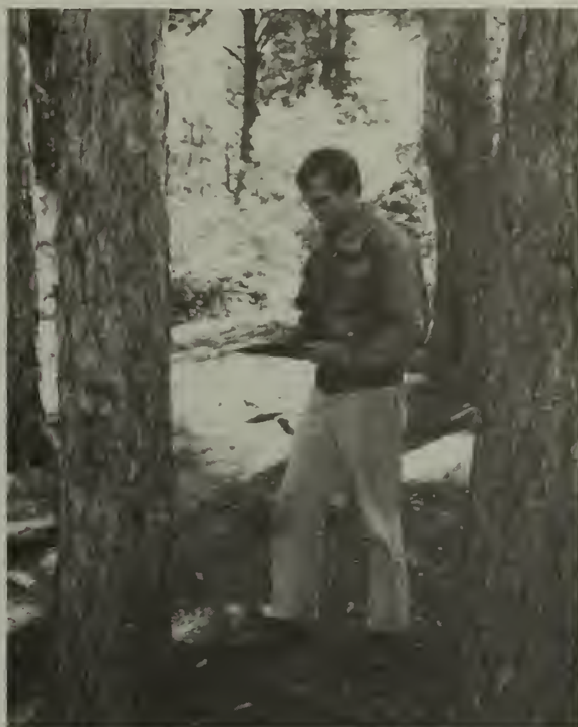
Developing a Natural Resource Inventory and Monitoring Program for Visitor Impacts on Recreation Sites: A Procedural Manual

Jeffrey L. Marion

Natural Resources Report NPS/NRVT/NRR-91/06



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October 1991

United States Department of the Interior
National Park Service
Denver, Colorado

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Introduction

The first European settlers regarded the immense wilderness of the North American continent as both an asset to be developed and an obstacle to be overcome. The island remnants of that vast wilderness are today preserved primarily in our national parks and forests. Coinciding with this loss of wild America has been an evolving public opinion: today we speak of preserving natural environments from civilization. The human values of preserving natural environments will expand dramatically in the future as surrounding lands become increasingly modified by humankind. However, these values are contingent on the effectiveness and success of our managing these irreplaceable resources. The threats to these resources are numerous, pervasive, and intractable.

> National Parks were made necessary by man's growing dominance over nature, and it is the exponential growth in that capacity that presents the parks with their greatest challenge today (Adler, Hager, and Copeland 1986).

This manual addresses one of many threats to preserving natural environments: recreational use. State recreation and wildlife management programs often classify recreational users as either consumptive (hunters/anglers) or nonconsumptive (hikers/campers/nature photographers). The clear and direct threats to fish and wildlife populations resulting from consumptive recreational pursuits have long been recognized. Considerable research and management attention has been directed towards developing regulatory programs for consumptive users and habitat management techniques to provide sustainable harvests of fish and wildlife resources. In contrast, recognition, research, and management of the resource impacts associated with nonconsumptive recreational pursuits received relatively little attention until the early 1970s. At that time a wave of environmentalism swept the country, giving birth to a back-to-nature movement and resulting in an unprecedented growth in backcountry and other forms of resource-based visitation.

The nonconsumptive user became a myth as resource managers recognized that resource impacts were occurring as an inevitable consequence of recreational use in any form. Wilkes (1977) rejected the nonconsumptive label, pointing out that while these users do not "consume" resources, they certainly impact them. Parks have developed large and sometimes ecologically sensitive areas with facilities to accommodate visitor use. Visitors unintentionally trample vegetation, erode soil, and disturb wildlife. By virtue of their massive numbers, these users pose a real and significant threat to the very resource they so cherish. From an ethical perspective, Wilkes argues that such recreational use is no longer a right, it is a privilege that should be actively managed as is done for consumptive users. "We would rather see the price for the privilege of using it paid in personal liberty than in the erosion of the unique character of the landscapes left to us" (Wilkes 1977).

National parks were perhaps an inevitable consequence of population growth and associated resource development, and the pressures of this growth present parks with their greatest challenge today. The National Park Service (NPS) has recognized the need for effective visitor management and resource protection programs to balance visitation with its associated resource impacts. The recurring question, "are we loving our parks to death?" increasingly challenges managers to develop and implement management policies, strategies, and actions that permit the recreational use of parks without compromising their ecological and aesthetic integrity. Furthermore, managers are frequently forced to engage in this balancing act under the close scrutiny of the public, competing interest groups, and the courts.

As with other prominent and critical resource issues, managers can no longer afford a wait-and-see attitude or rely on subjective impressions of deterioration in resource conditions. Managers require scientifically valid research and monitoring data. Such data should describe the nature and severity of resource impacts and the relationships of controlling visitor use and biophysical factors. Research has revealed that these relationships are complex and not always intuitively obvious. A reliable information base is therefore essential to managers seeking to develop and implement effective visitor and resource management programs.

This manual guides managers and scientists through the process of developing a scientifically valid natural resource inventory and monitoring program for visitor impacts on recreation sites. Although the procedures and techniques in this manual were developed for backcountry campsites, they can also be applied to frontcountry visitor use areas, including campgrounds, picnic areas, and popular attraction sites. Campsites, because they serve as a focal point for visitor activity, receive concentrated use and are usually the most heavily impacted areas in backcountry regions (Table 1). Such backcountry impacts are best "managed" by preventing or minimizing their occurrence, in contrast to frontcountry settings where paving, fencing, signing, and facility developments may be more effective or appropriate.

Table 1. Resource impacts caused by camping activities.

Vegetation Changes	Soil Changes	Additional Concerns
• Loss of Vegetation Cover • Alteration of Composition • Loss of Species • Damage to Trees • Exposure of Tree Roots • Loss of Tree Regeneration	• Loss of Organic Matter • Erosion • Compaction • Reduction in Soil Moisture	• Littering • Threats to Water Quality • Threats to Human Health • Threats to Wildlife

The NPS Inventory and Monitoring Initiative sponsored the development of this manual to provide assistance to park managers. NPS *Management Policies* (USDI 1988) specifically require implementing natural resource inventory and monitoring programs. Such efforts provide managers with information that is essential to professionally managing natural resources and their recreational use. The new NPS *Natural Resources Management Guideline*, NPS-77 (USDI 1991), defines these terms and purposes as follows:

Natural resource inventory - The process of acquiring, managing, and analyzing information on park resources, including but not limited to the presence, distribution, and condition of plants, animals, soils, water, air, natural features, biotic communities, and natural processes.

Natural resource monitoring - 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.

This manual focuses on the process of developing an inventory and monitoring program for visitor impacts on recreation sites. The manual is organized into seven steps that guide users in (1) evaluating the need for a program, (2) initiating an inventory and impact monitoring program, (3) reviewing impact monitoring approaches, (4) developing impact assessment procedures, (5) documenting monitoring protocols, (6) conducting monitoring fieldwork, and (7) developing analysis and reporting procedures. The products of each step are highlighted at the end of each section, and specific monitoring approaches and procedures are included as examples to illustrate the process. While all aspects of the process of developing an inventory and monitoring program are reviewed, this manual is not intended to serve as a comprehensive source of information. Users are strongly urged to consult other sources of information in selecting, modifying, or developing a monitoring program that reflects their specific management needs.

As with other monitoring efforts, park managers should consider agency or cooperative university research contracts as an option in developing a monitoring program. Qualified scientists should be involved during program development and for periodic reviews to ensure that appropriate data quality assurance measures are incorporated and that the monitoring program is scientifically defensible.

Numerous reasons for developing a program are described in Step 1. However, the actual value of these programs is entirely dependent upon the park managers who initiate and manage them. Programs developed with little regard to data quality assurance or operated in isolation from resource protection decision making will be short-lived. In contrast, programs that provide managers with reliable information that is necessary to develop and evaluate resource protection policies, strategies, and actions can be of significant value. Perhaps in the future we may be able to provide objective answers to the question, "are we loving our parks to death?"

Step 1. Evaluate Need for Monitoring Program

Legislative mandates, management policies and guidelines, and specific park resource protection objectives should be reviewed when evaluating the need to develop an inventory and monitoring program for visitor impacts. A comprehensive review and documentation of these needs are often critical in enlisting organizational support for initiating and sustaining monitoring programs.

Legislative Mandates

The National Park Service Organic Act of 1916 (16 *United States Code* (USC) 1) established the National Park Service, directing it to

> promote and regulate the use of the Federal areas known as National Parks, Monuments, and Reservations . . . 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 wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

Clearly, Congress intended park visitation to be contingent upon the National Park Service's ability to preserve park environments in an unimpaired condition. What constitutes an impaired resource is ultimately a management determination. This legal mandate presents the agency with a management paradox: research has clearly demonstrated that resource impacts are inevitable, even with light recreational use (Wagar 1964; Cole 1982, 1985; Marion 1984). Strictly interpreted, the legal mandate may not be achievable, yet it serves as a useful goal for managers in balancing these two competing objectives.

Parks with nationally designated wilderness areas within their boundaries have even stronger resource protection mandates. Wilderness, as defined in the Wilderness Act of 1964 (16 USC 1131-1136), is "an area where the earth and its community of life are untrammeled by man . . . which is protected and managed so as to preserve its natural conditions and which generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable. . . ."

The Wilderness Act established the same use and preservation management paradox implied by the Organic Act. 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. . . ."

The National Environmental Policy Act of 1969 (42 USC 4321 *et seq*) directs the federal agencies to use all practicable means to "attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences. . . ." Title I of the act requires that federal agencies "monitor, evaluate, and control on a continuing basis their agency's activities so as to protect and enhance the quality of the environment." Other legislative acts, such as each park's enabling legislation, the Wild and Scenic Rivers Act (16 USC 1271-1287), the National Trails System Act (16 USC 1241-1251), and the Endangered Species Act (16 USC 1531-1544), should also be consulted for legal mandates. International resource protection programs such as the UNESCO International Biosphere Reserve Program and the World Heritage Convention Program may provide additional mandates.

Management Policies and Guidelines

Authority for implementing congressional laws is delegated to agencies, which identify and interpret all relevant laws and formulate management policies to guide their implementation. For the National Park Service, these policies are set forth in the *Management Policies*, revised in 1988. These policies provide direction for management decisions, and adherence to the policies is "mandatory unless waived or modified by an appropriate authority." More specific procedures for implementing servicewide policy are described in the NPS Guideline Series.

Several statements in the *Management Policies* specifically require resource inventory and visitor impact monitoring:

> The National Park Service will assemble baseline inventory data describing the natural resources under its stewardship and will monitor those resources at regular intervals to detect or predict changes. The resulting information will be analyzed to detect changes that may require intervention and to provide reference points for comparison with other, more [human-]altered environments. (Chapter 4:4)
>
> Backcountry use will be managed to avoid unacceptable impacts on park resources or adverse effects on visitor enjoyment of appropriate recreational experiences. The National Park Service will identify acceptable limits of impacts, monitor backcountry use levels and resource conditions, and take prompt corrective action when unacceptable impacts occur. (Chapter 8:3)
>
> In every park containing wilderness, the conditions and long-term trends of wilderness resources will be monitored to identify needs for, and results of, management actions . . . every wilderness monitoring program will not only assess physical and biological resources, but also identify what impacts people have on resources and values and what impacts they have on other people using the wilderness. (Chapter 6:5)
>
> Potential impacts on soil resources will be routinely monitored. (Chapter 4:20)

Resource inventory and monitoring are also recommended for parks that have restricted visitor use:

> Any restrictions on recreational use will be limited to the minimum necessary to protect park resources and values and to promote visitor safety and enjoyment. To the extent practicable, public use limits established by the National Park Service will be based on the results of scientific research and other available support data. (Chapter 8:2)

Two NPS natural resource management guidelines, NPS-75, the draft Guidelines for Natural Resources Inventorying and Monitoring (USDI 1988), and NPS-77, *Natural Resources Management Guideline* (USDI 1991), also have relevance to visitor impact monitoring. NPS-75 states:

> It is the policy of the National Park Service to assemble baseline inventory data describing the natural resources under its stewardship, and to monitor those resources forever; to detect or predict changes that may require intervention . . . and with growing awareness of the effects of human activities within the parks, natural resource baseline inventories and subsequent monitoring are an essential basis for park management. (Chapter 1:1)

NPS-77 also addresses resource inventory and monitoring programs:

> To fulfill the NPS mission of conserving parks, it is essential that park managers know the nature and condition of the resources in their stewardship, have the means to detect and document changes in those resources, and understand the forces driving the changes. (Chapter 5:20)

The NPS-77 Backcountry Recreation Management Chapter notes that superintendents are responsible for developing and implementing backcountry recreational use programs in parks. Restrictions on visitor use are to be the minimum necessary:

> Any restrictions on use should directly relate to the accomplishment of specific management objectives identified in the plan, or resolve specific, documented impacts. (Chapter 3:73)

Park Resource Protection Objectives

Legal mandates and management policies clearly state that park managers are obligated to manage visitor use so that resource impacts are minimized. Effectively managing visitor impacts requires objective and current information from inventory, monitoring, and research efforts. For example, managers will require information on where impacts are occurring, the types and severity of resource impacts, how impacts relate to amount and type of visitor use, how impacts relate to influential biophysical factors, and the effectiveness of management strategies and actions implemented to minimize resource impacts.

Scientists and managers have developed numerous impact monitoring systems to document and evaluate resource impacts resulting from visitor use. These management-oriented monitoring programs provide a standard approach for collecting and analyzing site-specific information on the nature and severity of visitor impacts over time (Table 2).

Table 2. Capabilities of visitor impact monitoring systems.

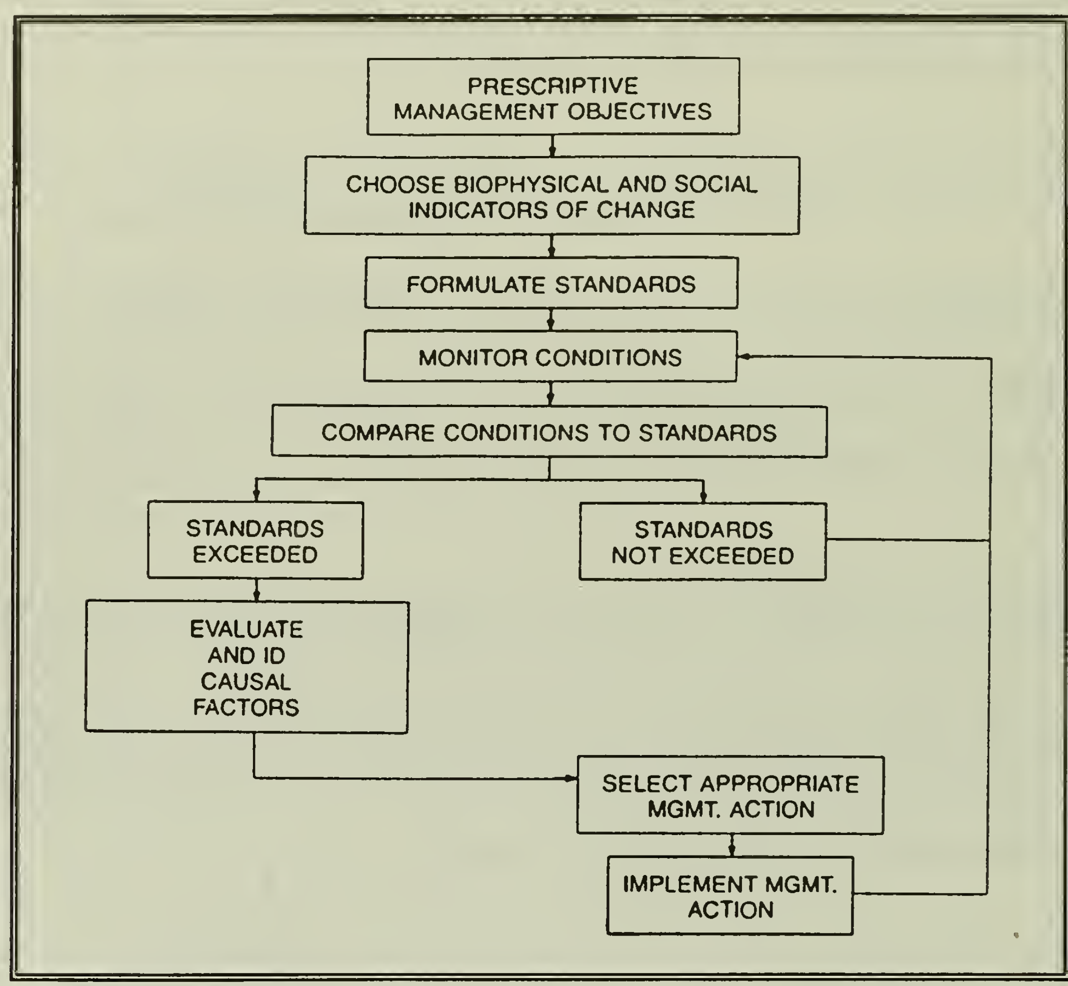
Monitoring Capabilities
• Identify and quantify site-specific resource impacts.
• Summarize impacts by environmental or use-related factors to detect and evaluate relationships.
• Aid in setting and monitoring management standards for resource conditions.
• Evaluate deterioration in resource conditions to suggest potential causes and effective management actions.
• Evaluate the effectiveness of resource protection measures.
• Identify and assign priorities to maintenance needs.

When implemented properly and with periodic reassessments, these programs can produce a data base that has significant benefits for the park manager. A monitoring program provides an objective record of changes occurring in visitor areas, even though individual managers may come and go. A monitoring program can help in detecting and evaluating trends by comparing data from present and past impact assessments. Deteriorating conditions can be detected before severe or irreversible impacts occur, allowing time to implement corrective actions. Relationships between specific impacts and use-related or biophysical information may suggest appropriate management actions. A monitoring program also helps in evaluating the success or failure of resource protection measures.

Finally, a visitor impact monitoring program provides an essential element for recreational resource planning and management frameworks such as the limits of acceptable change (LAC) (Stankey et al. 1985) or visitor impact management (VIM) (Graefe, Kuss, and Vaske 1990) systems (Table 3). These frameworks evolved from and are currently replacing management approaches based on carrying capacities (Marion, Cole, and Reynolds 1985). As noted earlier, the NPS *Management Policies* requires using approaches that identify and monitor acceptable limits of change in backcountry settings.

Under the LAC and VIM frameworks, numerical standards can be set for individual impact parameters to specify the limits of acceptable change. These limits define the critical boundary line between acceptable and unacceptable conditions, establishing a measurable reference point to which future conditions can be compared. A visitor impact monitoring program provides the information that is needed by managers to formulate realistic standards and to periodically assess and evaluate resource conditions in relation to these standards.

Table 3. Schematic illustrating LAC and VIM planning and management frameworks.



Step 1 Products

- A comprehensive review and documentation of needs for a visitor impact inventory and monitoring program.

Step 2. Initiate Monitoring Program

This step highlights the need to secure organizational support for the inventory and monitoring effort. Recommended actions include preparing and circulating a Resource Management Plan project statement and a monitoring proposal that describe the need for and management utility of an inventory and monitoring program for visitor impacts.

A Resource Management Plan project statement is generally required before initiating any inventory and monitoring program. The project statement should describe the nature and severity of visitor impact problems and the history of pertinent management actions. Developing a visitor impact inventory and monitoring program should be listed as a recommended course of action. The project statement should then be submitted to the superintendent for review and approval.

Preparing a visitor impact inventory and monitoring program proposal is also recommended. This proposal should review and incorporate the evaluation of inventory and monitoring needs from Step 1 and identify specific monitoring objectives. The history of visitor use areas, their use and management, resource impact problems, and descriptions of any previous impact monitoring efforts are also potential topics. A signature page on the proposal formally establishes the monitoring program and may ensure its continuance over time as personnel change.

The value and longevity of an inventory and monitoring program for visitor impacts will be dependent largely upon its integration with and responsiveness to park management and decision making. A failure to cultivate organizational support for a monitoring program by neglecting to describe its usefulness to managers will ultimately lead to its termination or result in a program that is operated in isolation by a particular individual, district, or division. Achieving and maintaining a broad base of support for the monitoring effort should be a primary objective for those involved with developing and implementing a monitoring program.

Developing organizational support begins by discussing the proposed monitoring program with individuals in each park division. The approved proposal should be circulated to communicate the program's intent and to provide background information. Additional and more specific information that needs to be addressed by the monitoring effort should also be solicited.

Visiting representative recreation use areas and discussing current and expected resource impact problems and concerns will help to define the types of impacts that should be monitored. A variety of related inventory parameters are also typically included in a monitoring program. Inventory information may be used to stratify impact data for evaluation purposes or may serve the informational needs of one or more divisions and programs. Examples of representative inventory and impact parameters are listed in Table 4.

Table 4. Representative examples of recreation site inventory and impact monitoring parameters.

Inventory Parameters		Impact Parameters	
Site Number/Name	Tree Canopy Cover	Recreation Site Area	Shrub Loss
Inventory Personnel	Distance from Trail	Vegetation Cover Loss	Soil Erosion
Assessment Date	Tentsite Capacity	Vegetation Composition Change	Trail Development
Ranger District	Vegetation Type	Organic Litter Loss	Litter/Trash
Management Zone	Landform Type	Exposure of Mineral Soil	Human Waste
USGS Quadrangle	UTM Coordinates	Barren Core Area	Horse Impacts
Elevation	Firewood Availability	Soil Compaction	Fire Sites
Water Source	Site Facilities Present	Tree Damage	Shoreline Disturbance
Type of Site Use	Facility Condition	Tree Root Exposure	Exotic Species
Amount of Site Use	User-Built Facilities	Tree Stumps	Wildlife Disturbance
Intersite Visibility		Tree Reproduction	

Meetings should be held to discuss how the monitoring program will be integrated into a formal LAC or VIM management framework or into existing park management and decision making. A clear linkage to management's informational needs should also be established. A list of recommended inventory and impact parameters should be developed and approved. The relative accuracy and precision of information that is needed by managers should also be described to aid in monitoring program development.

Finally, additional funding and personnel needs for the monitoring program should be estimated and used in preparing appropriate budget and personnel requests. At the earliest possible time, the monitoring program should be base-funded and formally assigned to appropriate park divisions and staff positions.

Step 2 Products

- An approved Resource Management Plan project statement recommending the initiation of a visitor impact inventory and monitoring program.
- An approved proposal with clearly specified visitor impact monitoring needs and objectives.
- A clear understanding of how the monitoring program will support management information needs.
- Informed and supportive park staff.
- A list of recommended inventory and impact parameters.
- A clear understanding of the relative accuracy and precision of information needed by managers from the monitoring program.
- Budget and personnel requests.

Step 3. Review Existing Monitoring Approaches

This step reviews the different types of visitor impact inventory and monitoring approaches that have been developed and applied by resource managers and scientists. For each of three general monitoring approaches, specific systems are briefly described and references are provided so that program developers can obtain and review systems that offer the most potential for addressing park-specific site monitoring needs. General criteria for evaluating and selecting the most appropriate approach and system are also included. Most systems will require at least some modification to address park-specific information needs or attributes. Procedures for accomplishing these modifications are described in Step 4.

Types of Monitoring Approaches and Systems

Most of the following monitoring approaches and systems were developed for backcountry campsites, although with modifications, they could be applied to a variety of frontcountry settings. These systems differ significantly in the type, accuracy, and precision of information collected, assessment approaches used, and assessment time required. Three general impact monitoring approaches have been used: (1) photographic systems - based on repeat photographs taken at permanently established photo points; (2) condition class systems - based on descriptive visual criteria of overall site conditions; and (3) multiparameter systems - based on individual measurements or appraisals of many specific resource impacts. A brief summary of the approaches and systems follows. See Cole (1989) for a more comprehensive review of these systems, as well as the references cited for each specific system.

Photographic Systems

Photographic systems were among the first developed for documenting visitor use impacts (Magill and Twiss 1965). These systems provide comparable visual records of conditions on visitor use sites (Figure 1). Many disadvantages exist, however. Photographic quality and comparability are often inconsistent due to variability in staff experience, equipment, exposure, lens focal lengths, lighting, and type of film. Also, photographing all areas and aspects of a site or areas where potential site expansion may occur is inefficient. Finally, accurate quantitative measurements of specific resource changes from photographs is often difficult or impossible to obtain. Brewer and Berrier (1984) and Magill (1989) provide the most comprehensive reviews of photographic monitoring methods.

Figure 1. Photographic monitoring of vegetation changes. Photographs of a recreation site at Delaware Water Gap National Recreation Area clearly document a dramatic loss of vegetation cover from 1986 (top) to 1990 (bottom).

Condition Class Systems

Condition class systems consist of several statements that describe increasing levels of impacts on a visitor use site. Observers compare site conditions to these descriptive condition classes and simply record the class that most closely matches the conditions of the site being assessed. A commonly used condition class system developed by Frissell (1978) is presented in Table 5. This type of system is easy and quick to apply and provides a useful summary measure of resource impact. However, as with photographic systems, this approach does not provide quantitative measurements of specific resource changes. Furthermore, the visual criteria used in these systems require careful training of personnel to achieve consistent results.

Table 5. A five rating condition class impact assessment system.

Condition Class System		
1	=	Ground vegetation flattened but not permanently injured. Minimal physical change except for possibly a simple rock fireplace.
2	=	Ground vegetation worn away from around fireplace or center of activity.
3	=	Ground vegetation lost on most of the site, but humus and litter still present in all but a few areas.
4	=	Bare mineral soil obvious. Tree roots exposed on the surface.
5	=	Soil erosion obvious. Trees reduced in vigor or dead.

Multiparameter Systems

Multiparameter systems are based on independent assessments of several inventory and impact parameters (see Table 4 for representative examples). Many of these systems were developed and implemented in national parks beginning in the 1970s. Several systems based on rapid estimation techniques as well as more objective but time-consuming measurement-based systems have been developed. Some of the following approaches were not designed to serve as long-term monitoring systems but could be modified for this purpose.

An early system by Moorhead and Schreiner (1976) for Olympic National Park emphasized areal measurements of bare ground. For each campsite, the distances from a centerpoint along eight radiating transects to the first live plant were measured. The average of these transect distances was used as the radius of a circle to calculate bare ground area. Additional impact parameters included a count of adjacent trails and the number of trampled depressions around trees from tethered horses. This system is the first to use a fixed radial transect method for areal measurements. However, only eight transects were used and the centerpoint was not permanently referenced.

A survey of campsite impacts conducted by Bratton and others (1978) at Great Smoky Mountains National Park also emphasized areal measurements, although several impact parameters were included. This system was based on measurements rather than estimates, but some of the procedures reduced the accuracy and precision of the data for monitoring purposes. For example, areas were measured as rectangles, an inaccurate procedure given the complexity of many recreation site boundaries. Furthermore, measurements were not referenced to permanent features.

Parsons and MacLeod (1980) developed a system for Sequoia and Kings Canyon National Parks based on categorical ratings of eight impact parameters: total site area, devegetated core area, density of vegetation, composition of vegetation, litter and duff, tree damage, campsite development, and number of associated trails. Evaluators assign ratings from one to five to each impact parameter based on rapid estimates of impacts and comparison to descriptive or numerical impact categories. Ratings are averaged and rounded to an integer to provide a summary impact score. However, because the assessment units vary between parameters (for example, numbers of trails versus square feet of site area), averaging such data is an improper statistical procedure that may produce misleading results. In addition, observers were directed to record only the summary ratings, so information regarding specific types of resource change is lost.

A system developed by Cole (1983b) and applied in several wilderness areas is patterned after that of Parsons and MacLeod. Assessments for each impact parameter are recorded separately. For each impact parameter, observers estimate or conduct a rapid measurement of the degree of impact and record one of three predefined impact ratings. For example, given the impact parameter, "Campsite Area," with the following impact ratings,

(1) Site area = <100 ft^2, (2) Site area = 101-300 ft^2, (3) Site area = >300 ft^2,

an observer obtains and records a measurement of 190 ft^2 and a rating of "2" for this impact parameter. Procedures are designed so that site assessments typically require two workers 5 to 10 minutes to complete. Ratings, rather than the measured values, are emphasized with the rapid assessment approaches, due to the low accuracy of assessment procedures. A summary impact score for each site is often computed by summing the individual impact parameter ratings, although as noted earlier, this is an improper procedure.

More recently, Marion has developed and refined multiparameter systems based largely on measurements: Marion 1988 (Delaware Water Gap National Recreation Area), Marion and Snow 1989 (Everglades National Park), Marion 1990 (New River Gorge National River), and Marion 1991 (Jefferson National Forest). These systems require two workers 10 to 15 minutes to assess a typical site. The most recent system, applied to day-use and overnight recreation sites at Delaware Water Gap, is presented in Appendix A to serve as an example for several steps of this manual. Site evaluation begins with a condition class assessment. For lightly impacted sites (condition classes 1 and 2), the site is photographed and its size measured using the geometric figure method. For moderate to highly impacted sites (condition classes 3-5), a more intensive measurement-based assessment is completed. This dual approach maximizes the quantity and quality of monitoring data on sites of most concern to managers while minimizing assessment time.

Research-level approaches for measuring visitor impacts have also been developed, but the time and expertise required typically make them impractical for most monitoring purposes. These approaches use quadrats or transects and more complex sampling procedures to obtain more accurate data on species-specific vegetation changes, soil changes, and others (Cole 1982, 1983a, 1986; Marion 1984b; Stohlgren and Parsons 1986; Cole and Marion 1988).

Evaluation and Selection Criteria

This review of impact monitoring systems is not inclusive; evaluating and selecting appropriate monitoring approaches will require a more thorough literature review. Park and forest staff and scientists involved with implementing impact monitoring programs may also be contacted for additional information and advice.

Evaluating and selecting an appropriate impact monitoring system should take into account each of the monitoring needs and objectives identified in Step 1. The following questions highlight additional considerations:

- What types of information are needed? Will a summary impact measure suffice or are data required for a variety of specific impacts?

- How many sites are there and what percentage should be monitored? Monitoring may be conducted on a census or sample basis. The basis for sampling may be geographical (management district, zone, trail), biophysical (vegetation type, elevation zone), use-related (type or amount of site use), or impact-related (level of impact, type of impact). Monitoring only a sample of sites will cost less but may not yield representative information or document changes in the number and spatial distribution of sites.

- Who will conduct the monitoring and how often? Condition class and ratings-based systems generally require less time and expertise and are more easily incorporated into the existing duties of field personnel than measurement-based systems.

The answers to these questions should help in selecting a general monitoring approach and in identifying potential existing systems. Keep in mind that any system is likely to require some modifications to address park-specific monitoring needs and objectives.

Additional criteria for evaluating specific monitoring systems include the following:

- Measurement scale. Condition class and ratings systems are based on ordinal measures of change: categories or levels of impacts can be ordered from low to high, but the distance between categories is not meaningful. A condition class 4 site may not be twice as impacted as a condition class 2 site. Many summarization procedures and statistical measures and tests are inappropriate for ordinal-level data. Measurement-based systems rely predominantly on ratio measures of change where distances between numeric values are meaningful as numbers and a true zero point exists.

- Accuracy and precision. Accuracy refers to how close measurements are to the true value; precision refers to how close repeated measurements of the same thing are to each other. Both are important: an accurate system correctly describes how much change has occurred, a precise system permits an objective comparison of these changes over time to document trends in resource conditions.

- Sensitivity. This criterion refers to how large a change must be for it to be identified confidently as a real change in resource conditions. A system that uses broadly defined ratings categories will have low sensitivity. For example, in a three-rating system whose third site size class is defined as ">300 ft^2," a site of 350 ft^2 could triple in size without a change in impact class. Measurement-based systems using ratio scales are not necessarily more sensitive to change, however. A poorly implemented system or a system using inaccurate or imprecise measurement methods may yield highly erroneous impact values. Such values would contain unknown and misleading measurement error components.

- Cost. The amount of staff time required is often a critical consideration. Constraints here, however, should not "force" the adoption of a technique that fails to meet other management criteria. A sampling approach, rather than a census of all sites, may be a better approach for areas with a large number of sites.

Step 3 Products

- An identified visitor impact inventory and monitoring system that, following modifications, will address park management needs.

Step 4. Develop Monitoring Procedures

The purpose of this step is to modify or develop specific assessment procedures for each inventory and impact parameter to be included in the monitoring program. Reference to literature on other systems is required to identify and evaluate various assessment options. Trade-offs between assessment time, precision, and accuracy are often necessary. Recommendations for writing, testing, and refining assessment procedures are also offered.

Review and Select Monitoring Parameters and Procedures

Inventory and impact parameters to be included in the system should now be finalized, based on management informational needs and input from other park divisions. A comprehensive review of assessment options should be initiated once the list of parameters is complete. Potential sources of information on prospective assessment procedures include the campsite monitoring sourcebook by Cole (1989), specific monitoring system references, personnel at other parks and forests, and scientists. During this review process, program developers should identify specific approaches that satisfy management informational needs, requirements for data accuracy and precision, and constraints on personnel time and expertise.

Condition class systems may require modifications to address specific management concerns and environmental types. For example, the Frissell system (Table 5) is not effective for nonforested sites due to its reliance on tree root exposure and vigor. A system based solely on changes in ground cover was developed for more universal application in eastern environments by Marion (Appendix A). More specific management concerns and application to desert or beach environments may require other modifications. Classes should describe the full range of impact conditions using mutually exclusive and clearly defined categories.

Using a multiparameter approach requires selecting and modifying field assessment procedures for each parameter. Numerous specific approaches, which vary with respect to accuracy, precision, and assessment time, exist for evaluating any given parameter. This is illustrated in the following section by a more detailed examination of procedures used to assess a commonly included parameter: recreation site size.

An Example: Recreation Site Size

The ability to precisely delineate areas that are disturbed by visitor use is critical because many other impacts, such as vegetation loss, tree damage, and litter (trash), are often only assessed within recreation site boundaries. Precision may be more important than accuracy for these parameters. For example, the most "accurate" approach for assessing tree damage would be to evaluate all the human-damaged trees associated with a particular site, including those in adjacent offsite areas. However, it is more "precise" to evaluate damaged trees only within site boundaries because workers will expend different levels of effort searching for damaged trees in adjacent offsite areas. Also, damaged trees located between sites are difficult to consistently assign to the same site, and offsite searches are very time-consuming.

Subsequently, for many impact parameters, it is necessary to compromise accuracy to ensure precision. For these parameters, the precise delineation of site boundaries is critical and low precision in this parameter may result in reduced precision for several other parameters.

The sizes of areas disturbed by visitor use may be either estimated or measured. Estimation, or rapid assessment approaches, described in Step 3, typically use three to five site size categories. Site size is either estimated by the observer, or a few quick site dimensions are taken to establish an estimate.

Several methods for measuring site size have been developed. All methods are predicated on the ability to specify recreation site boundaries so that independent evaluators measure the same site areas. Site boundaries are not always clearly defined and may be dependent upon one or more of the following factors: vegetation cover, vegetation composition, vegetation height/disturbance, topography, or organic litter (see Campsite Boundary photographs, Appendix A).

Two commonly used measurement methods are the geometric figure method (Appendix A) and the fixed radial transect method. The geometric method involves superimposing one or more geometric figures over site boundaries; area measurements of the geometric figures permit calculation of the site size. The fixed radial transect method involves measurements along transects from a centerpoint to the site boundary at fixed compass bearings (every 45° yields 8 transects, every 30° yields 12 transects, etc.).

Experience in employing these methods has revealed several potential sources of error. The geometric method is difficult to apply on sites with complex shapes and sinuous boundaries. This method also requires excellent judgment mentally superimposing the geometric figures to balance onsite and offsite areas included and excluded from the geometric figures used. The fixed radial method requires only judgments regarding site boundaries but is inaccurate on sites with complex shapes, unless a large number of transects are used.

Research sponsoring this manual's development led to new methods and procedures for resolving these problems. Greater accuracy in measuring site sizes was achieved by developing a variable radial transect method. A principal difference of this method is that evaluators match the number and direction of transects to the unique shape of each recreation site. Transect endpoints along or near the site boundary are flagged by evaluators, with the objective of defining a polygon whose area closely approximates the recreation site area. Transect distances and compass bearings are then recorded for determining site area and for future reference. A more detailed description of assessment procedures for the variable radial method is included in Appendix A.

Site remeasurement procedures can also substantially reduce errors resulting from differences in recreation site boundary determinations. During site remeasurement, the centerpoint and transect endpoints are relocated using the data recorded from the former site evaluation. Evaluators either shorten or lengthen the transects, depending upon changes in site boundaries. Subjectivity regarding boundary determinations is minimized by requiring compelling evidence that the boundary has changed. No change in transect length is made if the boundary is unclear and the current point is a reasonable approximation.

Finally, arithmetic procedures for accurately computing site size from transect lengths and compass bearings were developed and incorporated into dBASE programs. These programs will accept either fixed or variable transect data. Prior procedures relied upon tedious site mapping and planimeters to determine site size.

A set of trials on six hypothetical recreation sites were conducted to compare the accuracy and measurement time required by the site measurement methods previously described. Average percent error in site size and average measurement times for the three methods are illustrated in Figure 2. The geometric figure method had the lowest measurement times in these trials but was intermediate in accuracy. Readers are cautioned that the accuracy of this method is highly variable, depending upon the experience, care in application, and shape or complexity of the sites measured. The variable transect method, in comparison to the fixed method, was slightly higher in measurement times (due to the identification of boundary points), but was consistently more accurate. The higher accuracy of the variable method is illustrated in Figure 3, which depicts these methods as applied to one of the hypothetical sites. The number of transects employed by the variable transect method was constrained to match the number used by the fixed transect method. However, field experience has shown that 10-15 transects are normally sufficient.

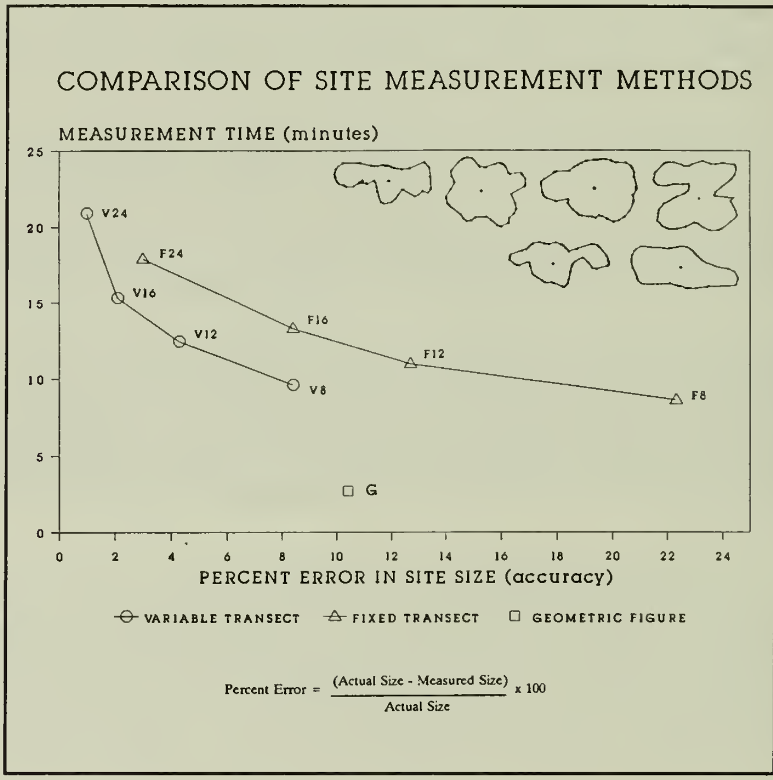


Figure 2. Comparison of three methods for measuring recreation site size. Values reported are averages for each method as applied to six sites (shapes illustrated). Data labels refer to the number of transects used. The "actual" size of each site was determined by arithmetic calculations using more than 60 transect measurements; transect endpoints are shown on the site shapes above.

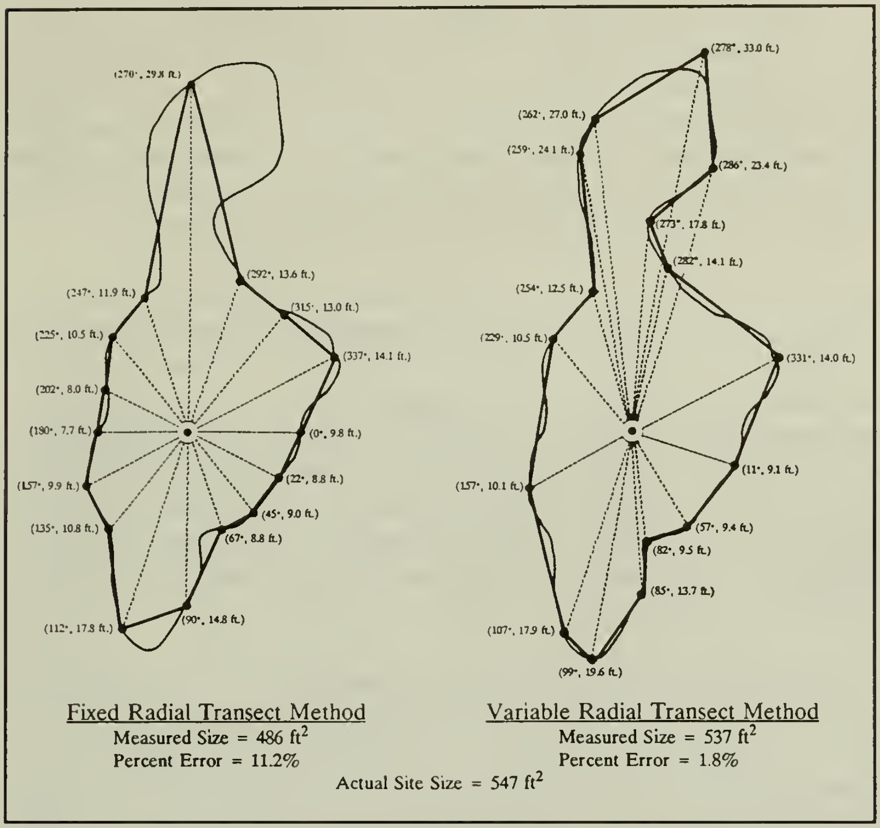


Figure 3. Fixed and variable radial transect methods for measuring recreation site size. "Actual" site size was determined by arithmetic calculations using 64 measurements.

Test and Refine Monitoring Procedures

Impact assessment procedures will typically require at least some modification due to differences in management needs, environmental conditions, and types of impacts. Revise procedures as necessary to accommodate park-specific circumstances and to make them comprehensive, understandable, and concise. Critical terms, such as "damaged tree" and "vegetation cover" must be clearly defined. Procedures should be written for an individual who has no previous experience with visitor impact assessments. Time should be allowed to circulate draft field assessment procedures for management and field staff review and for field pretesting. Procedures should be field-tested on the widest possible variety of environments and use- or impact-related conditions. Individuals not involved in the development process should participate in the field testing to remove bias introduced by close familiarity with the assessment procedures. Appropriate revisions should then be made and recirculated to earlier reviewers for further comments.

Impact parameters that are evaluated in discrete categories, such as the three-class campsite area ratings described earlier, should be calibrated so that approximately equal percentages of sites fall within each impact rating category (Marion 1984a, Cole 1989). Failure to calibrate a system in this fashion may lead to a disproportionate clustering of sites in some categories. Sites that may differ significantly in extent of impact are then included in a single broadly defined category, and pronounced changes may occur without causing them to shift to another category. Calibration requires field staff to record the estimated or measured value of each impact parameter during the first assessment period. Cumulative frequency distributions of these values may then be used to define impact category boundaries so that the number of sites falling into each category is approximately equal. Continuing the practice of recording the estimated or measured values for each impact parameter, in addition to the impact rating, is recommended to maximize flexibility in analyzing and interpreting data.

Not all sources of error may be removed from impact measurements, in spite of efforts to develop and carefully apply accurate and precise procedures. Estimates of measurement error for impact parameters are needed to interpret data from a single assessment, to examine differences between assessments, or to compare data with management standards. Given that every measurement or rating contains an error component, how large must a change be for us to safely conclude that a "real" change has, in fact, occurred? Methods are available for determining measurement error and defining a "minimum detectable change" for each impact parameter, but they require special studies. Procedures outlined by Cole (1989) require 5-10 field workers evaluating the same 10-20 sites to derive these statistics. Measurement error investigations should be conducted with experienced field evaluators near the middle or end of field seasons.

Preliminary measurement error investigations, by Cole (1989) and the author (unpublished), while not optimal in terms of numbers of sites, evaluators, or their experience level, have raised concerns regarding the precision of existing procedures. Cole found a higher level of precision when impact parameters were assessed using rating categories rather than actual measurements. Broadly defined impact parameter rating categories tend to conceal measurement errors because a single rating is recorded for a wide range of estimated values. As noted earlier, the rapid estimation and counting methods used by rating systems are relatively imprecise so the concealment of measurement errors is perhaps appropriate. Precision for these systems is only critical when the estimated values are close to category boundaries. Unfortunately, using such broad ratings categories reduces sensitivity to real changes in conditions: change equal to the breadth of parameter categories can occur without causing a shift in rating.

When carefully implemented, measurement-based assessments are more sensitive to real changes in resource conditions than are ratings methods. The trade-off, however, is that measurement errors are directly reflected in each recorded value, i.e., real changes in resource conditions are confounded with measurement errors. Therefore, efforts to develop measurement error estimates for each impact parameter are recommended, and error estimates should be considered when analyzing and interpreting data. Practices to minimize measurement error, such as using accurate and precise measurement procedures and developing comprehensive monitoring manuals and training programs, and other quality assurance practices, are also critical.

Step 4 Products

- A refined set of assessment procedures for each inventory and impact monitoring parameter.

Step 5. Document Monitoring Protocols

This step outlines developing a comprehensive monitoring manual, incorporating information from the impact monitoring proposal, and well-documented field assessment procedures, field data forms, database structure and management, and staff training. The primary purpose of this extensive documentation is to promote data quality assurance and ensure that future staff will be able to continue the program and interpret historical data.

Develop Monitoring Manual

Developing a comprehensive monitoring manual is a critical but often neglected step in implementing many monitoring programs. This manual should describe the scope, purpose, and operation of the monitoring program. In contrast to water or air quality monitoring, no standard or widely accepted methods and instrumentation have been developed for monitoring visitor impacts. Many types of impacts are difficult to objectively measure, and differences between the assessments of separate evaluators are likely to be large in the absence of carefully defined and documented procedures. Finally, without a monitoring manual, changes in personnel would ultimately lead to a situation in which managers are unable to continue site monitoring or to interpret previously collected monitoring data.

Developing the monitoring manual should begin with an outline of its contents. Potential topics include the rationale and objectives for monitoring, data utility and application to park management, personnel responsibilities, budget and staffing requirements, monitoring frequency, staff training, field assessment procedures, database structure and management, data analysis, and reporting requirements. Some of these topics should have been addressed in the monitoring program proposal. The manual should be developed on a word processor so that revisions can be easily made. All copies should be clearly dated and archived to facilitate data interpretation in the future.

The field assessment procedures section of the manual is the most critical with respect to quality assurance. Assessment procedures applied to recreation sites at Delaware Water Gap National Recreation Area recreation sites are included in Appendix A as examples. Inventory and impact parameters should be ordered and numbered to correspond with field data forms. Parameter descriptions should be written with the assumption that the reader has no resource monitoring experience. Procedures must be comprehensive, detailed, and fully defined yet also concise and understandable. Diagrams, illustrations, and photographs should be used to convey more complex procedures or to illustrate distinctions between resource conditions. Where appropriate, "rules of thumb," cautions, advice, and other comments should also be included in these procedures.

Develop Field Data Forms

Properly designed field data forms can speed both the recording and computer entry of monitoring data while addressing important data quality assurance concerns. From the standpoint of field use, parameters should be arranged on data forms in formats that will facilitate their use in the field. Codes and category descriptors, unless extensive, should appear on the forms, assessment procedures should not. Use as few sheets as possible to avoid time spent searching for parameters and flipping pages. Number parameters identically on the form and in the procedural manual so that assessment procedures can be quickly reviewed during fieldwork. A supply of waterproof field forms should be maintained for wet days, and the manual should be copied on waterproof paper or laminated in plastic.

From the standpoint of computer data entry, parameters on the form should be arranged in columns where possible to facilitate orderly data entry. A vertical arrangement also permits field workers to quickly scan a completed form to determine if any parameters were overlooked. Codes for categorical parameters should be recorded on the forms during fieldwork rather than transcribed later. To facilitate data entry, dBASE users can develop customized data entry screens that mimic the appearance of field forms. Data conversions and error-checking functions can also be programmed into the format files that produce these screens. For example, letters entered in lowercase can be automatically converted to uppercase, fields can be restricted to numeric data, and data range restrictions can be established.

The use of field data forms can be reduced or replaced by field data recorders, electronic devices resembling a large calculator. Data entry procedures programmed into these recorders prompt users to input data for each parameter. In the office, the data recorder is linked by cable to a desktop computer and field data is automatically downloaded, eliminating the manual data entry step.

Develop Computer Data Base

A strong recommendation is to input monitoring data into a computer data base such as dBASE. Data in hardcopy format are seldom used to the extent possible because of the tedious and time-consuming nature of manual data analysis and summarization methods. In contrast, computer data bases offer a highly efficient medium for storing, analyzing, and summarizing inventory and monitoring data. Computerized procedures and programs for entering and analyzing data can also ensure quality assurance. Finally, menu-driven analysis and reporting procedures provide staff timely access to data, encouraging its use in management decision making.

A computer data base for the monitoring data should be developed concurrently with the manual and field form development. Constraints imposed by computer data entry, database structure, and data analysis often require changes in the content or format of data forms. Database development begins by defining what constitutes a record of information; for example, all data associated with a single recreation site assessment. If more than one data base is used, a field that is common to both, such as a recreation site code, is necessary to relate the data bases. Next, list all database fields, including fields needed to stratify sites during data analysis and fields generated by the computer through computations. Examples of the latter include vegetation cover loss and recreation site size. Most calculation and transcription errors can be avoided if intermediate formula calculations are conducted by computer rather than by calculator with subsequent computer entry.

Database field names and types (Table 6) must be defined based on the type and format of information collected for each parameter. Parameters assessed in discrete categories, such as vegetation type, should be coded. Letter codes are more easily remembered and less subject to transcription and computer input errors than numeric codes. Data in a narrative format should be avoided, as it is more time-consuming to enter and cannot easily be analyzed.

Procedures for handling missing data should also be specified at this time. Coding missing data with a "-9" is a common and necessary practice, as blank numeric fields in dBASE are treated as zeroes in all calculations. Missing data can then be excluded from analyses using "for" clauses (e.g., average size for size .NE. -9). Coding "missing" data differently from "not applicable" responses may also be helpful.

Table 6. Database field types (dBASE).

Character	Used for categorical parameters, typically coded.
Numeric	Used for quantitative parameters, counts, or measurements.
Date	Used for dates in a numeric format.
Logical	Used for data in a true/false format.
Memo	Used for qualitative information that cannot be coded.

Develop Staff Training Program

Although the monitoring manual should contain all information that is necessary to conduct the monitoring program, a formal field staff training program is still essential. The objective of staff training is to communicate and illustrate field procedures, develop and refine experience and judgment in a variety of field settings, and build a commitment to quality. A three- to four-day training program might look like this:

Day 1 - Field staff read and discuss the full monitoring manual. Instructor emphasizes monitoring program objectives, data uses, and the need for accurate and precise data (quality assurance).

Day 2 - Assessment procedures are demonstrated on a typical recreation site. Following a discussion and question/answer session, field staff separate into groups to apply and practice procedures.

Day 3 - Field staff, independently or in small groups, apply procedures to a common group of sites. Evaluations for each site are then reviewed by the entire group, and differences are examined and resolved by referring to the manual and group critiques.

Day 4 - As necessary, Day 3 activities are repeated until an acceptable level of precision is achieved.

Step 5 Products

- A comprehensive visitor impact inventory and monitoring manual.
- Field data forms.
- Computer data base.
- Staff training program.

Step 6. Conduct Monitoring Fieldwork

Recommendations for planning and managing fieldwork are discussed in this step. The number of workers and the fieldwork scheduling have important implications for data quality assurance. Developing guidelines for conducting fieldwork is recommended.

Several options exist concerning the number and scheduling of field staff. Monitoring could be completed quickly by assigning a sufficient number of personnel to the task. Alternately, monitoring could be completed over longer periods of time by making it a collateral duty of existing personnel. Experience in several national park and forest areas has shown that the most reliable results will be obtained with a relatively small number of evaluators working full time for a short period of time. Consequently, using a small number of highly trained full-time evaluators is strongly recommended. Managers should avoid making site monitoring a collateral duty. Visitor impact monitoring requires consistent and practiced judgment to achieve accurate and precise results. Such judgment is difficult to develop on a part-time basis and larger numbers of workers introduce unnecessary bias.

Monitoring work can be accomplished with park seasonal staff, with seasonal and permanent staff working together, with permanent staff temporarily assigned to the monitoring program, or with university students through cooperative research contracts. A small number of seasonal workers dedicated exclusively to the impact monitoring program can be hired and intensively trained. Although these workers can conduct impact assessments, additional seasonal or permanent staff can be employed as necessary. These workers can provide assistance in locating visitor use sites and conducting measurements. Regardless of the personnel used, the roles and responsibilities of all staff should be clearly defined and incorporated into their performance evaluations. To the extent possible, personnel should not be subject to extended interruptions due to fire fighting or search and rescue duties.

Monitoring fieldwork should be conducted only towards the middle or end of the season(s) when recreation sites are used most intensively. During site reassessment, evaluations should be conducted at the same time of year (within 2 to 4 weeks of the date) they were initially evaluated. This schedule is necessary to avoid the confounding influence of factors such as phenological changes in vegetation growth and differences in cumulative site use at different times of the year. The frequency and nature of future monitoring efforts are dependent upon management objectives and how rapidly environmental conditions change on visitor use areas. For example, managers could reevaluate only those impact parameters that form the basis for LAC management. Managers could simply reevaluate parameters for which backcountry managers suspect more rapid or significant changes are occurring. High-use areas could be monitored more frequently than low-use areas (although conditions on lightly used sites have the potential for experiencing more dramatic changes). Regardless, a comprehensive reevaluation of all areas should be conducted at some interval, perhaps every 5 to 10 years.

Adding statements to clarify procedures or terms will be an ongoing process; adopting improved estimation or measurement procedures may also be considered. The impact of proposed changes on comparability with previously collected data should be carefully weighed and considered. Changes should be clearly documented and dated; copies of all versions of the manual, marked with the dates they were used, should be permanently archived for future reference.

Other quality assurance measures include field staff rotation, unless they work independently, to ensure uniformity of judgment as the field season develops. All field staff should get together to discuss problems and manual revisions and to compare independent evaluations of several sites as during initial staff training. This type of mid-season training and worker calibration will ensure that the judgments of the evaluators do not diverge significantly as they gain more experience and confidence. It is also a good practice for field staff to conduct the computer data entry, perhaps on rainy days. Problems they encounter with missing data, improperly coded data, or illegible data will then serve to reinforce the need to be more diligent during fieldwork.

Step 6 Products

- Guidelines that address how and when the monitoring fieldwork will be conducted and other quality assurance recommendations regarding managing field staff.

Step 7. Develop Analysis and Reporting Procedures

This step reviews basic types of data analyses and methods for conducting them. Developing guidelines for data analysis and report writing are recommended.

Data analysis and reporting procedures will depend on management objectives and the intended uses of the information. A review of several types of data analyses, including methods and examples, is provided by Cole (1989). Reports on monitoring systems in various national parks and forests should also be consulted for ideas, methods, and illustrations of commonly used techniques (Marion 1990, 1991; Parsons and Stohlgren 1987). Several types of analyses are outlined in Table 7.

Table 7. General types of analyses commonly conducted with visitor impact inventory and monitoring data.

Number and Distribution of Recreation Sites - A summary of the number and percentage of sites stratified by geographical area (e.g., river segment, trail, or district) and other parameters.

Data Listings - Listings of raw data for specific inventory and impact parameters with the ability to sort or stratify output by any parameter and to list only sites less than, equal to, or greater than a specified value for any parameter.

Descriptive Statistics - Frequency distributions and basic statistics (e.g., mean or median, standard error, and range) for each inventory and impact parameter.

Impact Parameter Analyses - Evaluations or statistical testing of differences between mean values of impact parameters as stratified by inventory parameters.

Trend Analyses - Evaluations or statistical testing of differences between monitoring data from two separate assessments.

Data analysis is most efficiently conducted by computer. Work sponsored in developing this manual led to the creation of dBASE data bases, menu-driven programming, and linkages to dBASE STATS, an inexpensive auxiliary statistical package. The goal of this work was to develop a standard database environment with comprehensive but largely menu-driven data analysis capabilities. All the analyses presented in Table 7 can be conducted using these files and packages. Due to differences in monitoring programs, using this system requires developing database files and format screens, and some modifications to the programming. Contact the author to obtain copies and guidance.

Typically, managers will want to examine the relative amounts of impact on different recreation sites or between different geographical areas. Analyses are most easily conducted for each impact parameter separately, using raw data listings or averages from groups of sites. A single summary impact score is also often computed from selected impact parameter values. Such scores can be used to rank order sites by amount of combined impact or overall change, a useful procedure for identifying the "worst" and "best" sites. As noted in Step 3, users of categorical impact ratings systems have averaged impact parameter ratings, an improper statistical procedure because the parameters are assessed in different units. Cole (1989) offers additional discussion on analysis with categorical ratings.

Impact assessment methods that rely on actual measurements or counts permit more latitude in selecting statistically appropriate procedures for analyzing data and computing summary impact scores. Specific procedures for analyzing and standardizing impact parameters and computing summary impact scores are discussed further in Appendix B.

Geographic information systems (GIS) offer another option for analyzing and presenting the results of monitoring work. Exploratory work by the author with the Shenandoah National Park GIS program revealed significant capabilities for visually conveying monitoring results by linking dBASE data bases with a GIS program to produce maps (Figure 4). The only additional step required for this work was the inclusion of latitude and longitude fields in the data base. GIS analysis capabilities were generally less useful or could be conducted more efficiently in the dBASE environment. For many attributes, such as vegetation or soil types, the data contained in most GIS systems is too coarse to be meaningful when analyzing site impact/attribute relationships. Data is best collected for these attributes as an inventory parameter during the actual site assessments for use during data analysis.

The results of data analyses must be objectively presented and interpreted in a management report. Reports should be kept brief by referencing the monitoring manual for pertinent background information. Graphical illustrations should be used whenever appropriate while lengthy tables and statistical analyses should be omitted or included in appendixes. Reports should focus on interpreting findings and their implications for management.

Figure 4. GIS map showing distribution and condition classes of inventoried campsites in trail corridor at Shenandoah National Park.

Appendix A. Inventory and Visitor Impact Monitoring System[1]

1 - This system was developed for monitoring resource impacts on day-use and overnight recreation sites along the Delaware River in Delaware Water Gap National Recreation Area. The monitoring manual is included in this report to serve as an example of a visitor use impact monitoring system and to illustrate standard methods for designing forms and documenting field procedures by using written descriptions, diagrams, and photographs. As noted in Step 3, many different types of monitoring systems have been developed, each with distinct advantages and disadvantages. Managers are encouraged to review the literature and to select, modify, and implement the system that best addresses their own management needs and constraints.

Delaware Water Gap Recreation Site Monitoring Form A

Revision Date: 6/91

1) Recreation Site Number: __________ 2) Site Name: _____

3) Site Designation: (D=designated U=undesignated) _____

4) River Segment: (N=North Boundary-Milford Beach M=Milford Beach-Dingman's D=Dingman's-Bushkill B=Bushkill-Smithfield S=Smithfield-South Boundary) _____

5) Site Location: (I=Island P=PA shoreline N=NJ shoreline) _____

6) Describe location of site so others could find it: ______________________________

____

____

7) Tag Tree 8) Inventoried by: __________________ 9) Date: _ _ / _ _ / _ _

(Locate and label site on map)

Inventory Parameters

10) Substrate of Landing Area: (B=bedrock C=cobble S=sand O=soil) _____

11) Shoreline Disturbance: _____ feet

12) Height Above River: _____ feet

13) Number of Other Recreation Sites Visible: _____

14) Tree Canopy Cover: (1=0-25% 2=26-50% 3=51-75% 4=76-100%) _____

15) Number of 8x10 Tent Pads: (1=1-2 sites 2=3-5 sites 3=>6 sites) _____

16) Toilet: (C=clivus P=pit toilet N=none) _____

Impact Parameters (Begin with Recreation Site Boundary Determination)

17) Condition Class: (3, 4, or 5) _____

18) Vegetative Ground Cover Onsite: (Use categories below) _____
(1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%)

19) Vegetative Ground Cover Offsite: (Use categories above) _____

20) Soil Exposure: (Use categories above) _____

21) Tree Damage: None/Slight __________ Moderate __________ Severe ________

22) Root Exposure: None/Slight __________ Moderate __________ Severe ________

23) Number of Tree Stumps: _____

24) Number of Trails: _____

25) Number of Fire Sites: _____

26) Litter/Trash: (N=None S=Some M=Much) _____

27) Human Waste: (N=None S=Some M=Much) _____

28) Comments/Recommendations: ______________________________

____

____

29) Take Centerpoint and Recreation Site Photographs

Recreation Site Centerpoint References		Transect Data Bearing	Distance (ft)
1)	Site Photo		
2)	1)		
3)	2)		
4)	3)		
	4)		
Satellite Site Dimensions	5)		
	6)		
	7)		
	8)		
	9)		
	10)		
	11)		
	12)		
Island Site Dimensions	13)		
	14)		
	15)		
	16)		
	17)		
	18)		
	19)		
	20)		
Recreation Site Area from Program __________	21)		
+ Satellite Area __________	22)		
- Island Area __________ =	23)		
30) Total Recreation Site Area __________ (sq. ft.)	24)		

Delaware Water Gap Recreation Site Monitoring Form B

Manual revision date: 6/91

1) Recreation Site Number: ____________ 2) Site Name: ______

3) Site Designation: (D=designated U=undesignated) ______

4) River Segment: (N=North Boundary-Milford Beach M=Milford Beach-Dingman's D=Dingman's-Bushkill B=Bushkill-Smithfield S=Smithfield-South Boundary) ______

5) Site Location: (I=Island P=PA shoreline N=NJ shoreline) ______

6) Describe location of site so others could find it: ______________________________

____

____

____

7) Tag Tree 8) Inventoried by ____________________ 9) Date _ _ / _ _ / _ _

17) Condition Class (1 or 2) ______ 30) Recreation Site Size ________ (ft^2)

(Locate and label site on map, photograph site)

DESCRIPTION OF PROCEDURES

Manual Revision Date: 6/91

For the purposes of this manual, recreation sites are defined as river-accessed areas of vegetation and soil disturbance caused by visitor overnight camping and/or day-use activities. A fire site may not be present. In areas with multiple sites there may not always be undisturbed areas separating sites, and an arbitrary decision may be necessary to define separate sites. For each site, monitoring begins with an assessment of Condition Class:

CONDITION CLASS DEFINITIONS

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

Class 2: Recreation 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.

For recreation sites rated Condition Class 1 or 2, complete Form B; for recreation sites rated Class 3, 4, or 5, complete Form A. Form B is an abbreviated version of Form A and greatly reduces the amount of field time. The rationale for this approach is that detailed information on lightly impacted recreation sites is not as critical to management.

During subsequent surveys an attempt should be made to relocate and reassess all sites from the preceding survey. Former designated sites that have been closed should be treated as illegal sites. Always note information regarding the history of site use under the Comments parameter.

Materials:
- Compass, peephole or mirror type (not corrected for declination)
- Topographic maps
- Tape measure, 100-foot (marked in tenths)
- Flagged wire pins (25 minimum), one larger steel centerpoint stake
- Camera, 35mm SLR, 35mm lens and ASA 400 color print film recommended, photo log
- Aluminum tree tags, 2-inch aluminum nails, hammer
- Clipboard, pencil, field forms (some on waterproof paper), field procedures
- Steel nails (5-inch)
- Magnetic pin locator (type which locates only ferrous metals)

Form A Procedures

General Site Information

1. Site Number: Each site is to be numbered consecutively from the park upstream boundary to the downstream boundary. When sites are reassessed, examine the mapped locations and field forms to determine if each site was present during the previous survey. Number new sites with the number from the closest upstream site, plus 0.01. For example, a new site located just downstream from site 121 is numbered 121.01.

2. Site Name: Traditional/geographic names for groups of sites. Code as below. Enter 20 "Unnamed Site" for sites without names.
   1=Calestini 2=Minisink 3=Namanock 4=Sandyston 5=Hornbeck 6=Shapnack 7=Buck Bar 8=Tom's Creek 9=Valley View 10=Peter's 11=Quinn 12=Decker's 13=Sambo 14=Freeman 15=Hamilton 16=Depew 17=Poxono 18=Hialeah 19=Schellenberger 20=Unnamed Site

3. Site Designation: Designated sites are marked with a brown camping sign and a posted set of camping rules. Illegal sites will not have either of these signs. Group sites may share common river access landings and camping signs. Code as below.
   D=designated U=undesignated (illegal)

4. River Segment: Indicate the river segment within which the site is located:
   N=North Boundary-Milford M=Milford-Dingman's D=Dingman's-Bushkill B=Bushkill-Smithfield S=Smithfield-South Boundary

5. Site Location: Code as below.
   I=Island P=PA shoreline N=NJ shoreline

6. Describe Site Location: Describe the location of the recreation site using local geographic features and distances in sufficient detail so that someone five years later could relocate the site.

7. Tag Tree: Label a round 1.5-inch aluminum tag with the complete recreation site number and attach with a 2-inch aluminum nail as high as possible on the backside of a larger healthy tree, preferably just beyond the site boundary furthest from the river. Leave approximately 1 inch of the nail exposed to allow for tree growth. The intent is to select a location that is least likely to be noticed by visitors. During site remeasurement look for old tags to verify site numbers. Replace any lost tags.

8. Inventoried By: List the names of field personnel involved in data collection.

9. Date: Month, day, and year the recreation site was evaluated (e.g., June 12, 1989 = 06/12/89).

10. Substrate of Landing Area: The landing area is defined as the area of human disturbance extending from average water level up to the beginning of the recreation site access trail. Use your best judgment concerning where average water level is. Record the predominant substrate for this area using the coded categories below.
B=bedrock - shelf bedrock
C=cobble - includes gravel size stone and up
S=sand - includes sandy beach soils that do not form a surface crust in trampled areas
O=soil - includes clays to loamy sands

11. Shoreline Disturbance: Measure the combined distance (nearest foot) along the shoreline where the vegetation is absent or highly disturbed from human trampling. This distance should be measured approximately 1 foot beyond (above) the leading edge of adjacent undisturbed vegetation. If the shoreline area is naturally barren of vegetation, record a 0. If several sites share a common access, record the shoreline disturbance for the closest site and record a 0 for all other sites.

12. Height of Site Above River: Elevation difference (to the nearest foot) between average water level and front edge of recreation site. This measurement can be made by standing on the shore at the average water level and sighting across to a point level with your eyes on the bank. Walk to this point and sight again higher on the bank. Repeat this process until the level of the front edge of the site is reached. Multiply the number of times the process was repeated (include a fraction of your height for the final measurement) by the height in feet from the ground to your eye level. This process will provide a sufficiently accurate site height.

13. Number of Other Recreation Sites Visible: Record the number of other recreation sites, which, if occupied, would be visible from the recreation site or its shoreline access. This is a social variable to assess site intervisibility, i.e., to assess where visitors might experience solitude or camp with other visitors in a more social setting.

14. Tree Canopy Cover Over Site: Estimate the percentage of tree canopy cover directly over the recreation site: 1=0-25% 2=26-50% 3=51-75% 4=76-100%

15. Number of 8x10-foot Tent Pads: Number of relatively level and rock/stump-free sites (excluding satellites) where an 8x10-foot tent could be comfortably erected allowing for social space differences, i.e., take into account how close to each other tents would be set up by a larger party. The intent is to determine which sites are appropriate for group use versus use by small parties.
Code as shown: 1=1-2 sites 2=3-5 sites 3=>6 sites

16. Toilet: Search general area for the presence of any NPS-provided toilet. For Clivus Multrum composting toilets, include only if the toilet is visible from the site. Code as below.
C=Clivus toilet
P=pit toilet
N=no toilet present

Impact Parameters

The first step is to establish the recreation sites' boundaries and measure its size. The following procedures describe use of the variable radial transect method for determining the sizes of recreation sites. This is accomplished by measuring the lengths of linear transects radiating from a permanently defined centerpoint to the recreation site boundary.

Step 1. Identify Recreation Site Boundaries and Flag Transect Endpoints. Walk the recreation site boundary and place flagged wire pins at locations which, when connected with straight lines, will define a polygon whose area approximates the recreation site area. Use as few pins as necessary, typical recreation sites can be adequately flagged with 10-15 pins. Look both directions along recreation site boundaries as you place the flags and try to balance areas of the recreation site that fall outside the lines with offsite (undisturbed) areas that fall inside the lines. Pins do not have to be placed on recreation site boundaries, as demonstrated in the diagram following these procedures. Project recreation site boundaries straight across areas where trails enter the site. Identify recreation site boundaries by pronounced changes in vegetation cover, vegetation height/disturbance, vegetation composition, surface organic litter, and topography (refer to photographs following these procedures). Many sites with dense forest overstories will have very little vegetation and it will be necessary to identify boundaries by examining changes in organic litter, i.e., leaves that are untrampled and intact versus leaves that are pulverized or absent. In defining the recreation site boundaries, be careful to include only those areas that appear to have been disturbed from human trampling. Natural factors such as dense shade and flooding can create areas lacking vegetative cover. Do not include these areas if they appear "natural" to you. When in doubt, it may also be helpful to speculate on which areas typical visitors might use based on factors such as slope or rockiness.

Step 2. Select and Reference Recreation Site Centerpoint. Select a recreation site centerpoint that is preferably a) visible from all the recreation site boundary pins, b) easily referenced by distinctive permanent features such as larger trees or boulders, and c) approximately 5 feet from the steel firegrate. Embed a 5-inch nail in the soil at the centerpoint location so that the head is 3-4 inches below the surface. During future site assessments a magnetic pin locator can be used to locate the centerpoint. Locating the centerpoints near the firegrates, which are semipermanently anchored, will simplify their relocation. However, interference with the steel in the grates may be encountered if the centerpoint nail is closer than 5 feet to the grate. Next, insert a large steel stake at the centerpoint and reference it to at least three features. Try to select reference features in three opposing directions, as this will enable future workers to triangulate the centerpoint location. For each feature, take a compass bearing (nearest degree) and measure the distance (nearest 1/10 foot) from the centerpoint to the center of trees or the highest point of boulders. Also measure the approximate diameter of reference trees at 4.5 feet above ground (dbh). Be extremely careful in taking these bearings and measurements, as they are critical to relocating the centerpoint in the future. Record this information on the back of the form.

Examples:
1. Mockernut Hickory, 0.7 ft dbh, 12.4 ft at 52° (tree with recreation site sign)
2. Red Maple, 1.2 ft dbh, 23.2 ft at 208° (tree with recreation site number tag)
3. Boulder, 17.9 ft at 312° (distance and bearing to highest point)
4. Sycamore, 1.4 ft dbh, 29.5 ft at 78° (only sycamore in area)

Take a photograph that clearly shows the centerpoint location in relation to nearby trees or other reference features, such as the steel grate, nearby trees, or boulders. Record a photo description, such as "Centerpoint location for site 78," in the photo log.

Options: Some sites may lack the necessary permanent reference features enabling the centerpoint to be accurately relocated. If only one or two permanent reference features are available, use these and take additional photographs from several angles. If permanent features are unavailable, simply proceed with the remaining steps without permanently referencing the centerpoint. This option will introduce more error in comparisons with future measurements, particularly if the recreation site boundaries are not pronounced. Note your actions regarding use of these options in the Comments section.

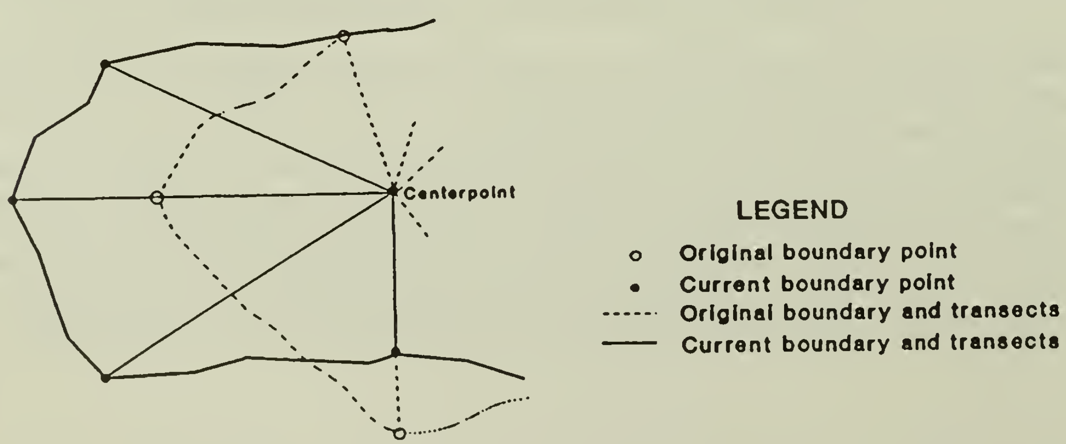
Step 3. Record Transect Azimuths and Lengths. Standing directly over the centerpoint, identify and record the compass bearing (azimuth) of each recreation site boundary pin working in a clockwise fashion (in the exact order you would encounter them if you were walking the recreation site boundary). Be careful not to miss any pins hidden behind vegetation or trees. Be extremely careful in identifying the correct compass bearings to these pins as error in these bearings will bias current and future measurements of recreation site size. Next, anchor the end of your tape to the centerpoint stake, measure and record the length of each transect (nearest 1/10 foot), starting with the same boundary pin and in the same clockwise order as before. Be absolutely certain that the appropriate pin distances are recorded adjacent to their respective compass bearings. Leave boundary pins in place until you finish all other recreation site measurements.

Step 4. Measure Island and Satellite Areas. Identify any undisturbed "islands" of vegetation inside recreation site boundaries (often due to clumpings of trees or shrubs) and disturbed "satellite" use areas outside recreation site boundaries (often due to tent sites or cooking sites). Use recreation site boundary definitions for determining the boundaries of these areas. Use the geographic figure method to determine the areas of these islands and satellites (refer to the diagrams following these procedures). This method involves superimposing one or more imaginary geometric figures (rectangles, circles, or right triangles) on island or satellite boundaries and measuring appropriate dimensions to calculate their areas. Record the types of figures used and their dimensions on the back of the form; the sizes of these areas should be computed in the office with a calculator.

Site Remeasurement: During site remeasurement use the data from the last monitoring period to reestablish the centerpoint and all recreation site boundary pins. If steel centerpoint nails were embedded in the ground, a magnetic pin locator can assist in this process. Place flagged wire pins at each transect boundary point. Boundary locations based on the following procedures:

1. Keep the same transect length if that length still seems appropriate, i.e., there is no compelling reason to alter the initial boundary determination.
2. Record a new transect length if the prior length is inappropriate, i.e., there is compelling evidence that the present boundary does not coincide with the pin and the pin should be relocated either closer to or further from the centerpoint along the prescribed compass bearing. Use different colored flags to distinguish these current boundary points from the former boundaries.
3. Repeat Steps 1 and 3 from above to establish additional transects where necessary to accommodate any changes in the shape of recreation site boundaries (diagram below). Also repeat Step 4.
4. Leave all pins in place until all procedures are completed. Pins identifying the former site boundaries are necessary for tree damage and root exposure assessments.

These additional procedures are designed to eliminate much of the measurement error associated with different individuals making subjective judgments on those sites or portions of sites where boundaries are not pronounced. These procedures may only be used for sites whose centerpoints can be relocated.



17. Condition Class: Record the Condition Class you assessed for the site using the categories described earlier.

18. Vegetative Ground Cover Onsite: An estimate of the percentage of live non-woody vegetative ground cover (including herbs, grasses, and mosses and excluding tree seedlings, saplings, and shrubs) within the flagged recreation site boundaries using the coded categories listed next (refer to photographs following these procedures). Include any disturbed "satellite" use areas and exclude undisturbed "islands" of vegetation. For this and the following two parameters, it is often helpful to narrow your decision to two categories and concentrate on the boundary that separates them. For example, if the vegetation cover is either category 2 (6-25%) or category 3 (26-50%), you can simplify your decision by focussing on whether vegetative cover is greater than 25%.

    1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%

19. Vegetative Ground Cover Offsite: An estimate of the percentage of vegetative ground cover in an adjacent but largely undisturbed "control" area. Use the codes and categories listed earlier. The control site should be similar to the recreation site in slope, tree canopy cover (amount of sunlight penetrating to the forest floor), and other environmental conditions. The intent is to locate an area that would closely resemble the recreation site area had the recreation site never been used. In instances where you cannot decide between two categories, select the category with less vegetative cover. The rationale for this is simply that, all other factors being equal, the first campers would have selected a site with the least amount of vegetation cover.

20. Soil Exposure: An estimate of the percentage of soil exposure, defined as ground with very little or no organic litter (partially decomposed leaf, needle, or twig litter) or vegetation cover, within the recreation site boundaries and satellite use areas (refer to the photographs following these procedures). Dark organic soil, which typically covers lighter colored mineral soil, should be assessed as bare soil. Assessments of soil exposure may be difficult when organic litter becomes highly decomposed and forms a patchwork with areas of bare soil. If patches of organic material are relatively thin and few in number, the entire area should be assessed as bare soil. Otherwise, the patches of organic litter should be mentally combined and excluded from assessments. Code as for vegetative cover.

21. Tree Damage: Tally each live tree (>1 in. diameter at 4.5 ft.) within or on recreation site boundaries to one of the tree damage rating classes described below (refer to the photographs following these procedures). **Include** trees within undisturbed "islands" and **exclude** trees in disturbed "satellite" areas. Assessments are restricted to all trees within the flagged recreation site boundaries in order to ensure consistency with future measurements. Multiple tree stems from the same species that are joined at or above ground level should be counted as one tree when assessing damage to any of its stems. Assess a cut stem on a multiple-stemmed tree as tree damage, not as a stump. Do not count tree stumps as tree damage. Take into account tree size. For example, damage for a small tree would be considerably less in size than damage for a large tree. Omit scars that are clearly not human-caused (e.g., lightning strikes).

    During site remeasurement, begin by assessing tree damage on all trees within the site boundaries identified in the last measurement period. Place boxes around each tally for trees in areas where boundaries have moved closer to the centerpoint, i.e., former site areas that are not currently judged to be part of the site. Next, assess tree damage in areas where boundaries have moved further from the centerpoint, i.e., expanded site areas that are newly impacted since the last measurement period. Circle these tallies. These additional procedures are necessary in order to accurately analyze changes in tree damage over time.

    None/Slight - No or slight damage such as broken or cut smaller branches, one nail, or a few superficial trunk scars.
    Moderate - Numerous small trunk scars and/or nails or one moderate-sized scar.
    Severe - Trunk scars numerous with many that are large and have penetrated to the inner wood; any complete girdling of tree (cutting through tree bark all the way around tree).

22. Root Exposure: Tally each live tree (>1 in. diameter at 4.5 ft.) within or on recreation site boundaries to one of the root exposure rating classes described below. **Include trees within undisturbed "islands" and exclude trees in disturbed "satellite" areas.** Assessments are restricted to all trees within the flagged recreation site boundaries in order to ensure consistency with future measurements. Where obvious, omit exposed roots that are clearly not human-caused (e.g., stream/river flooding).

During site remeasurement, begin by assessing root exposure on all trees within the site boundaries identified in the last measurement period. Place boxes around each tally for trees in areas where boundaries have moved closer to the centerpoint, i.e., former site areas that are not currently judged to be part of the site. Next, assess root exposure in areas where boundaries have moved further from the centerpoint, i.e., expanded site areas that are newly impacted since the last measurement period. Circle these tallies. These additional procedures are necessary in order to accurately analyze changes in root exposure over time.

None/Slight - No or slight root exposure such as is typical in adjacent offsite areas.
Moderate - Top half of many major roots exposed more than one foot from base of tree.
Severe - Three-quarters or more of major roots exposed more than one foot from base of tree; soil erosion obvious.

23. Number of Tree Stumps: A count of the number of tree stumps (> 1 in. diameter) within or on recreation site boundaries. **Include trees within undisturbed "islands" and exclude trees in disturbed "satellite" areas.** Do not include cut stems from a multiple-stemmed tree.

During site remeasurement, begin by assessing stumps within the site boundaries identified in the last measurement period. Place boxes around each tally for stumps in areas where boundaries have moved closer to the centerpoint, i.e., former site areas that are not currently judged to be part of the site. Next, assess stumps in areas where boundaries have moved further from the centerpoint, i.e., expanded site areas that are newly impacted since the last measurement period. Circle these tallies. These additional procedures are necessary in order to accurately analyze changes in stumps over time.

24. Number of Trails: A count of all trails leading away from the outer recreation site boundaries. Do not count extremely faint trails that have untrampled tall herbs present in their tread or trails leading out to any satellite areas.

25. Number of Fire Sites: A count of each fire site within recreation site boundaries, including satellite areas. Include old inactive fire sites as exhibited by blackened rocks, charcoal, or ashes. Do not include locations where charcoal or ashes have been dumped. However, if it is not clear whether or not a fire was built on the site, always count questionable sites that are within site boundaries and exclude those that are outside site boundaries.

26. Litter/Trash: Evaluate the amount of litter/trash on the site: N=None or less than a handful S=Some - a handful up to enough to fill a standard 2 1/2-gallon bucket M=Much - more than a 2 1/2-gallon bucket

27. Human Waste: Follow all trails connected to the site to conduct a quick search of likely "toilet" areas, typically areas just out of sight of the recreation site. Count the number of individual human waste sites, defined as separate locations exhibiting toilet paper and/or human feces. The intent is to identify the extent to which improperly disposed human feces is a problem. Use the following coded categories: N=None S=Some - 1 - 3 sites evident M=Much - 4 or more sites evident

28. Comments: An informal list of comments concerning the site: note any assessments that you felt were particularly difficult or subjective, problems with monitoring procedures or their application to this particular recreation site, suggestions for clarifying monitoring procedures, recommendations regarding site management, or any other comments.

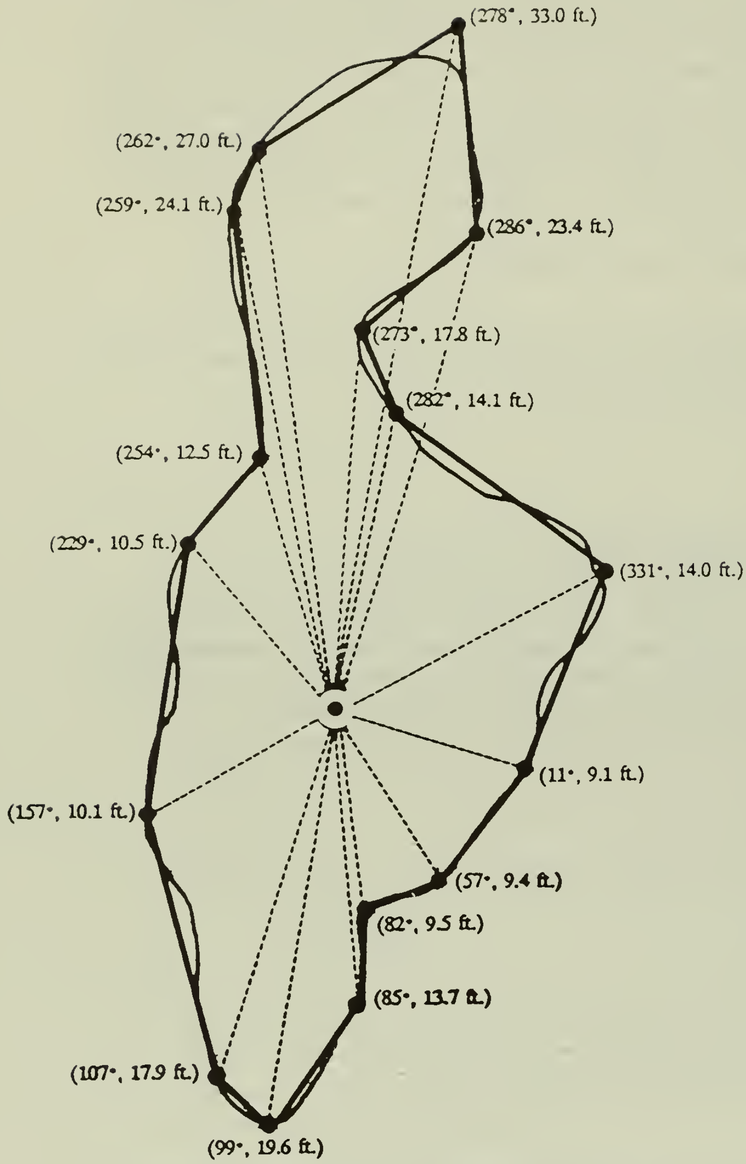
29. Recreation Site Photograph: Select a good vantage point for viewing the entire recreation site, preferably one of the recreation site boundary flags, and take a picture of the recreation site. Note the compass bearing and distance from the centerpoint to the photo point and record in the space indicated on the back of the form (ASA 200 color print film and a 35mm wide angle lens is recommended). The intent is to obtain a photograph that includes as much of the site as possible to provide a photographic record of site conditions. The photo will also allow future workers to make a positive identification of the recreation site. Record the film type and ASA (or DIN), and photo description, recreation site number, and focal length in the photo log. At the earliest possible date label the backs of 3x5 prints with this information; also store and label the negatives. Staple the recreation site picture, the centerpoint location picture, and any others to a blank sheet of paper and attach to the recreation site form.

* Collect all recreation site boundary pins, the centerpoint stake, and all other equipment.

30. Total Recreation Site Area: A computer program will be used to calculate recreation site area based on the recorded transect measurements. Add the area of any satellite sites and subtract the area of any undisturbed islands to obtain the Total Recreation Site Area.

Form B Procedures

Refer to the procedures described earlier, all procedures are the same with the exception of recreation site size. Measure recreation site size using the geometric figure method. Typically, Class 1 and 2 recreation sites are quite small in size and this method should be both efficient and accurate. Refer to Step 4 above for additional guidance; be sure to record on Form B the types of figures used and all necessary dimensions.



Step 1. <u>Identify Site Boundaries and Flag Transect Endpoints.</u> Walk the site boundary and place flagged wire pins at locations which, when connected with straight lines, will define a polygon whose area approximates the site area. Use as few pins as necessary, typical sites can be adequately flagged with 10-15 pins. Look both directions along site boundaries as you place the flags and try to balance areas of the site that fall outside the lines with offsite (undisturbed) areas that fall inside the lines. Pins do not have to be placed on site boundaries, as demonstrated in the diagram at left. Project site boundaries straight across areas where trails enter the site.

Step 2. <u>Select and Reference Site Centerpoint.</u> Select a site centerpoint that is 1) visible from all the site boundary pins, and 2) easily referenced by distinctive permanent features such as larger trees or boulders. Place a steel stake at the centerpoint and reference it to at least three features. Try to select reference features in three opposing directions as this will enable future workers to triangulate the centerpoint location. For each feature, take and record a compass bearing (nearest degree) and measure the distance (nearest 1/10 foot) from the centerpoint to the center of trees or the highest point of boulders. Also measure the approximate diameter of reference trees at 4.5 feet above ground (dbh). <u>Be extremely careful in taking these bearings and measurements as they are critical to relocating the centerpoint in the future.</u> Take a photograph that clearly shows the centerpoint location in relation to nearby trees or other reference features. Record photo description and site number in a photo log.

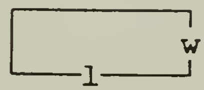
Step 3. <u>Record Transect Azimuths and Lengths.</u> Standing directly over the centerpoint, identify and record the compass bearing (azimuth) of each site boundary pin working in a clockwise fashion (in the exact order you would encounter them if you were walking the site boundary). Be careful not to miss any pins hidden behind vegetation or trees. <u>Be extremely careful in identifying the correct compass bearings to these pins as error in these bearings will bias current and future measurements of site size.</u> Next, anchor the end of your tape to the centerpoint stake, measure and record the length of each transect (nearest 1/10 foot), starting with the same boundary pin and in the same clockwise order as before. <u>Be absolutely certain that the appropriate pin distances are recorded adjacent to their respective compass bearings.</u> Leave boundary pins in place until you finish all other site measurements.

Step 4. <u>Measure Island and Satellite Areas.</u> Identify any undisturbed "islands" of vegetation inside site boundaries (often due to clumpings of trees or shrubs) and disturbed "satellite" use areas outside site boundaries (often due to tent sites or cooking sites). Use site boundary definitions for determining the boundaries of these areas. Use the geographic figure method to determine the areas of these islands and satellites.

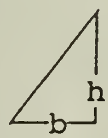
Geometric Figure Method

This method for determining the area of recreation sites, disturbed "satellite" sites, and interior undisturbed "island" sites is relatively rapid and is accurate if applied with good judgment. Begin by carefully studying the site's shape, as if you were looking down from above. Mentally superimpose and arrange one or more simple geometric figures to closely match the site boundaries. Any combination and orientation of these figures is permissible; see the examples below. Measure (nearest foot) the dimensions necessary for computing the area of each geometric figure. It is best to complete area computations in the office with a calculator to reduce field time and minimize errors.

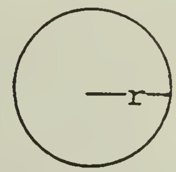
Good judgment is required in making the necessary measurements of each geometric figure. As boundaries will never perfectly match the shapes of geometric figures, you will have to mentally balance disturbed and undisturbed areas included and excluded from the geometric figures used. For example, in measuring an oval site with a rectangular figure, you would have to <u>exclude</u> some of the disturbed area along each side in order to balance out some of the undisturbed area <u>included</u> at each of the four corners. It may help, at least initially, to place plastic tape or wire flags at the corners of each geometric figure used. In addition, be sure that the opposite sides of rectangles or squares are the same length.



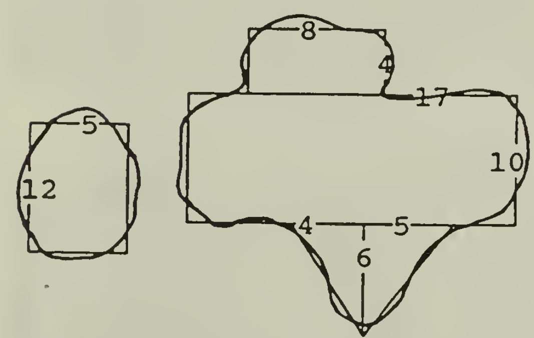
A = l x w



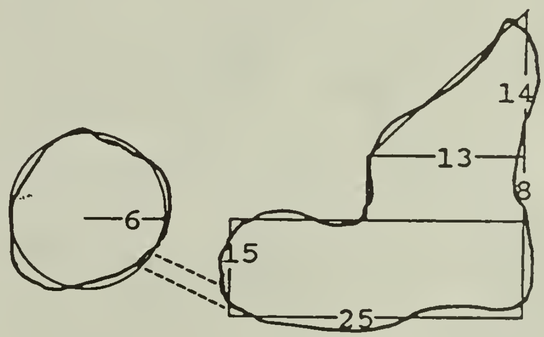
A = 0.5 x b x h



A = 3.14 x r x r



A = (8x4)+(17x10)+(5x12)+
(.5x4x6)+(.5x5x6)
A = 289



A = (.5x13x14)+(13x8)+
(15x25)+(3.14x6x6)
A = 683

SITE BOUNDARIES

Identified by pronounced changes in vegetation, organic litter, or topography.

Vegetation Cover

Vegetation Composition

Vegetation Height/Disturbance

Topography

Organic Litter

Organic Litter

SITE BOUNDARIES

Yellow triangles indicate flagged pin locations which delineate site boundaries.

Site boundaries determined by pronounced changes in vegetation cover.

Site boundaries determined by pronounced changes in vegetation height/disturbance.

VEGETATIVE GROUND COVER

Live non-woody vegetative ground cover (including herbs, grasses, and mosses).

1=0-5%

2=6-25%

3=26-50%

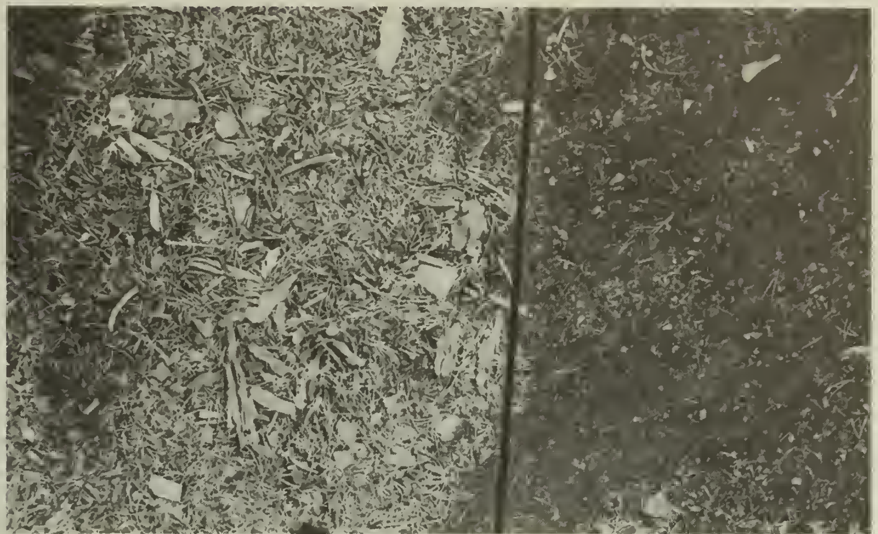
4=51-75%

5=76-95%

6=96-100%

SOIL EXPOSURE

Areas of predominantly bare soil; very little or no organic litter or vegetation cover.

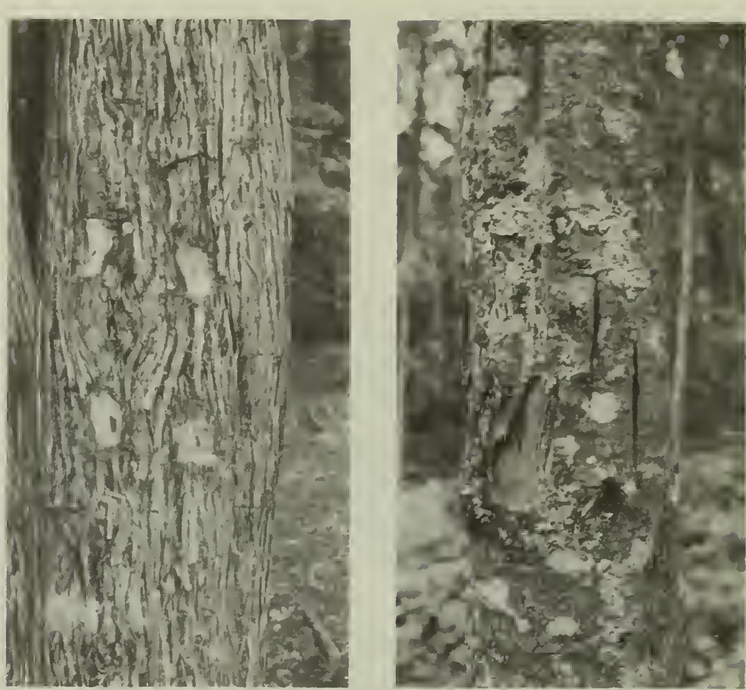


Organic litter on left is pulverized but still covers underlying organic and mineral soil. Dark organic soil on right, which covers lighter colored mineral soil, should be assessed as bare soil.

As organic litter is pulverized and eroded from sites the remaining materials often clump together, resulting in a patchwork of organic litter and bare soil which is difficult to evaluate. If patches of organic material are relatively thin and few in number, as illustrated in the photo above, the entire area should be assessed as bare soil. Otherwise, the patches of organic litter should be mentally combined and excluded from assessments.

TREE DAMAGE

NONE/SLIGHT

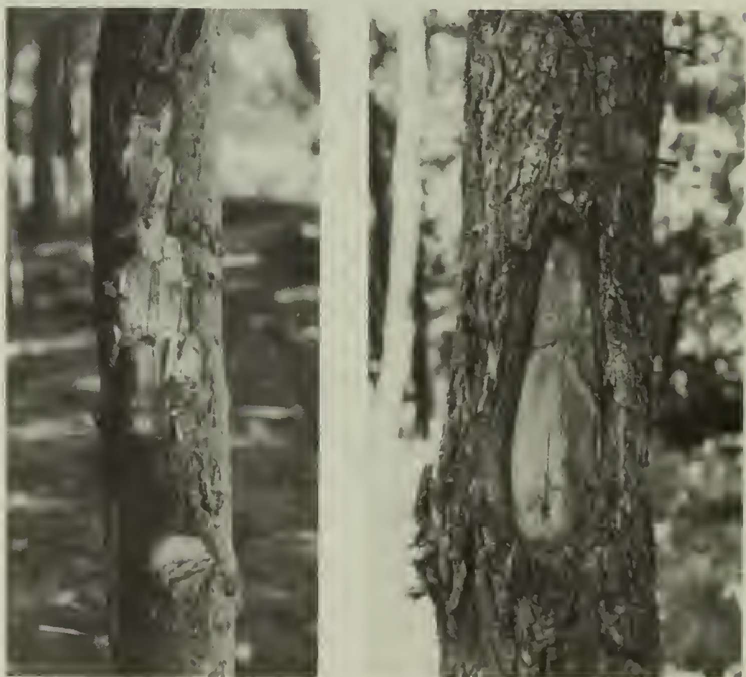


MODERATE

NONE/SLIGHT: No or slight damage such as broken or cut smaller branches, 1 nail, or a few superficial trunk scars.

MODERATE: Numerous small trunk scars and nails or 1 moderate sized scar.

SEVERE: Trunk scars numerous with many that are large and have penetrated to the inner wood; any complete girdling of tree.



SEVERE

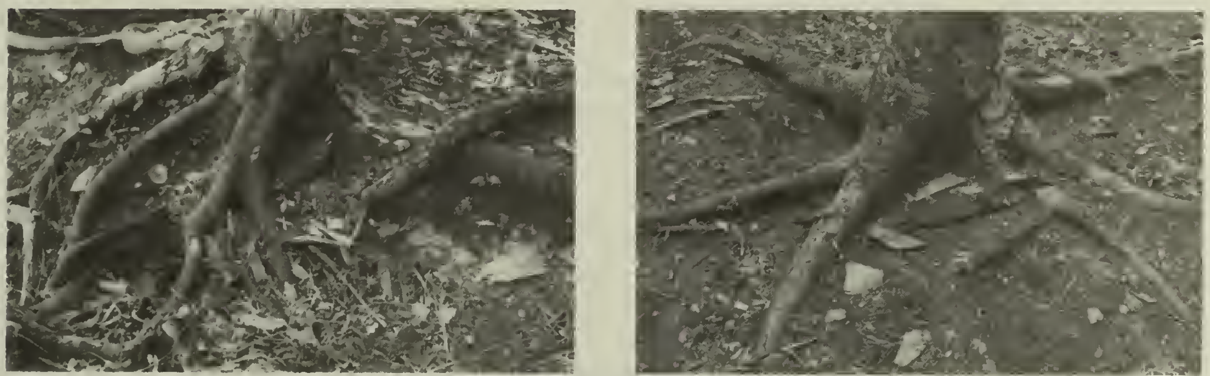
ROOT EXPOSURE

NONE/SLIGHT: No or slight root exposure such as is typical in adjacent offsite areas.

MODERATE: Top half of many major roots exposed more than 1 foot from base of tree.

SEVERE: Three-quarters or more of major roots exposed more than 1 foot from base of tree; soil erosion obvious.

NONE/SLIGHT



MODERATE

SEVERE

Appendix B. Data Analysis and Standards

Where possible, data analysis should be conducted using the raw data for each impact parameter. The influence of factors such as vegetation type, elevation, or amount of site use can be evaluated by stratifying various site impact parameter values by the categories of these factors. Impact parameters can also be stratified by management districts, geographic locations, or management zones. Mean impact parameter values can be computed for each strata of the factor being investigated. If the monitoring survey represents a census (all visitor use sites were monitored), these mean values should be directly compared to evaluate differences. Statistical testing to determine the significance of differences between means is appropriate only if a sample of sites were monitored.

If statistical testing is conducted, the distribution of values for each impact parameter should be evaluated for normality and equal variances. Most statistical packages include the necessary procedures and tests to accomplish this. Typically, any problems encountered can be corrected by data transformations such as the natural log or square root functions.

A disadvantage in analyses of raw data is that the relative degree of impact for various impact parameters cannot be directly compared because they are assessed in different units. For example, the amount of tree damage (numbers of damaged trees) cannot be compared to the amount of soil exposure (percent of site area or square feet). For this reason raw data is often standardized to permit direct comparisons of the relative magnitude of change for various impact parameters. Standardized values for each impact parameter can also be weighted and summed to produce a single summary impact score for each visitor use site.

Percentiles

A simple method for standardizing impact parameter values is to compute percentiles, a procedure that divides the distribution of values for an impact parameter into 100 groups with equal frequencies. Percentile ranks can be computed with most statistical packages and are easily interpreted. For example, one half of all sites would have soil exposure in excess of the site receiving a percentile rank of 50, the median value. A summary percentile score can also be obtained by calculating percentiles from the summed weighted or unweighted percentile ranks of several impact parameters.

Using percentiles has several disadvantages, however. First, because percentiles are computed using only the ranks of the measured impact values, the relative "distances" between the original values are lost. To illustrate, consider the area of soil exposure for two pairs of campsites in Table 1. Soil exposure on site 3 is 2 ft^2 more than on site 2; the difference in percentiles is 4. Soil exposure on site 21 is 848 ft^2 more than on site 20, but the difference in percentiles is only 5. Dramatic and managerially important changes in resource conditions will be missed if percentiles are used for comparing amount of change. Their use should be restricted to ranking sites and for determining the percentage of sites below or above a specified rank. Percentiles also begin to "lose" information when the number of unique values for an impact parameter exceeds 100. When this happens, sites with different values are combined into common categories and given the same percentile rank.

Table 1. Two standardized measures computed from soil exposure measurements taken on 21 wilderness campsites in the Jefferson National Forest.

Site	Exposed Soil		
Number	Actual (ft^2)	Percentile	Z-Score
1	31	5	-0.83
2	**110**	**10**	**-0.71**
3	**112**	**14**	**-0.71**
4	119	19	-0.69
5	127	23	-0.68
6	145	28	-0.65
7	216	32	-0.54
8	236	37	-0.51
9	273	41	-0.46
10	288	46	-0.43
11	298	51	-0.42
12	426	55	-0.22
13	467	60	-0.16
14	512	64	-0.09
15	563	69	-0.01
16	701	73	0.20
17	724	78	0.24
18	960	82	0.60
19	1096	87	0.82
20	**1841**	**91**	**1.97**
21	**2689**	**96**	**3.28**

Z-scores

A commonly used statistical method for standardizing raw data is to compute a Z-score or standard score. For each impact parameter a standard deviation is calculated, telling us the "average" number of units by which each site deviates from the mean. Z-scores are calculated by subtracting the mean from each raw score and then dividing by the standard deviation. The resulting distribution of values has a mean of 0 and a standard deviation of 1. Consider a site with three damaged trees from a distribution with a mean of six damaged trees and a standard deviation of 3. The Z-score for this site is -1.0 [(3-6)/3]. The Z-score indicates that the site is 1 standard deviation below the mean. Now reconsider the two pairs of campsites discussed above. The difference in Z-scores between sites 2 and 3 is 0.02, while the difference between sites 20 and 21 is 1.31. Z-scores offer the advantage of standardization while preserving the original raw score distribution and the relative "distances" between individual scores.

Decimal points in the Z-score values, if bothersome, can be removed by multiplying each score by 100. The mean remains zero but the standard deviation will become 100.

Z-scores also permit a number of statistically appropriate comparisons. First, the extent of change for each impact parameter on a particular site can be directly compared. For example, in Table 2, site 1 is less than average in site size and exposed soil, average in vegetation loss, and above average for damaged trees and shoreline disturbance. Second, the extent of change for impact parameters can be compared between sites. Site 1 is nearly 4 standard deviations smaller than site 3. With the exception of shoreline disturbance, site 1 is considerably less impacted than site 3. Finally, Z-scores from separate impact parameters can be weighted and summed to form a summary Z-score. The values of this score can no longer be interpreted in terms of standard deviation units but they do provide an appropriate ranking measure to determine the least and most highly impacted sites.

The summary Z-score values for each site can also be averaged after sites are stratified by factors such as vegetation type or management district. As noted earlier, for census data these mean values should be directly compared to evaluate differences. For statistical testing of sample data, the Z-scores should be computed separately for each strata of the stratifying parameter in order to avoid statistical dependency. For example, a statistical test to evaluate differences in impact associated with sites in various vegetation types would proceed as follows. First, the mean and standard deviation for each impact parameter would be computed separately for each vegetation type. These values would be used to compute Z-scores and summary Z-scores within each vegetation type. An analysis of variance and multiple-range testing can then be performed on the summary Z-score values.

Table 2. Z-scores computed for selected impact parameters from three recreation sites at Delaware Water Gap National Recreation Area.

Site Number	Site Size	Exposed Soil	Vegetation Loss	Damaged Trees	Shoreline Disturbance
1	-1.95	-1.23	0.12	1.33	1.87
2	-0.04	-0.65	-0.71	0.27	0.09
3	2.03	1.95	1.45	2.51	1.27

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NPS D-693 October 1991