019). Managed by four federal agencies, the U.S. Forest Service (FS), National Park Service (NPS), Bureau of Land Management (BLM), and U.S. Fish & Wildlife Service (FWS), wilderness lands are singled out for their exceptional ecological and/or social values and managed to provide a higher degree of protection overlayed on standard agency land management guidance. Wilderness lands comprise 4.5% of the U.S. land area and 18% of the lands managed by these four federal agencies.

Wilderness is defined by Congress as:

- *an area where the earth and its community of life are untrammeled by man -- where man himself is a visitor who does not remain;*

*- undeveloped federal land retaining its primeval character and influence, without permanent improvements or human habitation;*

*- which is protected and managed so as to preserve its natural conditions;*

*- which generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable;*

*- which has outstanding opportunities for solitude or a primitive and unconfined type of recreation*.

The Wilderness Act established the same use and preservation management paradox implied by other federal agency land management guidance: protecting natural resources and processes while accommodating appropriate types and amounts of wilderness-dependent visitation. Wilderness areas:

“*shall be administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness and so as to provide for the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness...”*

Wilderness human and ecological values are largely dependent on their degree of naturalness and the success of dedicated wilderness managers and volunteers. While perhaps no areas on the planet are entirely free of human impact, wilderness areas are *intended* as areas where anthropogenic activities and effects (*impacts*) are intended to be minimal, with the goal of preserving natural ecological processes and integrity. While some impacts are external, associated with anthropogenic climate change or air and water pollution, other impacts are internal, including both consumptive activities (e.g., hunting and fishing) and the indirect impacts of a diverse and growing list of recreational activities (e.g., backpacking, boating, climbing, horseback riding, and photography). Managing wilderness recreational visitation is one of the core responsibilities of wilderness managers, who are charged with accommodating increasing visitation while minimizing any associated negative resource impacts. Approximately half of Americans, 151.8 million, engaged in outdoor recreation activities in 2018 with a collective 10.2 billion outdoor outings (Outdoor Foundation, 2019). Wilderness visitation is more difficult to track, but FS data reveals an increase in wilderness visitation from 8.72 million in 2011-15 to 8.98 million for 2015-19 (Forest Service, 2019).

*“If future generations are to remember us with gratitude rather than contempt, we must leave them something more than the miracles of technology. We must leave them a glimpse of the world as it was in the beginning, not just after we got through with it.”*

-- Lyndon B. Johnson *(36th President of the United States)*, on the Wilderness Act

Agency Policy Guidance on Monitoring Visitor Impacts

Authority to implement congressional legislation is delegated to agencies, who identify and interpret all relevant laws and formulate management policies to guide implementation. As an example, let’s review this guidance for the NPS by examining their “Management Policies 2006” (NPS 2006), along with other guidelines and unit-specific planning documents. This document describes their standard NPS land management guidance while recognizing the additional legislative considerations that must be overlayed by a wilderness designation. It also states that lands possessing wilderness qualities must be managed so that wilderness eligibility is not diminished.

Managers must first look to their enabling legislation, as modified by any subsequent laws, for guidance related to managing recreational use. Agency management policies generally provide additional interpretations of relevant laws and more comprehensive and specific guidance to agency staff. For example, the NPS Organic Act of 1916 (P.L. 64-235) directs the agency to:

*"promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations".*

The NPS Management Policies (NPS 2006) recognizes that appropriate recreational uses are a “fundamental purpose of all parks” (section 8.1.1) and provides additional guidance on what constitutes an “impaired” condition:

“*The impairment that is prohibited by the Organic Act and the General Authorities Act is an impact that, in the professional judgement of the responsible NPS managers, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values. Whether an impact meets this definition depends on the particular resources and values that would be affected; the severity, duration, and timing of the impact; the direct and indirect effects of the impact; and the cumulative effects of the impact in question and other impacts”* (section 1.4.5).

Even limited recreational activity can cause measurable degradation to vegetation so managers must strive to achieve a balance between their recreation provision and resource protection objectives. Consistent with park purposes, managers are directed to avoid those impacts that can be avoided, and to minimize those that cannot:

“*NPS managers must always seek ways to avoid, or to minimize to the greatest degree practicable, adverse impacts on park resources and values”* (section 1.4.3). Additionally, *“When proposed park uses and the protection of park resources and values come into conflict, the protection of resources and values must be predominant”* (section 1.5).

The National Parks Omnibus Management Act of 1998 (P.L. 105-391) provided a specific monitoring mandate by establishing a framework for fully integrating natural resource monitoring and other science activities into NPS management processes:

*"The Secretary shall undertake a program of inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources"* (section 204).

Natural resource monitoring can be defined as “the systematic collection and analysis of resource data at regular intervals, in perpetuity, to predict or detect natural and human-induced changes, and to provide the basis for appropriate management response” (NPS 1991). The NPS Management Policies recognize monitoring as a core tool in visitor use management decision-making:

*“If, in monitoring a park use, unanticipated impacts become apparent, the superintendent must further manage or constrain the use to minimize the impacts, or discontinue the use if the impacts are unacceptable”* (section 8.1.2).

They direct managers to: *“continually monitor all park uses to prevent unanticipated and unacceptable impacts”* (section 1.5), to *“identify, acquire, and interpret needed inventory, monitoring”* data *“at regular intervals,”* and to *“analyze the resulting information to detect or predict changes … that may require management intervention”* (section 4.2.1). Further, that such data be used to *“predict, avoid, or minimize adverse impacts on natural and cultural resources and on visitors and related activities, …*and identify alternative strategies for potentially resolving them,” and to “*provide a sound basis for policy, guidelines, and management actions”* (section 4.2.1). In backcountry settings NPS managers are additionally directed to: *“identify acceptable limits of impacts, monitor backcountry use levels and resource conditions, and take prompt corrective action when unacceptable impacts occur*” (section 8.2.2.4).

The NPS Management Policies also provide limited additional guidance regarding the management and monitoring of recreational use in wilderness. Recreational uses *“will be of a type and nature that ensures that its use and enjoyment (1) will leave it unimpaired for future use and enjoyment as wilderness, (2) provides for the protection of the area as wilderness, and (3) provides for the preservation of wilderness character”* (section 6.4.3). Regarding monitoring, *“the conditions and long-term trends of wilderness resources will be monitored to identify the need for or effects of management actions. The purpose of this monitoring will be to ensure that management actions and visitor impacts on wilderness resources and character do not exceed standards and conditions established in an approved park plan”* (section 6.3.6.2).

Additional guidance pertaining to recreation impact monitoring and visitor use management in wilderness may be found within other federal agency documents, such as the NPS Director’s Order #41 on Wilderness Stewardship (NPS 2013). Unit-specific documents such as their enabling legislation and management plans, including General Management Plans and Backcountry and Wilderness Plans, provide additional guidance.

For the FS, core guidance is provided in their manual #2300-90-2, Recreation, Wilderness, and Related Resource Management (Forest Service 2007), the 2012 Planning Rule (36 CFR 219.12), Forest Service Manual 1900, Chapter 1920 Land Management Planning, Handbook 1909.12, in regional standards and guides, and in forest plans. For the BLM applicable guidance is contained in “Planning for Recreation and Visitor Services” Manual 8320, and Handbook H-8320-1, and for the FWS in their Planning Policy 602 FW 3 and 605 FW 1. Staff working to develop and implement unit monitoring programs should find, follow, and cite such guidance to justify and sustain their monitoring efforts, along with ensuring that the products of monitoring are fully described and archived, analyzed and summarized, and fully incorporated into relevant decision-making and adaptive management programs. Failure in these tasks will only add to the numerous historic examples of agency monitoring programs that are short-lived and/or disconnected from daily management decision-making.

*“What America does not do well is anticipate and avoid problems. Unfortunately, many environmental phenomena involve thresholds that, when passed, caused damage that is essentially irreversible. If we wait until the damage occurs and then respond, it will be too late.”*

-- Denis Hayes *(American environmentalist and coordinator of the first Earth Day in 1970)*

Monitoring Objectives and Capabilities

The core value of visitor impact monitoring programs is that they provide quantitative documentation of the types and extent of specific natural resource impacts, which allow protected area managers to make objective evaluations of impact acceptability and to select and evaluate the efficacy of impact management strategies and actions. When implemented with careful attention to quality control and management information needs, periodic assessments of the resource conditions affected by visitation can produce a database with significant benefits to managers. Monitoring program objectives and capabilities include the ability to:

* Identify and quantify site-specific resource impacts.
* Summarize impacts by use-related, environmental, and managerial factors to evaluate relationships.
* Aid in establishing and periodically evaluating resource condition standards/thresholds of quality.
* Perform relational analyses to identify causal and influential factors and effective management actions.
* Evaluate the efficacy of resource protection measures as part of an adaptive management process.
* Assign priorities to alternative impact management actions.

Data from the first application of a long-term monitoring program can objectively document base-line conditions for the types and extent of recreation-related resource impacts. Such data provide information for establishing and evaluating realistic biophysical indicator standards, as required by visitor use management planning and decision-making frameworks. A variety of frameworks have been developed, including Limits of Acceptable Change (LAC) (Stankey et al. 1985), Visitor Experience and Resource Protection (VERP) (NPS 1997), and a newer visitor use management framework (VUM) developed by an interagency council of the six federal land management agencies (IVUMC 2016). These frameworks describe adaptive management processes whereby managers prescribe their desired resource and social conditions through the selection of visitation-related indicators and standards (thresholds). See Williams, Szaro, and Shapiro (2009) for a more comprehensive review of adaptive management guidance for the Department of the Interior.

Monitoring programs also provide the essential mechanism for periodically reevaluating resource conditions in relation to standards (thresholds) that specify the minimally acceptable condition associated with an indicator (IVUMC 2019). When standards are exceeded, managers can evaluate monitoring data to identify the relative influence of use-related, environmental, and managerial factors to select and implement corrective visitor impact management actions. Subsequent monitoring allows managers to evaluate efficacy, and to guide and justify further actions when needed.

A permanent visitor impact monitoring program provides an objective long-term dataset of conditions that facilitate evaluations of trends, the rate and magnitude of change, and early detection of deteriorating conditions. Such data can support proactive interventions that avoid the occurrence of unacceptable impacts and impairment; they reveal whether desired conditions are achieved and maintained. Relational analyses of monitoring data can identify influential factors and provide insights allowing managers to sustainably design and manage their recreation infrastructure, modify visitor behavior, and avoid or postpone contentious limitations on use. However, when adaptive management decision-making demonstrates that numeric visitor capacities are required, monitoring data provides a reliable, defensible, and transparent justification in the court of law and public opinion for publicly salient management decisions.

As noted in Marion (1991), the value and longevity of a visitor impact monitoring program will be largely dependent upon its integration with and responsiveness to visitor use management and decision-making: *“A failure to cultivate support for the monitoring program by describing its usefulness to management will ultimately lead to its termination or result in a program that is operated in isolation by a particular individual, district, or division.”* Developing a formal monitoring proposal or plan with a signature page can help institutionalize the monitoring work, along with incorporation of monitoring functions into the position descriptions and annual responsibilities of permanent staff. Even more important is ensuring that monitoring data are periodically collected, analyzed, and summarized to fully support an ongoing adaptive management decision-making process. See the IVUMC Visitor Use Management website (<https://visitorusemanagement.nps.gov/>) and their Monitoring Guidebook (IVUMC 2019) for additional information and guidance.

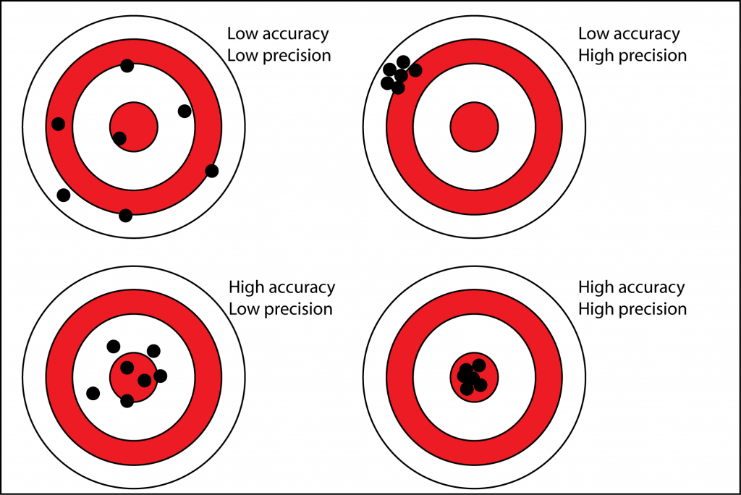
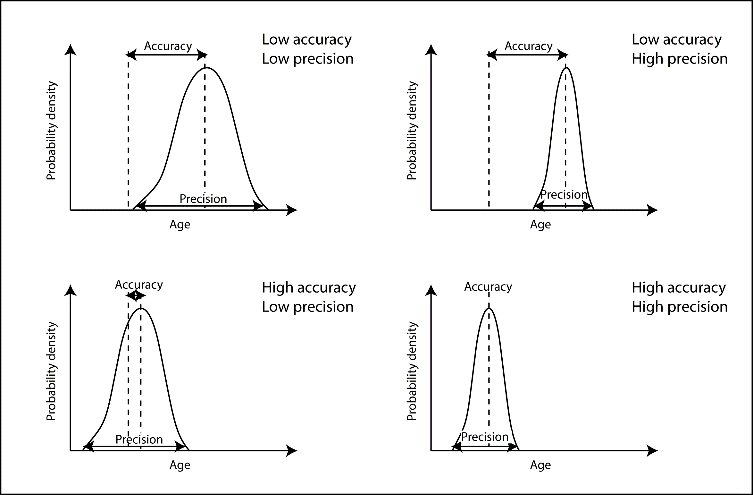
Selection of Indicators and Measurement Protocols

The IVUMC program and Monitoring Guidebook (IVUMC 2019) provide informative guidance for analyzing unit information needs, developing a monitoring strategy, and selecting indicators. Additional information is presented here to aid staff in considering indicator assessment options, quality control practices, and analytical practices.

## Indicator Assessment Options

Before considering indicator assessment options, let’s examine the concepts of accuracy, precision, and efficiency, as these are core constraints and trade-offs evaluated in every protocol development decision (Figure 1). A relevant example is the assessment of damaged trees on campsites. *Accuracy* is how close a field assessor is in counting ALL the damaged trees caused by visitors who used the campsite. *Precision* is the relative agreement between different field assessors who independently apply the protocols to the same set of sites. *Efficiency* reflects the amount of time required to perform the assessments. Trials conducted with agency field staff reveal variation in their diligence in locating and counting damaged trees in adjacent offsite areas, and trees located between two sites may be double-counted or omitted. These problems diminish both accuracy and precision, along with the added *cost* of excessive time (efficiency) spent by the most conscientious staff, and the *cost* that these measurement errors are confounded with “real changes in actual conditions,” which defeats the core purpose of monitoring. A common solution has been to restrict assessments of tree damage (and stumps) to within campsite boundaries, a less accurate but far more precise and efficient protocol. Even with this practice, altered site boundaries and sizes over time directly affect tree damage and stump counts, unless the protocol includes counts within both old and current boundaries. This would improve accuracy and precision but at a very substantial *cost* in efficiency. Another option would be to use campsite size to compute and compare these counts on a per square meter basis.

**Figure 1.** Precision is how close repeated separate measures under the same conditions are to each other. Accuracy is how close measures are to the “true” or actual value. The true value for the normal distribution curve graphs is the left-hand vertical dashed line.(From: Davies 2020)



In developing a monitoring strategy and protocols there are many options to consider, including photography, descriptive condition classes, ratings, and measurements. To illustrate these and describe their pros and cons we will consider *Site Size*, perhaps the most important and common indicator in recreation site/campsite monitoring programs. Site size is a preferred indicator because it directly measures the areal extent of intensive trampling impact, which indirectly affects other salient impacts such as the areal extent of vegetation loss and exposure of soil available for erosion.

**Photos** - While campsite photos have long been included in monitoring programs, these provide no quantitative information on site size unless taken from directly above, with little to no tree/shrub cover, and with a reference object of known dimensions. Three dimensional and structure-from-motion photography are also possible but technical challenges and low efficiency limit the utility of these options. Difficulties in determining campsite boundaries with accuracy and precision using photographs can also introduce substantial error on some to many sites. Photos are primarily used to provide a visual record ensuring the correct site has been relocated and to illustrate site changes over time to both managers and the public.

**Condition Classes** – Ratings derived from descriptive campsite condition classes have been another traditional method used to track changing site conditions (Figure 2). This is a highly efficient but subjective method that yields categorical ratings, an ordinal measurement scale that significantly limits analytical operations (Table 1).

**Figure 2.** Condition Class – Campsite conditions can be characterized by recording a rating from standardized site condition descriptions.

**Rock (R)**: Site is predominantly on rock surfaces so the effects of trampling are difficult to see/assess.

**Class 1**: Site barely distinguishable; slight loss of vegetation cover and /or minimal disturbance of organic litter.

**Class 2**: Site obvious; vegetation cover lost and/or organic litter pulverized in primary use areas.

**Class 3**: Vegetation cover lost and/or organic litter pulverized on much of the site, some bare soil exposed in primary use areas.

**Class 4**: Nearly complete or total loss of vegetation cover and organic litter, bare soil widespread.

**Class 5**: Soil erosion obvious, as indicated by exposed tree roots and rocks and/or gullying.

Let’s review the four levels of measurement to better understand the pros and cons associated with appropriate operations for analyzing and summarizing the resulting data (Table 2):

* *Nominal* data cannot be ordered or measured, such as the geographic area of a campsite (e.g., Muir Lake basin or Jones creek drainage) Ridge). Analyses are limited to reporting the number of campsites in each location and which location has the most sites.
* *Ordinal* data have values that can be ordered but the differences between the values are not the same or are meaningless. Condition classes can be ordered, but a site rated class 4 is not twice as degraded as class 2. Such data can be summarized with frequencies, mode, and median values but mean values are inappropriate.
* *Interval* data are measured along a standardized scale with equal distances between values, but they lack an absolute zero point. Examples include temperature (C or F), and pH, whose values can be added and subtracted but multiplication and division are not permitted. Consider that a temperature of 40°C is not twice as hot as a temperature of 20°C because 0° is an arbitrary number (i.e., you can have negative temperatures). This is proved by converting to F: 104°F vs 68°F, and 104 is not twice 68). Very few resource-related indicators fall into this category.
* *Ratio* data are the same as interval but with an equal and definitive ratio between each value and an absolute zero as the point of origin, i.e., negative numbers are not possible. Examples include campsite size, vegetation cover, and number of damaged or felled trees. There are no limitations on analyses with ratio data, so it is the most preferred scale of measurement.

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| --- | --- | --- | --- | --- |
| **Table 2.** Four possible levels of measurement and their appropriate (valid) operations for analyzing and summarizing data. | | | | |
| **Levels of Measurement** | | | | |
| **Analysis Operations** | **Nominal** | **Ordinal** | **Interval** | **Ratio** |
| Values can be ordered |  |  |  |  |
| Frequency Distribution |  |  |  |  |
| Mode1 |  |  |  |  |
| Median1 |  |  |  |  |
| Mean1 |  |  |  |  |
| Can quantify the difference between each value |  |  |  |  |
| Can add/subtract values |  |  |  |  |
| Can multiply/divide values |  |  |  |  |
| Has a “true” zero |  |  |  |  |
| 1 - Mode is the most common value for an indicator, median is the middle value, and mean is the average value. | | | | |

Condition classes provide no assessment or data on site size because they focus on the progression of impact to vegetation and organic litter cover to exposed and eroded soil. Sometimes that progression proceeds in parallel with site expansion, though intensively used small sites can easily degrade to the highest impact classes and large sites may have little to no intensively impacted areas.

**Multi-Parameter Ratings** – This efficient approach generally provides ratings for 6-12 indicators of campsite condition, defined by describing several categories for each indicator. While multi-parameter ratings are also very commonly applied, there are several important deficiencies that have not been widely recognized. Let’s examine a typical categorical rating format for the salient site size indicator:

**Site Size:** 1) <400 ft2, 2) Site area = 401-800 ft2, 3) Site area = >800 ft2.

The number of categories can vary, generally from 3 to 5 with 3 being the most common. Having only three categories allows field staff to efficiently rate a site without measurements but leads to *Problem 1*. Without measurements field staff may quickly but wrongly estimate site sizes, a particular problem when a campsite’s size is close to category boundaries (e.g., 400 or 800 ft2in our example). Adding more categories increases the difficulty of rendering accurate ratings unless site measurements are made, which reduce assessment efficiencies. In addition, experience with these categorical systems has revealed that managers commonly fail to calibrate their rating category boundaries to the distribution of values for each indicator (Marion 1991). This leads to *Problem 2*, low sensitivity in detecting change, i.e., change equal to the breadth of indicator categories can occur without causing a shift in rating. For example, if a single category contains 70% of all sites the category boundaries are too broadly defined, greatly reducing its ability to alert managers to changing conditions. Even if ratings are initially calibrated so that nearly equal percentages of sites fall into each category, change over time will eventually lead to imbalances that reduce monitoring sensitivity. Recalibrating rating categories at that point would prevent valid comparisons to all earlier data. Adding more categories reduces these problems but also reduces the accuracy and/or efficiency of ratings.

*Problem 3* for multi-parameter ratings systems is that they must include an upper category encompassing an unlimited level of change, e.g., sites sizes >800 ft2. This is a particularly significant deficiency in that managers care greatly about campsites that continue to expand, for example, not alerting managers to a four-fold expansion of a site from 801 ft2 to 3204 ft2. Finally, ratings systems produce ordinal data, *Problem 4*, that severely limits data summarization and most relational statistical analyses that could provide additional insights into causal or influential factors that managers might manipulate as corrective actions.

**Measurements** – Field staff can also perform counts or measures for each site condition indicator, which generally increases assessment accuracy and precision but decreases efficiency, *Problem 1*: extended assessment time. However, staff who develop monitoring programs should recognize that during monitoring fieldwork the time traveling to and from campsites or trail sampling sites greatly exceeds the assessment time at those locations. The “cost” in less efficiency of having two campsite assessment staff spend 10-15 minutes measuring campsite indicators vs. 5-10 minutes to assign ratings must be weighed against the “benefits” of obtaining improved data quality and analysis capabilities.

To further illustrate trade-offs let’s consider three leading methods for measuring campsite sizes: the Geometric Figure (GF) method and the GPS method (both described later in this document), and the Variable Radial Transect (VRT) method (see Marion 1991). These methods have assessment times varying from about 3-5 minutes for the GF and GPS methods to 5-10 minutes for the VRT method. This leads us to *Problem 2*, every measurement method includes a generally unknown component of measurement error, though special studies can be conducted to assess measurement error and/or determine a “minimum detectable change” for each indicator (Cole 1989, Williams & Marion 1995). While assessment error is also applicable to categorical ratings, the breadth of the rating categories conceals and accounts for this error; for measurements the error component must be acknowledged and considered more directly.

The Monitoring Manual

Most sources of measurement error can be addressed and minimized by developing and documenting assessment protocols in a comprehensive but concisely written monitoring manual, augmented with supporting photos and diagrams (illustrated in the Monitoring Indicator Library). This process promotes quality assurance by fully documenting all protocols, also ensuring that future staff can continue monitoring efforts *and* interpret previously collected data. Protocol development work implicitly recognizes and makes trade-offs between assessment accuracy, precision, and efficiency. As part of this process monitoring program developers must also consider and carefully address each potential source of measurement error through the development of standardized protocols and quality assurance components, including field staff training and management. Monitoring manuals must include and field staff must doublecheck a *comprehensive* list of all items/devices required for monitoring work before they depart. Forgetting batteries or cords for recharging electronic devices can cause considerable inefficiencies.

The site size indicator will continue to be used as an example for protocol development and documentation as discussed in this section and illustrated in the Monitoring Indicator Library. The process begins by *defining the indicator attribute to be assessed*: the size of a campsite in our example, which may be a single degraded area of vegetative and soil impact caused by overnight camping, or a proximate collection of separate disturbed spots caused by sleeping, cooking, eating, social, water collection, dish washing, campfire, or food storage activities. The manual should also carefully consider and define whether a *census* of sites will be assessed, or if and how they will be *sampled* to yield a representative dataset. If sampling is involved, it will be important to obtain any necessary technical expertise and consider a formal peer review process of provided guidance.

For each disturbed spot, field staff must be able to accurately determine visually obvious human disturbance boundaries to enable precise and efficient measurements. Unfortunately, site boundaries range from clear-cut to ill-defined, dependent on the following attributes: vegetation cover, vegetation composition, vegetation height/disturbance, organic litter disturbance/absence, and lichen disturbance/absence on rock. Human disturbance boundaries may not be sufficiently discernable, preventing site size determinations in areas of rock substrates, substantial flooding, or intensive livestock grazing. Refer to the Monitoring Indicator Library for examples of these protocols and how photographs can be used to illustrate and improve accurate and precise field staff judgements.

The next step is the selection of an assessment method. The GPS method is a preferred site size measurement method when sub-meter units and sufficient open sky are available to permit accurate readings. Field staff simply walk campsite boundaries, collecting an adequate density of points that define a polygon whose shape accurately reflects the campsite boundaries. Accuracy can be improved by using the best available GPS units, a ground plane antenna, and post-processing algorithms, but challenging terrain, dense forests, and small sites can require recording averaged boundary points, reducing efficiency. In these situations, the GF method may be more efficiently substituted by superimposing one or more geometric figures over site boundaries and measuring their dimensions. This method is also optimal for field staff who are assigning sites to size categories in ratings systems. Alternately, the VRT method involves field staff walking the boundary to place pin flags at a minimal number of points (typically 5-15) that define a polygon that accurately depicts the site shape and area. Staff then select an easily identified permanent reference point and measure the distance and compass bearing to each pin flag. A spreadsheet program calculates site size from these measures. The VRT method may be more accurate and replicable but is less efficient than the GPS or GF methods.

Potential sources of this error for these site size measurements include differing judgements of campsite boundaries, spatial skills/experience in assigning geometric figures or polygon vertices, measuring distances and bearings with tapes and/or devices, GPS accuracy, and data recording errors. The ability of measurement-based monitoring protocols to detect and characterize resource change thus requires greater attention to measurement protocols, quality assurance, and staff training to minimize measurement error and its potentially confounding influence.

Data recording methods must also be carefully considered to minimize error. The traditional method of recording data on field forms is rapidly being replaced by direct entry to smartphone apps, tablet computers, and GPS units. Electronic methods have significant advantages as they can error-check data, prevent missing data, incorporate and link records to GPS coordinates and photos, and eliminate subsequent data entry and associated errors. Field staff are increasingly using cell phone apps due to their diversity and ease of use, easy linkage to complete protocol descriptions including diagrams and photos, ability to access phone GPS and camera capabilities, and to easily sync with and transfer data to cloud storage. Cell phones quickly store in a pocket when traveling between data collection sites, are smaller/lighter, and have lower power requirements than other devices. Most electronic devices allow customized screens with efficient data entry, error checking (e.g., restricting data entry to a range of values or set of codes), avoidance of missing data (notification or prohibition on saving an incomplete record), and power resupply from small portable batteries.

Modern smartphones generally access up to five GNSS constellations of GPS satellites, delivering accuracies in the range of 10-30 ft, compared to sub-meter accuracies for expensive high-end GPS units with post-processing differential correction capabilities. The accuracy of both suffer to some degree when used under dense forest canopies or near cliffs and steep terrain. In the best settings, sub-meter GPS units can be used to accurately document site locations and determine site sizes by walking boundaries; current smartphone GPS accuracies limit their use to documenting site locations (see D'Antonio et al. 2013, Marion et al. 2022).

**Staff Training, Management, and Calibration.**

In addition to ensuring the development and communication of clear, thorough, indicator assessment protocols, quality assurance and quality control are promoted by implementing a comprehensive program of staff training, management, and calibration. Staff training ensures that all field staff understand the monitoring objectives, the importance of accurately documenting actual changes in resource condition, minimizing measurement error, and the need for precision (consistency) between differing field staff. Some core components of staff training include: 1) reading and discussing the monitoring protocols and how collected data will be integrated into adaptive management decision-making, 2) field demonstration and practice in assessing all protocols in differing environmental conditions and impact severity sufficient to thoroughly train all staff, 3) full training and practice with all navigation, measurement, and data recording devices (e.g., GPS navigation to previous sites), 4) independent assessments following by comparison and discussion of differing assessments, 5) periodic changing of partners to promote development of consistent judgements in applying assessment procedures, and 6) how to respond to new situations where protocols are difficult to apply.

Field staff may encounter unanticipated assessment challenges, so they require an understanding of the accuracy, precision, and efficiency trade-offs previously discussed. When dilemmas present themselves during fieldwork these trade-offs should be discussed, with notes and photos taken to convey the new situation to monitoring program supervisors, along with the decisions made and records affected (for review and possible edits). When monitoring protocol edits are necessary their potential influence on comparability to pre-existing data must be evaluated. Monitoring manuals should always have versions and/or dates when they were in use and a new version/date should be recognized when any significant revisions are made.

Monitoring field staff can be seasonal or permanent staff but should be dedicated to the monitoring function and not available for extended alternate duties like firefighting. Quality assurance is enhanced by using a small number of full-time field staff to complete the monitoring in a short period of time, in contrast to a larger number of staff conducting monitoring as a collateral duty. Alternately, full-time monitoring staff can be paired with various district staff who may provide more efficient logistical support in navigating to or finding campsites. Staff should have sufficient outdoor knowledge, experience, and gear to operate safely and comfortably in remote settings and poor weather *and* collect high quality data. Field staff will perfect their assessment practices and judgement over time so it’s best to periodically exchange their partners and/or regroup to conduct calibration exercises. Supervisors should also periodically check collected data to look for possible problems, including unlinked or missing GPS coordinates and photos, and to back up all data.

Monitoring should consistently be performed in the mid- to late-use season due to the annual cycle of impact and recovery. Avoid early season monitoring of visitor impacts as resource conditions reflect off-season recovery and research reveals that impacts change rapidly in response to initial and increasingly but low levels of use, with resource conditions more stable through mid- to late-season periods. Also avoid extremely late season monitoring when leaves, needles, or snow fall and cover recreation site and trail surfaces. Monitoring can be applied on a fixed schedule, for example every five years, or 20% of sites assessed each year with a cycle completed over five years. Monitoring can also be flexibly applied when staff report changing or concerning conditions, possibly only in selected management zones on an “as needed” basis. While unit funding and staffing necessarily affect monitoring capabilities such resources should be planned for and institutionalized before initiating a long-term monitoring program. Responsibility for completing monitoring can be ensured by making it an essential element of staff job responsibilities.

Procedures have been described by Cole (1989) and William and Marion (1995) for assessing measurement error for indicators. While not essential, some idea of the size of measurement error for each indicator is helpful when interpreting data from a single measurement, examining longitudinal differences between monitoring cycles, or comparing data with management standards. Generally, these protocols require several field workers independently evaluating a common set of sites to derive these statistics. Measurement error investigations should be conducted with experienced field evaluators between the middle and end of fieldwork. Procedures used in William and Marion (1995) yielded percentage of variance estimates for different survey staff, campsites, and a miscellaneous error term. They also yielded estimates of precision associated with ***relative*** comparisons, whether an indicator’s condition exceeds that found on some other campsite or at some other time, and precision associated with ***absolute*** comparisons, such as with a standard. They found high precision for areal measures of change (site size and area of vegetation loss and exposed soil – these had low variance for field staff and the error term). In contrast, low precision was found when field staff were asked to distinguish between described levels of tree damage or root exposure. As a result, subsequent studies combined these categories as “damaged trees” or “trees with root exposure.”

**Data Summarization, Analyses, and Comparison to Standards**

Monitoring data serve little to no purpose when they are *not* analyzed, presented in formats that facilitate decision-making, or considered by decision-makers. Reporting procedures that specify data summarization, analyses, and the presentation and interpretation of monitoring findings are critical and should be included in performance duties and evaluations. GIS analyses permit powerful geospatial analytical and presentation capabilities that also improve the communication and use of monitoring findings. Reports should focus on the interpretation of findings and their implications for management.

Basic descriptive analyses include frequency distributions, appropriate measures of central tendency (mean, mode, median), boxplots, and calculation of confidence intervals and percentiles. For example, box plots (Figure 3) visually convey the range of data (vertical lines), central tendency (the box contains the middle 50% of values), and extreme values (outliers, lying beyond the vertical lines). While *selecting reasonable standards* that specify minimally acceptable conditions is an inherently value-laden and subjective process, presentation of representative data characterizing the distribution of indicator values and outlier or extreme values can assist the evaluation and selection process.

For example, boxplot outliers are those that are more than 1.5 times the value of the interquartile range (the difference between the 25th and 75th quartile). Another statistically derived option would be to consider the 90% or 95% upper confidence limits, e.g., the probability of observing a value outside the 90% confidence limit is less than 0.10. Yet another option is to consider the 90th or 95th percentiles, e.g., the 90th percentile omits the 10% highest values. Such measures provide statistically derived “places to start” the process of considering alternative standards that are potentially realistic given current indicator distributions. In the Figure 1 example of maximum trail tread incision for high use trails, these values are 4.5 inches for boxplot outliers, 2.5 for the 90% upper confidence limit, and 4.3 for the 90th percentile. Regardless, staff must recognize that the selection of actual standards/thresholds is inherently a subjective process focused on defining the point at which degradation reaches “unacceptable” levels based on agency laws, directives, professional judgement, and collaboration/input from stakeholders



Figure 3. Boxplots of maximum incision soil loss for low, moderate, and high use trails.

*Note:* Boxes represent first (lower line) and third (upper line) group quartiles (the 25th and 75th percentiles); lines inside the boxes represent the overall mean for each group; vertical lines (“whiskers”) represent the range of values; and outliers are “extreme values” that lay beyond the end of the upper whisker (from Marion 2006).

Also recognize that data collected in differing and seemingly non-comparable formats or scales can be standardized for comparison or inclusion in multi-parameter summary impact ratings or weighted indices (Marion 1991, Appendix 2). A common method for standardizing indicator values is to compute and use percentile ranks. However, recognize that this ranking method completely loses the relative distance between the original values, which may have important management implications. This method also loses any information when the number of unique values exceeds 100. The common z-score (normal score) statistical transformation is the preferred method as it standardizes values that preserve the relative distances between values by subtracting the mean from each raw value and dividing by the standard deviation. This creates a directly comparable distribution for each indicator with a mean of 0 and standard deviation of 1 (values range from negative to positive). These values can be directly compared across indicators or can be weighted and averaged to compute a standardized summary impact score, though the aggregate score values can no longer be interpreted in terms of standard deviation units.

Analytical work with representative monitoring data may also prove useful when considering *different types of standards*, including maximum, mean, and aggregate condition values, considered alone or on a per unit length or area basis (Williams & Marion 1995). Using the example of campsite size, a single maximum size like 800 ft2 could be applied to a census of monitoring assessments within a management district or zone to prevent the occurrence of larger sites. However, this option can permit substantial degradation to smaller sites before standards are exceeded. Using a mean or median value as a standard would allow a wide range in site sizes (to accommodate different group sizes) while constraining site expansion over time on all sites. However, a problem with this option is that exceptionally (perhaps “unacceptably”) large campsites can be offset by several smaller campsites elsewhere, or conditions could “improve” if new smaller sites were created by visitors (Marion 2006, Williams & Marion 1995). Thus, both types of standards fail to constrain the significant long-term problem of site proliferation, which is only addressed through an aggregate condition standard, e.g., aggregate campsite impact shall not exceed 15,000 ft2 in travel zone X, or within a 20-acre circle moved across the landscape (a density evaluation). Such a standard is not distribution dependent and is therefore sensitive to changes in campsite numbers *and* sizes. More than one type of standard can be used, and all types can vary by management zone or district, e.g., less restrictive in accessible front-country areas and more restrictive in wilderness areas.

In the case of soil loss on trails, a maximum condition tread incision indicator could be exceeded in several different specific but isolated places. One option to address this deficiency is to calculate a “moving average” by calculating an average from a fixed number of consecutive transects (e.g., 4 to 5), dropping the first and adding another at the end, hence the name “moving” average (Marion 2006). This option is available in many statistical software packages as it produces a set of averages that are less sensitive to single large “outlier” indicator values. A standard set on mean conditions and evaluated against the moving average values for each trail would be exceeded less frequently by extreme or atypical conditions associated with isolated locations. The number of trail points included in the average directly influences the sensitivity of this option, the smaller the number the more sensitive to any single point.

Yet others have suggested relative rate of change (percent-based) and probabilistic types of standards. Relative or percent-based standards specify a maximum rate of change between monitoring cycles, like <100% increase in damaged trees (IVUMC 2019). While these make good “red flag” indicators to alert managers of excessive change on individual sites, they can be problematic as standards by establishing *rates of change* as unacceptable, in lieu of actual resource conditions (Williams & Marion 1995). Further, consider that a 100% increase in damaged trees is far more critical with an increase from 10 to 20 than an increase from 1 to 2. For this reason, it is best to not use percent measures for most impact indicators; actual counts are a preferred measure. Probabilistic standards, commonly used for social/experiential indicators, can be more problematic for resource indicators. Consider the example, “Campsite size < 800 ft2 on more than 5% of campsites in travel zone x *or* on more than 1 campsite/20 acres.” Such standards are implicitly allowing for some degree of unacceptable conditions to be permanent on the land (unlike non-persistent social conditions), which muddies the management specification of acceptable conditions and permits a potentially large amount of long-lasting degradation (Williams & Marion 1995).

Finally, high quality monitoring data with interval or ratio scale assessments permit the greatest flexibility in conducting relational analyses, such as multiple regression modeling and statistical testing to identify influential factors, the statistical significance of changing conditions, or to examine temporal or geospatial trends. For example, Reid and Marion (2005) analyzed seven national park and forest monitoring datasets to evaluate campfire impacts and management policies using two indicators: number of campfire sites and the number of damaged trees/hectare, /site, and percent of damaged trees. Marion and Wimpey (2016) analyze data from three protected areas to model and clarify the influence of factors affecting soil loss that managers can manipulate to improve sustainable trail design and management. If managers lack the capability to perform such analyses their datasets can be shared with scientists through contractual agreements to perform such analyses.

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Monitoring Indicator Library: Recreation Sites & Campsites

This library of indicator protocols represents an effort to develop “standardized procedures” for conducting visitor impact assessments using the best available practices that have been informed or peer reviewed by the scientific literature. When possible, monitoring program staff are encouraged to download and apply these indicators and protocols “as is,” with minimal revisions when necessary to adapt them to local environmental conditions or information needs. Such edits should carefully consider the trade-offs between assessment accuracy, precision, and efficiency, along with improvements in technological devices for measuring and inputting data. Some indicators may be unnecessary (omitted) while others may be added. Note that collecting ratio and interval scale data allows subsequent categorization to enable comparisons with earlier data collected in categories. Before using this monitoring indicator library, please consult the more comprehensive guidance on monitoring objectives, legislative guidance, and use of monitoring data in visitor use management planning and adaptive management practices in the publications listed at the end of this document.

The procedures in this section are for recreation sites, including day use sites, but with a focus on overnight campsites. Three types of indicators are included: Inventory – pertaining to general attributes like site locations and types or use, Sustainability – pertaining to attributes that limit the areal extent of site impact, ensuring experiential quality, and functional attributes, and Impact – pertaining to site conditions and the extent of resource impact. Monitoring staff are encouraged to incorporate technological advances in their monitoring, particularly the use of smartphone apps that allow efficient electronic data entry with accurate GPS coordinates and high-resolution geo-referenced digital photos. Additional advantages are integrated real-time protocol “look ups,” data quality assurance procedures (e.g., out-of-range checks, inability to close/save records with missing data), automated linking of GPS coordinates to data and photos, and easy transference and safe “cloud” storage of *all* collected data whenever phone apps are “synched.” Other advances include use of increasingly accurate sub-meter GPS units and distance-measuring devices. On return from each fieldwork trip staff should *immediately* follow a checklist to synch all smartphones and download/double-check all data stored in the cloud. Data from any separate GPS units should also be transferred, checked, and backed up. Any problems with field assessments should be immediately discussed based on fieldnotes, with clarifications or edits made to the protocols, which must be updated/synched to all devices or printed guidance.

**Assessing Site Sustainability:** Recent recreation ecology research has yielded information enabling the selection of sites able to accommodate heavy use over time while minimizing the chronic problems of site expansion and proliferation. A primary objective for most land managers is to minimize the aggregate areal extent of visitor impact (e.g., the sum of site sizes for a management unit or travel zone). For example, this can involve restricting campsite numbers through a *containment strategy* that focuses use on limited numbers of established or designated campsites, sustainably selected in areas where sloping topography, rockiness, or uneven terrain will *permanently* constrict campsite expansion and proliferation. Alternately, a *dispersal strategy* and pristine site camping practices that prevent the creation of campsites can be applied, most effective with more experienced campers outside of popular trail corridors.

Including sustainability indicators allows managers to avoid and minimize camping impacts proactively and permanently. Research and monitoring data reveal that visitors most frequently select campsites in flat terrain near water or attraction features that facilitate rather than restrict campsite expansion and proliferation over time. The *campsite expansion potential* indicator promotes selection of campsites in areas where topography, instead of education or regulation, compels activity concentration and minimizes the aggregate areal extent of camping impact. This is the most important sustainability indicator. *Tree canopy cover* is also an influential indicator because sites with low tree cover have a lower threat from hazard trees and greater sunlight enhances the cover of resistant and resilient grasses and herbs. If camping on forested sites is necessary, this indicator reveals the most densely forested sites that support little to no plant groundcover – using these sites results in less loss of plant cover than compared to campsites under intermediate canopies that support more substantial plant groundcover. *Intersite visibility* and/or distance is the most important social/experiential indicator as this attribute can be considered or manipulated to ensure a desired level of solitude and natural quiet for visitors.

Campsite *functionality* indicators should also be considered to ensure the selected sustainable sites will be desirable to visitors and meet their needs. Site management work, like improving tent pads or installing site facilities, can improve a number of these attributes if sites with multiple negative ratings are needed.

Recreation sites and campsites are defined as areas of visually obvious disturbed vegetation, surface litter, or substrates caused by human recreational use within the geographic areas prescribed for monitoring. Recreation sites receive mostly day-time activities whereas campsites receive predominantly overnight use, though both uses can occur on the same sites. Note that both types of sites may be a single degraded area, ***or*** a proximate (adjacent) collection of separate disturbed spots caused by recreational uses. For example, a core campsite area with a fire ring or cooking area may include several nearby visually obvious smaller “satellite” tenting spots that would likely be used by a single group. Consistent judgment is needed to assign, and in later surveys reassign, these proximate disturbed areas, capturing changes in their size, merging, and/or creation of new spots. Assessing each of these areas as a separate site is an option, but one that is generally substantially less efficient.

Careful searches of all trail corridors are conducted to locate and assess a census of all recreation sites and campsites, generally found by following all formal and informal (visitor-created) trails, however faint. Efficiency can be gained by monitoring a stratified random sample of the geographic areas, within which a census of all sites is conducted. When sites are found, a determination will be made if there is sufficient human trampling-related disturbance to produce visually obvious site boundaries. If affirmative, then all assessments will be performed, if not, then only a subset of Inventory Indicators will be assessed.

Assessments are best restricted to the latter two-thirds of the visitor use season, but before leaf fall and/or the threat of snowfall (*specify approximate range of dates*). This restriction recognizes that site conditions generally recover during off-season periods of lower visitation, and reflect a rapid increase in impact during early season use. Site conditions and impacts are most pronounced and stable during the mid- to late-use season and reflect the resource impacts of that year’s visitation. When practical, site assessments in subsequent monitoring cycles should be completed as close in timing to the original year’s measures as possible to avoid phenological or use-related differences (plus or minus two weeks is best).

This monitoring guidance includes commonly used indicators calculated from field data, along with the computational descriptions. Perform these after field data has been checked/cleaned of any errors. Finally, recreation ecologists have developed and refined many analytical procedures and data presentation formats that aid in summarizing and communicating monitoring data findings. For examples, see Marion (2006) and Marion and others (2020a,b) for reports that include such presentations and how data can be used in VUM adaptive management decision-making.

**Recreation Site Library of Monitoring Protocols**

(version xx/xx/xxxx)

**Field Materials**

*Check carefully before leaving for the field*

 Topographic maps with roads, trails, and recreation sites from most recent survey (paper and/or digital).

 Submeter GPS unit w/charged or backup batteries, all cords, stylus, antenna/lead, and pack. Loaded with necessary maps, previous data, guidance, and data dictionaries.

 Sonin Combo Pro distance measuring unit w/new batteries and/or tape measure (100 ft. in tenths).

 Cell phones or tablets with data entry phone apps and backup batteries and cords. Loaded with necessary maps, previous data and photos, and error-checking data entry screens with look-up capability to view all protocols. Otherwise include printed field manuals and sufficient numbers of field forms.

 Umbrellas and zip-lock bags as needed to protect electronic gear from rain.

 Wire pin flags (15) *optional*.

 Small notebook and pens for recording progress or notes regarding monitoring issues, progress, and problems.

**Inventory Indicators**

**Date**: Assessment date (e.g., 07-12-22).

**Staff**: Identify the field personnel who conducted the site assessment.

**Site Number**: A unique alpha-numeric number with letters denoting management units, travel zones, or geographic areas (list these and their letters), and numbers for consecutive sites within these areas.

**Comments:** Record descriptive comments as needed. Include any old site numbers from prior surveys that should be tracked. If two former sites have merged use one of the site numbers and record the other site number as “merged.” If the site is recovering with no recent use and/or clear boundaries indicate this under use type.

**GPS Coordinates**: From the center of the site, record its location using a sub-meter GPS device if available (the WGS84 decimal degree datum is suggested). Otherwise use a smartphone data collection or GPS phone app (accuracy generally about 15-30 ft). Also collect coordinates for the center of any affiliated satellite use areas (e.g., separate visually obvious tent pads).

**Location Description**: Record comments that help to identify this site among others present in the event of low accuracy GPS data. Describe site location relative to the local topography and unique visually obvious features (e.g., 120 ft from river on E. side, on a flat bench 20ft above river, no other sites visible).

**Designation**: Designated, Established, No Designation, Closed/Recovering, Recovered

**Use Type** (predominant): Day Use/Vista, Campsite, Horse Campsite, Group Use, Commercial, Recovering (no recent use/no clear site boundaries – *omit assessments for all following indicators*)

**Estimated Use Level**:Low (1-10 nights/yr), Moderate (11-20 nights/yr), High (21-30 nights/yr), Heavy (>30)

*Note:* For the following three indicators actual distances could be derived from GIS procedures but should be recorded in the field is areas of inaccurate GPS signals (steep topography, dense canopies).

**Distance: Other Campsites**: Distance between site center points of closest other site: (<100 ft, 101-200 ft, 201-300 ft, >300 ft)

**Distance: Formal Trail**: Distance between the site center point and the nearest formal (designated) trail: (<100 ft, 101-200 ft, 201-300 ft, >300 ft)

**Distance: Water**: Distance between the site center point and the nearest permanent water source: (<100 ft, 101-200 ft, >200 ft but < 10 min walk, >200 ft but >10 min walk)

**General Comments**: As needed, describe significant impacts, difficult assessments, needed protocol edits, and site recommendations.

**Campsite Sustainability**

**Campsite Expansion Potential:** Walk the campsite’s boundary looking offsite and count the number of potentially usable 2-person tenting spots within a 30-ft buffer considering topography (sloping terrain), rugosity (rockiness, uneven terrain), and wet substrates. ***Disregard*** the presence of *any* herbaceous or woody vegetation and moveable woody debris and rocks (i.e., include counts in these areas if sufficiently flat and dry). For campsites that consist of several separate but proximate use or tenting areas conduct counts for each separately and sum, but do not double-count. Larger counts indicate less sustainable campsites.

**Tree Canopy Cover**: Imagine that the sun is directly overhead and estimate the percentage of the site that is shaded by the tree canopy cover; record the best mid-point value. Note: use “85.5” for nearly full tree canopy cover over the site; use “98” only if the cover is sufficiently dense that ground vegetation cover is substantially diminished (e.g., <50%):0‑5% **(2.5),** 6-25% **(15.5),** 26‑50% **(38),** 51‑75% **(63),** 76‑95% **(85.5),** 96‑100% **(98)**

**Intersite Visibility:** Number of campsites within 100 yrds that would be visible if occupied. This indicator reflects the relative opportunity for campsite solitude and natural quiet. A possible substitute measure is the calculation of inter-site distances with GIS software.

**Usable tent pads:** Number of usable tent pads within site boundaries. Usable pads should be large enough for a 2-person tent and relatively smooth and slightly sloped (well-drained). When considering this indicator consider that limited site maintenance work can often increase this number if needed; most good campsites should have 2-3 usable tent pads. Consider that sites with >4-5 tent pads could also be considered “too large” to be sustainable.

**Substrates:** Assess the percentage of the campsite that hasdurable substrates such as bedrock, rock, gravel, flood-prone sandbar/shoreline that are naturally devoid of vegetative cover: 0‑5% **(2.5),** 6-25% **(15.5),** 26‑50% **(38),** 51‑75% **(63),** 76‑95% **(85.5),** 96‑100% **(98)**

|  |  |
| --- | --- |
| **Campsite Functionality Indicators** | **Rating** |
| Rate each attribute as *negative*, *ok*, or *positive,* or *number* for the last three. Use the *Comment* field to describe any noteworthy problems for selected indicators. | |
| **Ease of water access:** Distance, terrain, and elevation difference. | – ok + |
| **Cat-hole potential:** Ease of digging, soil depth, and privacy. | – ok + |
| **Bear bag hang:** Presence of tall trees w/good limbs for hanging bags. | – ok + |
| **Scenic Attractiveness:** Of campsite, surroundings, and vista. | – ok + |
| **Seating:** Presence/quantity of usable rocks or logs. | – ok + |
| **Stove rock:** A large flat “kitchen” rock for camping stove and pots (#). | #: |
| **Fire Site:** Fire site (regardless of legality) (#). | #: |
| **Dead/Hazard Trees:** Dead campsite-proximate trees that could fall or drop limbs (#).  Field staff are *not* technically trained/qualified to make these assessments. This indicator provides an approximation of standing dead trees and trees with dead limbs on or near the site. | #: |
| **Comments:** | |

**Impact Indicators**

**Condition Class**: Compare site conditions to descriptive classes and record the most apt class number.

|  |  |
| --- | --- |
| **Rock (0)** | Site is predominantly on rock or naturally barren substrates (gravel/sand shorelines); the effects of trampling are difficult to see or assess (other than footprints in sand or wet soils). |
| **Class 1** | Site barely distinguishable due to slight loss of vegetation cover and/or minimal disturbance of organic litter. |
| **Class 2** | Site obvious; vegetation cover lost and/or organic litter pulverized in primary use areas. |
| **Class 3** | Vegetation cover lost and/or organic litter pulverized on much of the site, some bare soil exposed in primary use areas. |
| **Class 4** | Nearly complete or total loss of vegetation cover and organic litter, bare soil widespread. |
| **Class 5** | Soil erosion obvious, as indicated by exposed tree roots and rocks and/or gullying. |

***Note:*** An efficient but subjective method with categorical/ordinal ratings that limit analytical operations and omit areal measures of disturbance (e.g., a very large Class 3 site is likely worse than a small Class 5 site). This method also overestimates impact in areas with little natural vegetative cover or organic litter.

**Site Size**: Recreation sites are defined as areas of visually obvious disturbed vegetation, surface litter, or substrates caused by human recreational use within the geographic areas prescribed for monitoring (Figure 1). Recognize that some sites, such as those with dense overstories, may be too shady to support much ground vegetation cover, requiring determinations based on organic litter (dead leaves/needles) that are pristine and intact vs. litter that is pulverized or absent. For rock or barren surfaces compare to offsite pristine areas to focus on visually obvious trampling disturbance differences in plant (include moss/lichen) and organic litter cover, and/or the presence/absence of pinecones, small rocks, and gravel that are generally absent from use/tenting areas. Omit areas for sand or fine gravel substrates (e.g., along shorelines) that lack vegetation and organic litter from flooding; footprint densities in these naturally barren substrates are too dynamic and ephemeral to support objective boundary determinations.

Sometimes sites may include a proximate (adjacent) collection of separate disturbed spots caused by recreational uses. For example, a core campsite area with a fire ring or cooking area may include several smaller separate but proximate visually obvious “satellite” tenting spots that would likely be used by a single group. It is most efficient to combine these as a single site and assess them together.

If other agents of disturbance are present (e.g., grazing or trampling by livestock/wildlife, flooding) examine off-site areas to determine if their effects can be objectively assessed and omitted from boundary determinations. Apply judgement based on interpreting standard photos in Figure 1 (*with any necessary substitutions or additions to represent local vegetation and substrate types*). Do not assess any **Impact indicators** if >40% of site boundaries are indistinct (highly subjective) and/or if other agents of disturbance excessively interfere with determinations.

**GPS Measurement** – After boundary determinations are made position a sub-meter GPS unit at the approximate center of the largest disturbed area and record a >50 point average location position and label it with a unique campsite code. Next, put the GPS in vector mode and walk the site boundaries, ensuring that a point is collected at each significant boundary (polygon) vertex required to accurately render the site’s shape and size. Close and examine the feature and its area measure to verify that it provides an accurate representation of the site shape and area, if not then delete and repeat the process. If satellite reception problems prevent accurate site size data collection, substitute size measurements using the Geometric Figure method. Otherwise, continue to walk and collect the boundaries of all proximate disturbed spots associated with this site, labelling each with the same campsite code and a satellite site number. Averaged center points are not necessary but check each satellite use area to ensure that collected data continue to accurately reflect the site’s location, shape, and size. Sometimes it is more accurate and efficient to use the Geometric Figure Method on all small use areas (e.g., <12x12 ft).



Figure 1. Photographs illustrating site boundary determinations: defined as the most pronounced ***outer*** boundary of visually obvious human recreational disturbance in ground vegetation height (trampled vs. untrampled), cover, composition, or, when vegetation is reduced or absent, as pronounced changes in organic litter cover (intact vs. pulverized), or on rock of lichen or moss cover.

**Geometric Figure Method** – Campsite size is computed by measuring the dimensions of one of more geometric figures that closely correspond to a site’s shape and boundaries (Figure 2). This is an efficient method that can be quite accurate and precise if carefully applied using good judgement. Initially it is helpful to place wire pin flags at the geometric feature vertices. Study the site shape as though looking down from above to determine the optimal geometric figure, or combination of figures. Look both directions along site boundaries as you place the flags and try to mentally balance areas of the site that fall outside the lines with off-site (undisturbed) areas that fall inside the lines. Pins do not have to be placed on site boundaries, as demonstrated in Figure 2. Project site boundaries straight across areas where trails enter the site. Measure and record the essential computational dimensions of each geometric figure (nearest 0.1 foot) using a tape measure or accurate electronic device. Always conduct area computations in the office to reduce field time and avoid errors.



Figure 2. Illustration of the Geometric Figure Method for measuring site sized based on recording the dimensions of one or more superimposed geometric figures.

**Onsite Vegetation Ground Cover (%)**: Estimate the percentage of live vegetative ground cover <2 ft tall within site boundaries, including herbs, grasses, tree seedlings, shrubs, mosses, and folios (leaf-like) lichens. Include nearby "satellite" use areas and exclude rare undisturbed "islands" of vegetation within site boundaries. Refer to the categories and reference photos but record the midpoint values. For this and other indicators, it is helpful to narrow your decision to two categories and select the best midpoint value.



**Offsite Vegetation Ground Cover (%)**: Select a “control” area the site would resemble if never used; it should have similar topographic attributes and substrates, though use may have altered onsite (not control) vegetative attributes. As above, estimate the percentage of live vegetative ground cover <2 ft tall in the control area, selecting the best midpoint value.

***Percent Vegetation Cover Loss (%)*** *(calculated)*: Subtract onsite vegetation cover from offsite cover (midpoint values). Rarely, negative values can occur when woody cover is removed from sites, allowing resistant grass cover that can exceed the cover of plants under dense canopies in control areas.

***Area of Vegetation Cover Loss (ft2)*** *(calculated)*: Multiply percent vegetation cover loss by campsite size (in ft2) to obtain an estimate of the area over which vegetation cover has been lost on the site. This is the most ecologically significant indicator of vegetation impact.

**Onsite Exposed Soil (%)**: Estimate the percentage of exposed mineral or organic soil, defined as ground with little to no recognizable organic litter (decomposing leaves, twigs, pinecones) or vegetation cover within the site boundaries and satellite use areas (refer to reference photos). If the exposed soil has patches of organic litter or vegetation, then mentally combine and exclude the patches from estimates. Refer to the categories and record the best midpoint value.

**Categories:** 0‑5% (**2.5**), 6-25% (**15.5**), 26‑50% (**38**), 51‑75% (**63**), 76‑95% (**85.5**), 96‑100% (**98**)

**Offsite Exposed Soil (%)**: As above, estimate the percentage of exposed soil in the undisturbed control area, recording the best midpoint value.



**Exposed Mineral Soil**

**Organic Litter**



**Organic Soil**

***Percent Exposed Soil Loss (%)*** *(calculated)*: Subtract offsite exposed soil cover from onsite cover (midpoint values).

***Area of Exposed Soil Loss*** ***(ft2)****(calculated)*: Multiply percent exposed soil loss by campsite size (in ft2) to obtain an estimate of the area over which soil has been exposed on the site.

**Tree Damage (#)**: Count the number of live trees (>1 in. diameter) within or on site boundaries (include islands, exclude satellites) that are damaged from visitor use, consisting of numerous small trunk scars and/or nails or 1+ larger cut branch or scar with exposed inner wood. *Ignore* slight damage such as broken or cut small branches, a single nail, a few superficial scars, or damage from lightning and natural causes. Assess damage to a multiple stemmed tree (joined above ground level) as one tree, including a stem that is cut off.

***Tree Damage (#/acre)*** *(calculated)*: Divide the number of damaged trees on the site by site size (in ft2) and multiply by 43560 to obtain the number of damaged trees/acre.

**Root Exposure (#)**: Count the number of live trees (>1 in. diameter) within or on site boundaries (include islands, exclude satellites) that have at least the top half of many major roots exposed more than one foot from the base of the tree. Ignore root exposure from natural causes (flooding) by comparing to adjacent undisturbed areas.

***Root Exposure (#/acre)*** *(calculated)*: Divide the number of trees with root exposure on the site by site size (in ft2) and multiply by 43560 to obtain the number of trees with root exposure/acre.

**Tree Stumps (#)**: Count the number of new and old tree stumps (> 1 in. diameter) within or on site boundaries (include islands, exclude satellites).

***Tree Stumps (#/acre)*** *(calculated)*: Divide the number of tree stumps on the site by site size (in ft2) and multiply by 43560 to obtain the number of tree stumps/acre.

**Access Trails (#)**: Walk the campsite boundary counting all obvious trails leading away; for trails that branch or merge just beyond site boundaries make the count 10 ft from the boundary. Omit faint trails with untrampled plants or organic litter in their tread.

**Fire Sites (#)**: A count of fire sites within campsite boundaries (include satellites). Include old inactive fire sites as exhibited by blackened rocks, charcoal, or ashes. Omit locations where charcoal/ashes have been dumped, unless uncertain.

**Human Waste (#)**: Conduct an “intelligent” rapid search of likely "toilet" areas, typically screened areas just out of sight of the campsite. Count and record the number of individual human waste sites, defined as separate locations with human feces present (not just TP, which could be dug up or from peeing). The intent is to quantify surface disposed human feces.

**Site Photograph**: Select a vantage point that provides the best view of the entire site. Take a georeferenced photo with the camera pointed down to include as much of the site groundcover as possible, turning to take a second photo if needed. The objective is to positively identify the site *and* record a visual image of its condition. If there is any doubt in the accuracy of GPS data take a second photo that *clearly identifies the campsite* by inclusion of distinctive permanent/immovable features such as cliffs, bedrock/boulders, or large trees. Delete and retake the photo(s) as needed to obtain optimal exposure and focus. If prior site monitoring photos exist, position yourself as needed to replicate the earlier photos, moving or altering zoom settings to obtain the same coverage based on the positioning of trees or rocks.

**Photo Documentation:** Some photo apps reliably link photos to site data records. If not, then record the date and time of each photo to the site record, or possibly a photo number if you are certain that numbers are retained as part of the photo name when transferred to a computer (take great care in this!).

**\* Collect all gear and personal items before leaving.**

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