

**CHANGES IN CAMPSITE CONDITION:
RESULTS FROM CAMPSITE MONITORING
AT DELAWARE WATER GAP
NATIONAL RECREATION AREA**

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ii
LIST OF TABLES	iv
LIST OF FIGURES	vii
EXECUTIVE SUMMARY	viii
INTRODUCTION	1
JUSTIFICATION FOR VISITOR IMPACT MONITORING	3
Legislative Mandates	3
Management Policies and Guidelines	4
Park Monitoring Program Needs and Capabilities	5
RESEARCH AND MONITORING PROGRAM OBJECTIVES	7
Research Objectives	7
Monitoring Program Objectives	7
LITERATURE REVIEW	8
Types of Impact Assessment Systems	8
STUDY AREA	9
Camping History and Management	10
Campsite Use Levels	10
RESEARCH METHODS	12
RESULTS AND DISCUSSION	15
Campsite Distribution	15
Inventory Parameters	18
Campsite Condition Parameters	21
Relational Analyses	52
SUMMARY AND RECOMMENDATIONS	58
Monitoring Results	58
Recommendations	63
REFERENCES	66
APPENDIX A: 1991 Campsite Monitoring Manual	69
APPENDIX B: Listings for Large Designated Campsites and Undesignated Campsites ..	81

LIST OF TABLES

Table 1.	Resource impacts caused by hiking and camping activities.	1
Table 2.	Estimated annual river camping visitation, 1984-1991.	11
Table 3.	Estimated measurement error for eight campsite condition parameters. Values for median campsites reflect application of error estimates to the median values for designated campsites assessed in 1991.	14
Table 4.	Number and percent ¹ of designated and undesignated campsites for five Delaware River segments.	16
Table 5.	Designated and undesignated campsite density (no. sites/mile) for five Delaware River segments.	17
Table 6.	Number and percent of designated campsites assessed in 1986 and 1991 for selected inventory parameters.	19
Table 7a.	General statistics of designated campsites assessed in 1986 and 1991 for campsite size.	23
Table 7b.	Number and percent of designated campsites assessed in 1986 and 1991 by campsite size categories.	23
Table 7c.	General statistics of designated campsites common to both the 1986 and 1991 surveys for campsite size.	24
Table 7d.	Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in size.	24
Table 8a.	General statistics of designated campsites assessed in 1986 and 1991 for vegetation loss.	25
Table 8b.	Number and percent of designated campsites assessed in 1986 and 1991 by area of vegetation loss categories.	25
Table 8c.	General statistics of designated campsites common to both the 1986 and 1991 surveys for vegetation loss.	26
Table 8d.	Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in vegetation loss.	26
Table 9a.	General statistics of designated campsites assessed in 1986 and 1991 for exposed soil.	27
Table 9b.	Number and percent of designated campsites assessed in 1986 and 1991 by area of exposed soil categories.	27
Table 9c.	General statistics of designated campsites common to both the 1986 and 1991 surveys for exposed soil.	28
Table 9d.	Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in exposed soil.	28
Table 10a.	General statistics of designated campsites assessed in 1986 and 1991 for shoreline disturbance.	29
Table 10b.	Number and percent of designated campsites assessed in 1986 and 1991 by shoreline disturbance categories.	29

Table 10c.	General statistics of designated campsites common to both the 1986 and 1991 surveys for shoreline disturbance.	30
Table 10d.	Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in shoreline disturbance.	30
Table 11a.	General statistics of designated campsites assessed in 1986 and 1991 for damaged trees.	31
Table 11b.	Number and percent of designated campsites assessed in 1986 and 1991 by tree damage categories.	31
Table 11c.	General statistics of designated campsites common to both the 1986 and 1991 surveys for damaged trees.	32
Table 11d.	Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in damaged trees.	32
Table 12a.	General statistics of designated campsites assessed in 1986 and 1991 for trees with exposed roots.	33
Table 12b.	Number and percent of designated campsites assessed in 1986 and 1991 by root exposure categories.	33
Table 12c.	General statistics of designated campsites common to both the 1986 and 1991 surveys for trees with exposure roots.	34
Table 12d.	Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in root exposure.	34
Table 13a.	General statistics of designated campsites assessed in 1986 and 1991 for tree stumps.	35
Table 13b.	Number and percent of designated campsites assessed in 1986 and 1991 by tree stump categories.	35
Table 13c.	General statistics of designated campsites common to both the 1986 and 1991 surveys for tree stumps.	36
Table 13d.	Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in stumps.	36
Table 14a.	General statistics of designated campsites assessed in 1986 and 1991 for trails.	37
Table 14b.	Number and percent of designated campsites assessed in 1986 and 1991 by trails categories.	37
Table 14c.	General statistics of designated campsites common to both the 1986 and 1991 surveys for trails.	38
Table 14d.	Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in trails.	38
Table 15a.	General statistics of designated campsites assessed in 1986 and 1991 for fire sites.	39
Table 15b.	Number and percent of designated campsites assessed in 1986 and 1991 by fire site categories.	39

Table 15c.	General statistics of designated campsites common to both the 1986 and 1991 surveys for fire sites.	40
Table 15d.	Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in fire sites.	40
Table 16.	Condition class ratings for designated campsites in 1991.	50
Table 17.	Mean designated campsite conditions for five river segments.	52
Table 18.	Analysis of designated campsite conditions by site location: New Jersey shoreline, Pennsylvania shoreline, and islands.	53
Table 19.	Analysis of vegetative changes on designated campsites in relation to tree canopy cover: open (0-75%), and closed (75-100%).	54
Table 20.	Analysis of designated campsite conditions by site height above the river: low (0-6 ft), intermediate (7-16 ft), and high (17-40 ft).	55
Table 21.	Crosstabulation of toilet presence and type with number of occurrences of improperly disposed human waste.	57
Table 22.	Comparison of cumulative change (sum) values for all designated campsites and those designated campsites common to both surveys.	62

LIST OF FIGURES

Figure 1.	Capabilities of visitor impact monitoring programs.	5
Figure 2.	Schematic illustrating the LAC/VIM planning and management frameworks (from Marion et al. 1985).	6
Figure 3.	Research objectives.	7
Figure 4.	Campsite monitoring program objectives.	7
Figure 5.	Regional map showing the location of Delaware Water Gap NRA.	9
Figure 6.	Conditions class definitions applied at DWGNRA.	12
Figure 7.	Number of designated and undesignated campsites from the 1984-86 and 1991 surveys for five river segments.	16
Figure 8.	Number of designated and undesignated campsites per river mile from the 1984-86 and 1991 surveys for five Delaware River segments.	17

EXECUTIVE SUMMARY

Park managers require objective data describing the changing conditions of resources under their stewardship, particularly for changes that result from human use of park resources. This report documents and evaluates changes in resource conditions on river campsites within the Delaware Water Gap National Recreation Area. Campsite condition monitoring procedures were developed and applied in two campsite surveys, spaced five years apart. This effort, including the analytical and graphical procedures developed for this report, serves as a model for similar efforts in other protected environments. The information provided by these surveys establishes baseline resource conditions and permits an accurate evaluation of resource changes and the influential factors contributing to those changes. The monitoring effort can support traditional park management decision making, as is currently the case at Delaware Water Gap National Recreation Area (DEWA), or serve as an integral component of a formal management framework, such as the Limits of Acceptable Change model.

Assessments for monitoring resource conditions on both designated and undesignated (illegal) river campsites were initiated at DEWA in 1984. The initial survey was a cooperative effort with park staff, included as part of the environmental component of a more comprehensive river recreation research program. A multiparameter monitoring system emphasizing measurements, as opposed to ratings, was developed and employed by seasonal park staff during the summers of 1984-86. The initial survey assessed conditions on 179 campsites; 116 were designated and 63 were undesignated. Procedures were refined through additional research and reapplied in 1991 by two field staff hired and trained by the author. Only ten days were required to conduct the reassessment, indicating that this type of monitoring can be both efficient and cost-effective. The 1991 survey assessed conditions on 110 campsites; 87 were designated and 23 were undesignated.

Findings from the initial survey revealed both some problems and potential solutions with respect to minimizing the resource impacts associated with river camping. In 1984, visitors were required to camp at designated locations, indicated by the presence of metal camping signs visible from the river. However, specific campsites were not identified and visitors were free to select existing sites or establish new sites anywhere in the vicinity of these signs. While firegrates had been placed on some sites, they were often moved by visitors, or ignored in favor of rock firepits which could be built in any location. This policy led to the creation of numerous campsites, often in close proximity to each other, and to unnecessarily large areas of disturbance.

A number of recommendations were offered for responding to these problems, many of which were implemented by park staff in 1988/89. Foremost among these was a reevaluation of existing and potential new campsites with a set of eight site selection criteria provided in the initial survey report. Additionally, steel firegrates were installed on each designated campsite. The combined effect of these and other actions was a substantial reduction in all resource impacts assessed by the campsite monitoring program. In particular, the total area of disturbance affected by camping (the sum of campsite sizes) declined 50%, from 302,784 ft² in 1986 to 150,859 ft² in 1991. Only a portion of this reduced area of disturbance was a direct result of a reduction in campsite numbers from 116 to 87. For a sample of 73 campsites

common to both surveys, the total area of disturbance declined 37%. The reduced number of campsites, while accommodating approximately the same amount of use, are well-distributed along the river and the communication of their locations to visitors has been improved through additional signing and wide distribution of a river guide pamphlet that includes a map of all campsite locations.

Park managers now have improved control over the number and location of designated river campsites and the number of illegal sites has declined from 63 to 23. Management attention can now focus on the resource conditions of the 87 designated campsites. Site expansion remains a primary concern, with 23 sites (27%) greater than 2000 ft² (45 x 45 ft) in total area. Tree damage and improperly disposed human waste represent additional concerns. A number of recommendations and options are again offered for management consideration. These include: 1) continuation of the campsite monitoring program, 2) evaluation of five options for reducing the size of large campsites, 3) evaluation of two options for reducing damage to trees, and 4) development of a backcountry management plan incorporating a Limits of Acceptable Change management framework.

INTRODUCTION

This report describes the results from two monitoring assessments of primitive river campsites within Delaware Water Gap National Recreation Area (DEWA). Data describing campsite conditions from the first monitoring assessment conducted from 1984-86 are compared to similar data from the second assessment in 1991. Resource changes are described and summarized and their implications for park management are discussed.

The DEWA campsite monitoring program was initiated in 1984 as part of a comprehensive set of river recreation research studies conducted in three parks: DEWA, Upper Delaware Scenic and Recreational River, and New River Gorge National River. This research report address one element of the environmental component of that research program, monitoring the environmental impacts associated with river recreation use on day-use and overnight campsites along the Delaware River within DEWA. Though a central purpose for the creation and management of parks, visitation inevitably degrades park resources and the experiences of other visitors. This is particularly true along trails and at overnight campsites and day-use recreation sites, where visitation and its effects are concentrated.

Potential consequences of visitation include the trampling and subsequent loss of ground vegetation, shrubs, and tree seedlings; and felling of saplings; erosion of surface litter and humus; exposure, erosion, and compaction of mineral soil; and exposure of tree roots and damage to tree trunks (see Table 1) (Cole 1987, Marion 1984, Cole and Marion 1988). Visitors also perceive these recreational impacts. A recent survey of visitors to three eastern wilderness areas found that littering and human damage to campsite trees were among the most highly rated indicators affecting the quality of recreational experiences (Roggenbuck et al. 1993). These and other resource impact indicators, such as the amount of vegetation loss and bare ground around a campsite, were rated above many social indicators, including the number of people seen while hiking and encounters with other groups at campsites.

Table 1. Resource impacts caused by hiking and 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 National Park Service recognizes 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 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 changes and the relationships between controlling visitor use and biophysical factors. Research has revealed that these relationships are complex and not always intuitive. A reliable information base is therefore essential to managers seeking to develop and implement effective visitor and resource management programs.

Legislative, administrative, and park resource protection mandates and objectives are reviewed to provide justification for the initiation and continuance of this program. New comprehensive carrying capacity planning and management frameworks known as the Limits of Acceptable Change (LAC) and Visitor Impact Management (VIM) are described and recommended. Monitoring program objectives and capabilities are also described, as is the importance of integrating monitoring data into resource protection decision making.

Although numerous reasons for implementing a program are described in the following sections, the actual value of these programs is entirely dependent upon the park staff who 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 necessary for developing and evaluating resource protection policies, strategies, and actions can be of significant value. Only through the implementation of objective management frameworks that integrate defensible monitoring programs can we hope to provide legitimate answers to the question, "are we loving our parks to death?"

JUSTIFICATION FOR VISITOR IMPACT MONITORING

This section reviews legislative mandates, management policies and guidelines, park resource protection objectives, and visitor perceptions of recreation resource impacts. The purpose of this review is to describe legislative and management intent regarding the need to balance visitor use with resource protection objectives, and additionally, why visitor impact monitoring is essential to this endeavor. This review is included both to justify the implementation of a campsite monitoring program and to enlist organizational support for sustaining such a program over time.

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."

Congress clearly 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 demonstrated that some changes to resource conditions are inevitable, even with light recreational use (Wagar 1964, Cole 1982 and 1987, 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.

Congress acted on September 1, 1965 to establish DEWA, "for preservation of the scenic, scientific, and historic features contributing to public enjoyment of such lands and waters" (PL 89-158). In 1978, all federal lands within the 69,629 acre boundary were transferred to the National Park Service, and the Delaware River within the recreation area was designated as a scenic and recreational river under the Wild and Scenic Rivers Act (PL 90-542). The provisions of that act stipulate that designated rivers:

shall be administered in such manner as to protect and enhance the values which caused it to be included in [the wild and scenic rivers] system . . . primary emphasis shall be given to protect aesthetic, scenic, historic, archaeologic, and scientific features.

Finally, the National Environmental Policy Act of 1969 (42 USC 4321 *et seq*) directs 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." This amendment also directs agencies to "promote the development and

use of indices and monitoring systems (1) to assess environmental conditions and trends, (2) to predict the environmental impact of proposed public and private actions and (3) to determine the effectiveness of programs for protecting and enhancing environmental quality."

Management Policies and Guidelines

Authority to implement congressional legislation is delegated to agencies, who identify and interpret all relevant laws and formulate management policies to guide their implementation. For the National Park Service (NPS), these policies are set forth in *Management Policies*, revised in 1988 (USDI 1988). These policies provide direction for management decisions, and adherence to the policies is "mandatory unless waived or modified by an appropriate authority." Several statements in *Management Policies* specifically require resource inventories and monitoring of resource changes associated with visitor use:

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)

Potential impacts on soil resources will be routinely monitored. (Chapter 4:20)

More specific procedures for implementing servicewide policy are described in the NPS guideline series. Two NPS natural resource management guidelines, NPS-75, *Natural Resources Inventory and Monitoring Guideline* (USDI 1992), 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)

Park Monitoring Program Needs and Capabilities

Beyond legal and policy mandates for conducting visitor impact monitoring, there are numerous applied park needs which monitoring programs can address. Effective management of visitor impacts requires current and reliable information from inventory, monitoring, and research efforts. Expanding recreation use, public scrutiny, and participatory public land management have driven an increasing need for more objective information. Such information includes where impacts occur; their types, severity, and relationships to use-related and environmental attributes; and evaluations of the effectiveness of resource protection management strategies and actions.

Numerous monitoring approaches have been developed to document and evaluate visitor impacts and support management decision making. These applied monitoring efforts provide a standard approach for collecting and analyzing resource conditions as affected by visitor use. When implemented properly and with periodic reassessments, these programs can produce a data base with significant benefits to park managers (Figure 1). A monitoring program provides an objective record of changes in visitor areas, even though individual managers may come and go. A monitoring program can help detect and evaluate trends when data is compared between present and past impact assessments. Deteriorating conditions can be detected before severe or irreversible impacts occur, allowing time to implement corrective actions. Analysis of monitoring data can also assist in the selection of appropriate management actions and evaluate the effectiveness of implemented actions.

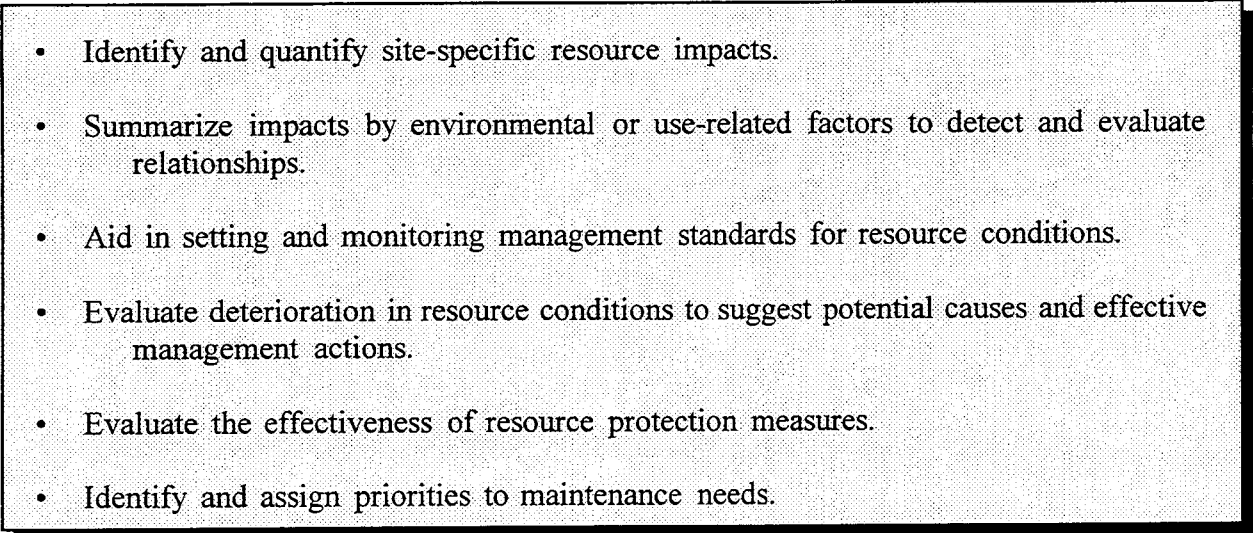
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- Identify and quantify site-specific resource impacts.
 - Summarize impacts by environmental or use-related factors to detect and evaluate relationships.
 - Aid in setting and monitoring management standards for resource conditions.
 - Evaluate deterioration 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.

Figure 1. Capabilities of visitor impact monitoring programs.

Finally, a visitor impact monitoring program provides an essential element for recreation resource planning and management frameworks such as the Limits of Acceptable Change (LAC) (Stankey et al. 1985) or Visitor Impact Management (VIM) (Graefe et al. 1990) systems (Figure 2). These frameworks evolved from and are currently replacing management approaches based on the more traditional carrying capacity model.

Under 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. The monitoring program developed and implemented by this research can provide the information necessary for formulating realistic standards and periodically evaluating resource conditions in relation to these standards.

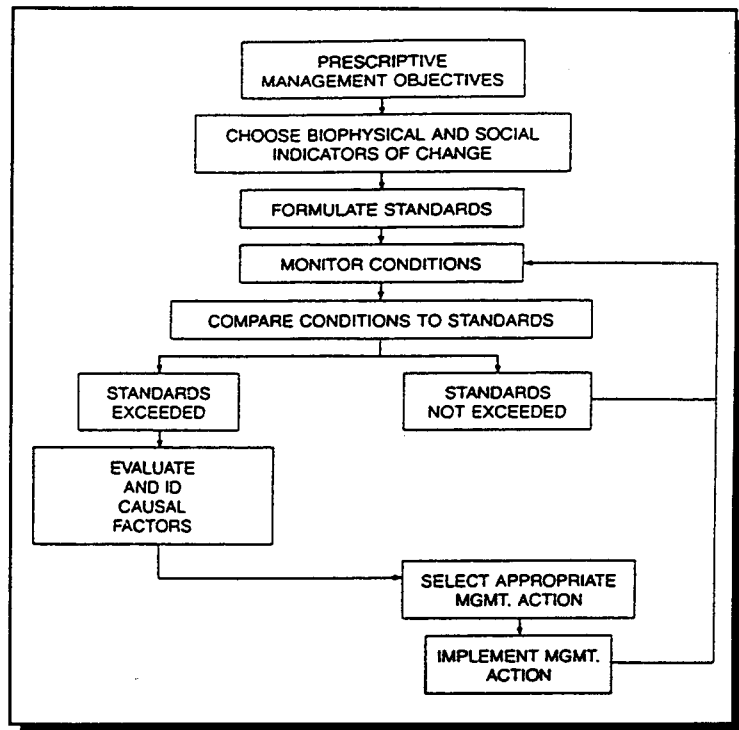


Figure 2. Schematic illustrating the LAC/VIM planning and management frameworks (from Marion et al. 1985).

RESEARCH AND MONITORING PROGRAM OBJECTIVES

Research Objectives

The principal goal of this research was to design and apply a monitoring system for documenting visitor-related changes on all river campsites within DEWA. Specific research objectives are listed in Figure 3.

1. Develop, refine, and apply a campsite impact monitoring system for DWGNRA river campsites. The monitoring system must address all park information needs with procedures which are flexible, cost effective, and scientifically defensible.
2. Develop a comprehensive monitoring program manual describing all procedures.
3. Prepare a report analyzing data from the monitoring assessment and comparing data from the 1984-86 assessment to identify changes in campsite conditions.
4. Evaluate current backcountry management policies, visitor regulations, and minimum impact practices. Note management implications and formulate appropriate recommendations.

Figure 3. Research objectives.

Monitoring Program Objectives

The principal goal of the river campsite monitoring program is to provide park managers with reliable, cost-effective data that document the changing conditions on campsites over time. Specific monitoring program objectives are listed in Figure 4.

1. Obtain quantifiable measurements for managerially relevant campsite impact parameters using scientifically valid and cost efficient procedures.
2. Provide campsite condition information in a format conducive to making and evaluating resource and visitor experience management decisions.
3. Maintain flexibility in the design and application of monitoring procedures to accommodate changes in management needs and constraints.
4. Improve data accuracy and precision by developing and documenting standardized monitoring procedures, quality assurance protocols, and staff training programs.

Figure 4. Campsite monitoring program objectives.

LITERATURE REVIEW

Types of Impact Assessment Systems

Campsite impact assessment 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 general site conditions; and (3) multiparameter systems - based on individual measurements and/or appraisals of many specific resource impacts. A brief summary of the approaches and systems follows. See Cole (1989) and Marion (1991) for a more comprehensive review of these systems.

Photographic systems were among the first developed for documenting visitor use impacts (Magill and Twiss 1965, Magill 1989). Photographic methods are generally easy to establish, require little time for repeat photographs, and yield easily understandable visual records of campsite conditions. Disadvantages include poor comparability due to inconsistent photographic quality, lack of quantitative measurements for specific types of changes, and changes that are missed in areas which are hidden from view or are not photographed.

Frissell (1978) developed the first condition class system consisting of a set of statements that describe increasing levels of impact. 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. 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.

Multiparameter systems are based on independent assessments of several inventory and impact parameters. Rapid estimation systems developed by Parsons and MacLeod (1980), Cole (1983), and Marion (1985) consist of six to ten impact parameters, each with three to five quantitatively defined impact ratings for assessing the severity of impact for that particular parameter. Common impact parameters include campsite area, exposed mineral soil, vegetation loss, tree damage, root exposure, and fire sites. For each impact parameter, observers estimate or conduct a rapid measurement of the degree of impact and record one of three predefined impact ratings. Procedures are generally designed so that two workers can complete a site assessment in five to ten minutes.

More recently, Marion (1991) has developed and refined multiparameter systems that emphasize more accurate measurements and estimates. This approach requires greater observer training and generally requires two observers 15 minutes to complete one site assessment. Other 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.

STUDY AREA

Delaware Water Gap NRA encompasses 70,000 acres in northeastern Pennsylvania approximately 60 miles northwest of New York City (Figure 5). The area's diverse topography, outstanding water and wildlife resources, and other scenic natural and cultural resources are readily accessible to nearly 30 million people living within 100 miles of the park. The park includes 40 miles of the Delaware River which forms the boundary between New Jersey and Pennsylvania. The river valley is semi-developed with narrow steep forested valley walls at the southern end which broaden through the middle and northern sections. Although the river banks are predominantly forested there are numerous agricultural fields adjacent to the river, and roads are occasionally visible from the water. The river is fairly wide, deep in places, with a few smaller rapids and riffles.

Current visitation to DEWA is estimated to be four million visits per year with 54,600 backcountry overnight stays (National Park Service 1992). The river is the primary recreational attraction within the area, particularly for canoeists and other boaters. Visitor use on the river was estimated at 108,800 in 1983 (Strauss, Miller and Lord 1985). River use is concentrated within the warmer months of May through September and is predominantly day oriented. Canoeing is the most popular recreation activity, other activities include fishing, tubing, boating, and swimming. Motorboats are restricted to a 10 mph speed limit in all but one river pool from April through September. Backcountry camping is permitted only within designated campsites along the river and on dispersed sites along the Appalachian Trail.

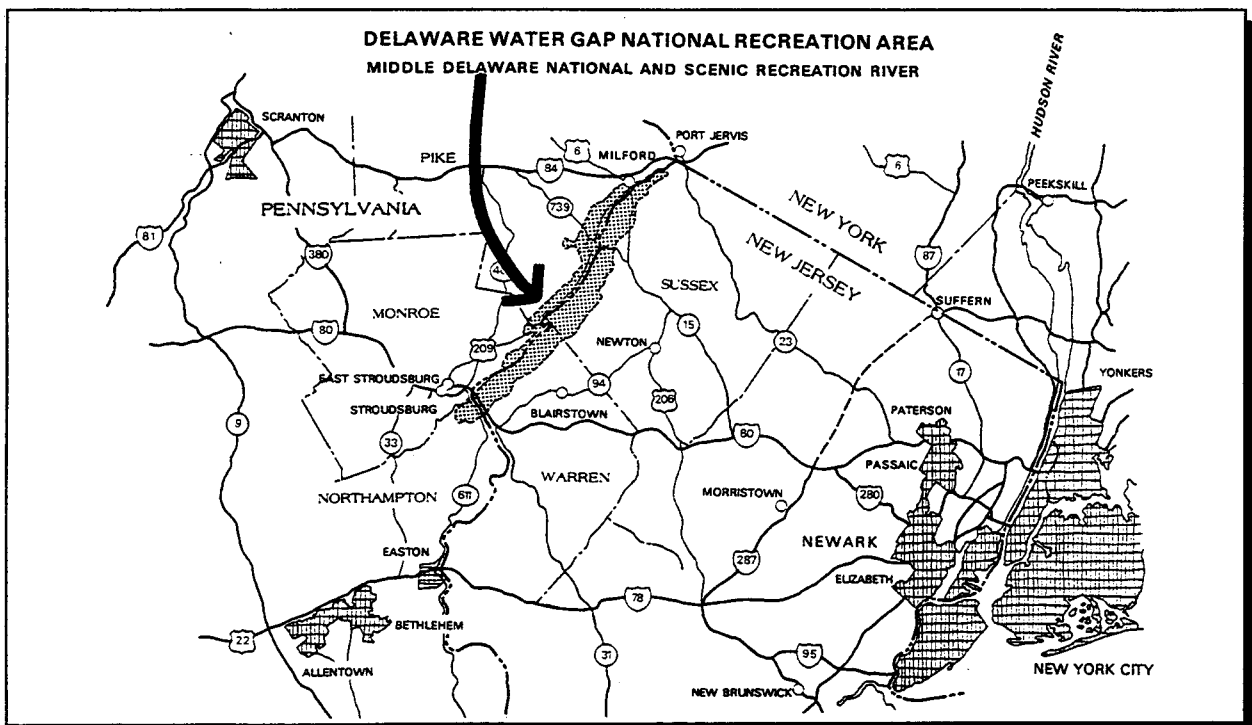


Figure 5. Regional map showing the location of Delaware Water Gap NRA.

River valley soils consist of glacial till and alluvium. Soils immediately adjacent to the river, upon which the river campsites are located, are composed of rich flood-deposited silts and sands. Plant communities along the river are predominantly forested with Acer saccharinum (silver maple), Fraxinus americana (white ash), and Betula nigra (river birch) comprising the most common trees. The forested river banks are interspersed with more open grassy vegetation in areas subjected to intensive flooding and ice damage during the spring thaws.

Camping History and Management

Archaeological digs have documented that camping has occurred on the banks of the Delaware River thousands of years before Columbus ever set foot in America. The area's first European explorers found a large indian village at Minisink Island, the main village of the Minsi Lenape Indians. The area, particularly on the New Jersey side, was thoroughly settled by the mid-1700's. More recently, in the mid-1900's, camping became a popular activity although it occurred primarily on private lands. In 1965 following federal designation, unrestricted camping was permitted anywhere along the river. Campsites were first established in popular areas in 1981 to consolidate the provision and maintenance of toilets and trash receptacles.

In 1983, a designated site camping policy was implemented and additional campsites were developed throughout the river corridor. In many instances, existing user-selected campsites were simply designated; criteria for official designation focussed primarily on eliminating sites too close to roads and river accesses. Campsites were designated by the placement of steel camping signs on trees visible from the river. The 1984-86 campsite survey found that individual sites were not clearly defined and that concrete and steel firegrates, present on only 22 percent (32) of the campsites, were often moved from one location to another. Therefore, in 1988 and 1989, steel firegrates were permanently anchored on all campsites. Fiberglass pit toilet latrines (open-sided) were also placed on all New Jersey and island campsites in 1987 and 1988. Health officials refused permission for the placement of toilets on the Pennsylvania side of the river.

Current river camping regulations limit camping to those boaters travelling from one access point to another, when the distance is too great to be covered in one day. Visitors may camp only at sites posted with a camping sign and having a steel firegrate. A river guide map is provided that indicates the approximate locations of all campsites. Campers are also limited to a one night stay at each area.

Campsite Use Levels

Overnight camping use on the river is estimated by park river district staff for monthly visitor use reports. Camping is estimated as a percentage of total river canoe use. Overnight visitation was assessed by aerial overflights conducted on eight weekends in 1984 and verified through periodic 5 AM river ranger patrols. Based on this data, an estimated 35% of river canoeists camp overnight along the river. The park's reported number of overnight river campers for the years 1984 through 1991 are presented in Table 2.

Average annual overnight visitation has remained relatively constant at approximately 31,000 from 1984 to 1991 (Table 2). However, dividing annual overnight visitation estimates by the number of designated campsites available each year reveals that individual campsites received approximately 28% more use in 1991 than in 1986 (based on three-year averages). Furthermore, as will be reported in the Results and Discussion section, the number of undesignated (illegal) campsites declined from 63 in 1986 to 23 in 1991, likely adding to the visitation of the 87 designated campsites.

Table 2. Estimated annual river camping visitation, 1984-1991.

Year	Estimated Number of Campers	Number of Designated Sites	Estimated Visitation/ Site
1984	28,837	116	249
1985	32,173	116	277
1986	32,399	116	279
1987	34,462	116	297
1988	32,361	100	324
1989	27,559	87	317
1990	29,102	87	335
1991	33,184	87	381

RESEARCH METHODS

Research objectives called for the development of a standardized impact assessment system to monitor resource conditions on river campsites. A primary concern was the need to maintain comparability with the 1984-86 assessment (Marion 1988, Appendix 1) while incorporating more recent advances in the development of campsite monitoring methodologies. Although revised procedures were presented and recommended for future assessments in the earlier monitoring report (Marion 1988, Appendix 4), developmental work was yielding further improvements for possible incorporation (Marion 1991). Alternative monitoring procedures were therefore developed, field tested, and refined in the spring of 1991 with the consultation of park staff.

The new monitoring procedures continue to emphasize the multiparameter measurement-based approach but add condition class assessments and photographs from permanent photopoints. The condition class rating provides a quick assessment of general site conditions and was applied to all campsites (Figure 6). The multiparameter approach provided more quantitative information on a wide variety of resource changes but was applied to only campsites rated condition class 3 through 5. These more highly impacted sites were assessed with Form A; condition class 1 and 2 sites were assessed with Form B (Appendix A). This approach was used because of the greater demand on staff time associated with the multiparameter system and the lessened need by management for data on lightly impacted campsites.

Condition Class Definitions

- Class 1:** Campsite barely distinguishable; slight loss of vegetation cover and /or minimal disturbance of organic litter.
- Class 2:** Campsite 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 in comparison to offsite areas, as indicated by exposed tree roots and rocks and/or gullying.

Figure 6. Conditions class definitions applied at DWGNRA.

Significant improvements were added to the multiparameter procedures, including use of the new Variable Radial Transect Method for assessing campsite size, color photographs to illustrate several impact parameter assessments, and added detail in parameter descriptions. These additions were designed to improve measurement accuracy (how close measurements are to "true" values) and precision (how close independent measurements of the same site are with one another). As with many field measurements, there is a trade-off between data accuracy, precision, and measurement time. Due to personnel constraints, procedures were designed so two employees could complete the necessary measurements at each site in five to ten minutes for condition class 1 and 2 sites, and 15 to 20 minutes for condition class 3, 4, and 5 sites. The monitoring manual and field forms are included in Appendix A.

Two field staff were hired and trained to conduct the campsite monitoring assessments, which were completed between June 6-25, 1991. Excluding training, ten days were required to locate and measure all river campsites, which were accessed by canoe. Campsite locations were described and mapped on 1:400 scale topographic maps. Campsites were defined as river-accessed areas of vegetation and soil disturbance caused by visitor overnight camping and/or day-use activities. Field staff conducted thorough searches for illegal, undesignated campsites in addition to legal, designated sites. Fire sites were not always present and a few areas may have been used exclusively for day-use activities. Developed river access areas were omitted.

A challenge associated with all resource inventory and monitoring programs is the efficient storage and evaluation of collected data. Because of the extensive time required for data input and analysis, monitoring data may not be interpreted or used in the planning and management process as originally intended. To alleviate this problem, a database and associated menu-driven programming were developed using dBASE III, a microcomputer database management package. The programming also links with dBASE STATS to allow additional menu-driven statistical analysis of the data. These databases and programming can be used for further analyses and future campsite monitoring data.

Study results are presented in both graphical and tabular formats to facilitate interpretation and use of the data. Both the mean (arithmetic average) and median (value above and below which half of the measurements fall) are reported where applicable. The mean is not always the best measure of central tendency due to the effect of outliers, values that are far removed from the rest, and distributions which are highly skewed, not distributed in the form of a bell-shaped curve. Median values provide a better estimate of central tendency when these occurrences are common, as with most campsite monitoring data. The standard deviation is also reported to indicate how variable the data are, along with the minimum and maximum values which illustrate the range of conditions.

Readers are cautioned to consider measurement error when reviewing study results. As with all measurements, every value for a campsite condition parameter consists of two components: (1) a component reflecting an accurate assessment of true conditions, and (2) a component reflecting measurement error. Efforts were made to minimize measurement error through the development of detailed measurement procedures and the hiring, training, and supervision of capable field staff. However, this component represents an unknown element of the values reported in the Results and Discussion section. Experimental assessments of measurement

were conducted in 1990 in Granddorado National Park using procedures similar to those applied in DEWA. These results, along with professional judgement and consultation with field staff, were used to derive error estimates for each campsite condition parameter, presented in Table 3. Percentages rather than absolute values are used for the error estimates because error is a function of the amount of change measured. For example, we might expect the measurement error for campsite size to be in the range of ± 20 ft² for a 100 ft² campsite and ± 200 ft² for a 1000 ft² campsite. For reference, these error estimates are reported for the median values of designated campsites from the 1991 survey. To illustrate, consider a campsite with five tree stumps. Multiplying the error estimate (20%) times five yields one, which is added and subtracted from five to yield a range of four to six tree stumps. We therefore infer that the "true" number of tree stumps lies within this range. When comparing to an earlier or later survey, the number of tree stumps would have to be <4 or >6 in order to conclude that a real change had occurred.

Table 3. Estimated measurement error for eight campsite condition parameters. Values for median campsites reflect application of error estimates to the median values for designated campsites assessed in 1991.

Campsite Condition Parameter	Estimated Error	
	(%)	Value for median campsite
Campsite Size (ft ²)	20	260
Vegetation Loss (ft ²)	20	183
Soil Exposure (ft ²)	20	180
Damaged Trees (#/1000 ft ²)	30	0.6
Root Exposure (#/1000 ft ²)	30	0
Tree Stumps (#/1000 ft ²)	20	0
Access Trails (#)	20	0.6
Fire Sites (#)	20	0.2
Shoreline Disturbance (ft)	20	0.6

RESULTS AND DISCUSSION

Results from the 1991 survey of DEWA river campsites are presented and discussed in four sections: Campsite Distribution, Inventory Parameters, Campsite Condition Parameters, and Relational Analyses. Where appropriate, data from the 1984-86 survey (hereafter referred to as the 1986 survey) are included for comparisons.

Campsite Distribution

A total of 110 campsites were located and measured in the 1991 survey, a reduction of 69 sites from the 1986 survey. The number of designated sites declined from 116 to 87. Two of these 87 designated campsites were formerly illegal campsites in 1986 and four were entirely new campsites. Campsite distribution results by river segment are presented in Tables 4 and 5 and graphically illustrated in Figures 7 and 8. The numbers of designated sites were reduced in 1988/89 when park staff selected individual sites for steel firegrate installation. As noted in the previous report:

"Individual campsite locations are not marked and up to a dozen campsites may be associated with only one camping sign on the river. This has led to situations in many areas where campfires and their associated zones of concentrated use tend to "migrate" throughout an area, causing substantial and unnecessary resource impacts... It is therefore recommended that ... steel firegrates be firmly anchored at each individual location where camping is to be permitted ..." (Marion 1988)

By designating specific campsites rather than camping areas, park staff were able to eliminate thirty-five (30%) of the campsites in designated camping areas. The majority of campsites eliminated were located in the Dingman's to Bushkill and Bushkill to Smithfield river segments, the two segments having the highest density of campsites in the 1986 survey (Table 5 and Figure 8). Subsequently, in addition to effectively containing and reducing resource impacts, the action enhanced solitude for visitors camped on the river. The River District Ranger reports that river camping use has remained approximately constant since the former survey, and, as in the mid-eighties, campsite demand exceeds supply for only one or two peak use weekends each year.

For the river corridor, there are an average of 2.2 designated campsites per river mile (Table 5). However, campsite density is quite variable, providing a range of social conditions for visitors (Figure 8). Designated campsite density is highest in the Bushkill to Smithfield river segment (4.2 sites/mile) and lowest in the segment below Smithfield Beach (0.4 sites/mile) (Table 5 and Figure 8). Nearly one-half of the designated campsites (40, 46%) are located on the New Jersey shore, followed by 25 (29%) on islands and 22 (25%) on the Pennsylvania shore. Finally, 49% of the designated sites are clustered in groups of five or more sites, down from 60% in 1986.

The number of undesignated (illegal) sites declined from 63 in 1986 to 23 (Table 4). River District Ranger Karle Theune attributes the reduction primarily to a 5:00 am river patrol

Table 4. Number and percent¹ of designated and undesignated campsites for five Delaware River segments.

River Segment	Designated Campsites				Undesignated Campsites				Totals			
	1986		1991		1986		1991		1986		1991	
	#	%	#	%	#	%	#	%	#	%	#	%
Above Milford	5	3	4	4	9	5	5	5	14	9	9	8
Milford-Dingman's	20	11	18	16	16	9	7	6	36	20	25	23
Dingman's-Bushkill	29	16	20	18	20	11	2	2	49	27	22	20
Bushkill-Smithfield	58	32	42	38	7	4	4	4	65	36	46	42
Below Smithfield	4	2	3	3	11	6	5	5	15	8	8	7
Totals	116	65	87	79	63	35	23	21	179	100	110	100

1 - All percentages refer to the percentage of the total number of sites (designated and undesignated) from each respective campsite survey.

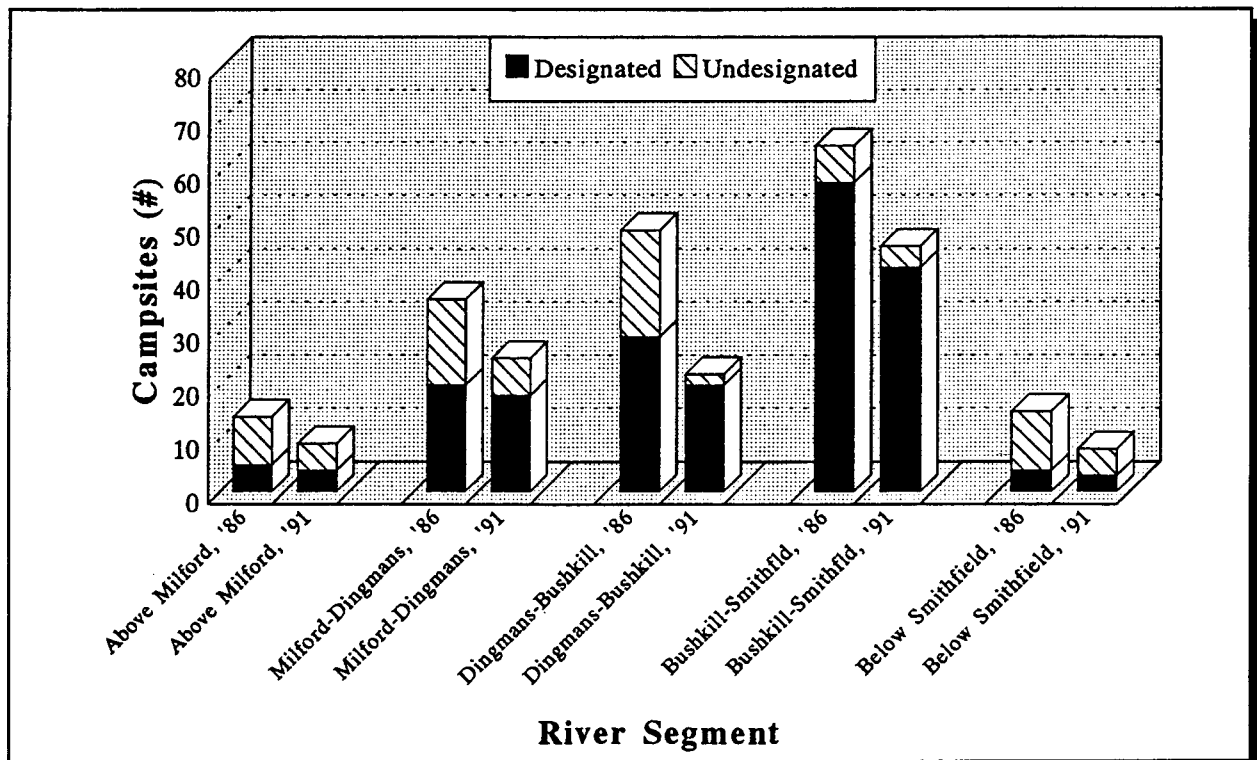
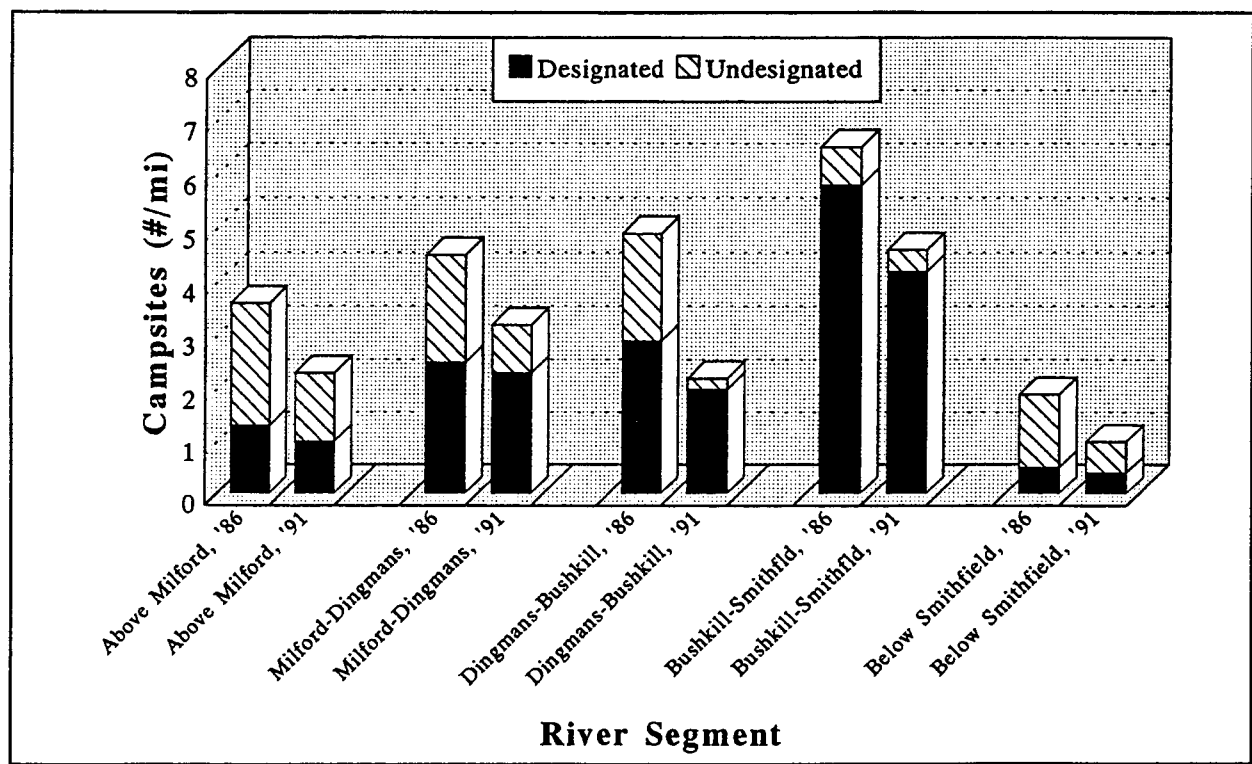


Figure 7. Number of designated and undesignated campsites from the 1984-86 and 1991 surveys for five river segments.

Table 5. Designated and undesignated campsite density (no. sites/mile) for five Delaware River segments.

River Segment	Segment Length	Designated Campsites		Undesignated Campsites		Totals	
		1986	1991	1986	1991	1986	1991
	<i>mi</i>	<i>#/mi</i>					
Above Milford	4	1.3	1.0	2.3	1.3	3.5	2.3
Milford-Dingman's	8	2.5	2.3	2.0	0.9	4.5	3.1
Dingman's-Bushkill	10	2.9	2.0	2.0	0.2	4.9	2.2
Bushkill-Smithfield	10	5.8	4.2	0.7	0.4	6.5	4.6
Below Smithfield	8	0.5	0.4	1.4	0.6	1.9	1.0
Average:		2.9	2.2	1.6	0.6	4.5	2.8

**Figure 8.** Number of designated and undesignated campsites per river mile from the 1984-86 and 1991 surveys for five Delaware River segments.

initiated in 1988 which improved compliance with the park's camping regulations. Rangers also began to routinely break up illegal fire rings and post "No Camping" signs on illegal sites receiving repeated use. In addition, the park river guide pamphlet was revised in 1989, to include information instructing visitors to camp only at locations with a camping sign and steel firegrate. Camping regulations were also posted at all river accesses.

Of the 23 undesignated campsites in 1991, 15 had been surveyed as undesignated sites in 1986, three were former designated campsites that did not receive firegrates, and five were created between surveys. Three of the undesignated campsites were on Tocks Island, part of the Worthington State Forest.

The density of undesignated campsites declined from 1.6 to 0.6 per river mile from 1986 to 1991 (Table 5). The greatest reduction in illegal sites occurred in the Dingman's to Bushkill segment (1.8 sites/mile) leaving it with the lowest density of illegal sites (0.2 sites/mile) (Table 5). Undesignated sites are equally split between the Pennsylvania and New Jersey shores (10 sites each) with three sites located on islands. These results indicate that illegal camping activities have been significantly reduced and would appear to be largely under control. Current management actions appear to be highly effective.

Inventory Parameters

Information was collected on a variety of inventory parameters which relate to particular site features as opposed to environmental impacts. Assessment procedures for inventory parameters are briefly described, see Appendix A for more detailed field procedures. Information is presented only for designated campsites due to their importance to management and the reduced number of illegal sites. Ten of the designated campsites were assessed with Form B procedures as they were rated as either condition class 1 or 2. Inventory parameters are omitted from these forms so the 1991 data includes 77 instead of 87 campsites. Information on designated sites from the 1986 survey (N=116) is also included for comparison. Data are presented in a frequency distribution format with the number and percent of campsites listed for each inventory parameter category. Some parameters were either not assessed in 1986 or their categories were redefined in 1991; these occurrences are noted by an NA (Not Applicable) listing in tables.

Boat Landing Substrate Type

Each campsite has an unimproved shoreline boat landing area with a trail leading to the campsite. The predominant substrate of boat landings at average river level was assessed using four categories: bedrock, cobble, sand, and soil. The most common landing substrate is cobble (47% of sites), followed by sand (32% of sites) and soil (20% of sites) (Table 6).

Campsite Intervisibility

Campsite intervisibility is a social variable used to assess where visitors might experience solitude or camp with other visitors in a more social setting. Visitor center staff might use this

Table 6. Number and percent of designated campsites assessed in 1986 and 1991 for selected inventory parameters.

Inventory Parameter	Designated Campsites			
	1986 Survey		1991 Survey	
	#	%	#	%
Boat Landing Substrate Type				
Bedrock	3	3	1	1
Cobble	27	28	36	47
Sand	26	27	25	32
Soil	18	18	15	20
Combinations	23	24	NA	
Campsite Intervisibility				
No sites visible	39	34	42	48
1 site visible	40	34	25	29
2 sites visible	18	16	11	13
3 sites visible	5	4	6	7
4 sites visible	14	12	3	3
Campsite Height Above River				
0-5 ft	NA		15	19
6-10 ft	NA		20	26
11-15 ft	NA		15	19
>15 ft	NA		27	35
Tenting Sites				
1-2	54	47	53	69
3-5	41	35	17	22
≥ 6	21	18	7	9
Toilets				
Present, visible from site	12	10	13	17
Present, not visible from site	18	16	32	42
Absent	86	74	32	42
Human Waste				
Not Evident	90	78	58	75
Some	21	18	11	14
Abundant	5	4	8	11
Litter/Trash				
None	45	39	72	95
Some	66	57	3	4
Abundant	5	4	1	1
Tree Canopy Cover				
0-25%	NA		1	1
26-50%	NA		3	4
51-75%	NA		5	7
76-100%	NA		68	88

parameter to direct visitors to locations which will best satisfy their interests. The current distribution of campsites offers a wide range of social conditions with campsite intervisibility ranging from zero to four sites (Table 6). Nearly half of the designated campsites (42 sites, 48%) are out-of-sight from other sites, providing ample opportunities for visitors to experience solitude while camping. Opportunities for more social camping experiences still are possible in some areas, with nine campsites have three or more other sites visible. Comparison of site intervisibility data between the 1986 and 1991 surveys indicate that the steel firegrate installations substantially reduced campsite intervisibility.

Campsite Height Above River

The elevation difference between average river level and the leading edge of campsites was assessed to the nearest foot. Site height ranged from 0 to 40 feet with an average of 12 feet. Nearly one-fifth of the designated sites (15 sites, 19%) were within five feet of average river level (Table 6). Such sites are easily flooded and may represent a visitor safety concern. In contrast, 27 sites (35%) were on higher benches greater than 15 feet above river level.

Tenting Sites

The number of relatively level tenting areas free of protruding rocks and stumps were assessed in three categories: 1-2 sites, 3-5 sites, and ≥ 6 sites. Results indicate that over two-thirds of the designated campsites (53 sites, 69%) have one or two tenting sites (Table 6). Larger parties are somewhat more restricted in their selection of sites. Seventeen campsites have between three and five tenting sites and only seven campsites can support groups requiring six or more tent sites. Comparisons between the 1986 and 1991 survey results reveal a marked reduction in the number of available tenting sites. This is likely a result of the concentration of use resulting from the placement of the firegrates, which are permanently anchored in specific locations.

Toilets

During the early 1980's large enclosed Clivus Multrum composting toilets were provided in several areas with high campsite densities. These facilities were accessible to campers on 30 of the campsites as determined by the 1986 survey. Fiberglass pit toilets (open-sided) were installed on most New Jersey and island campsites lacking toilet facilities in 1987-88. The 1991 survey reveals that at least 45 sites (59%) are currently served by toilet facilities (Table 6). The status of toilets on the ten designated sites assessed with the Form B procedures is unknown. Thirty-two campsites, primarily those on the Pennsylvania shore, currently have no toilet facilities. However, data reveals that ten of the sites on islands and five New Jersey sites lacked toilets. In some cases toilets are placed between two campsites and field staff may have attributed a toilet to only one of the sites. Trails leading from campsites to the toilets were occasionally overgrown and visitors may be unaware of their existence. Improved trail maintenance or a routed 4x4 treated post placed at the campsite boundary might help visitors to find the toilets.

Human Waste

This parameter and the next could be considered as resource impacts. However, both parameters are quite variable over a single season and the extent of these problems are inherently difficult to objectively measure. For these reasons they are included here as

inventory parameters. Evidence of improperly disposed human waste was assessed by following all trails in search of likely "toilet" areas. Human waste was assessed simply as none, some, or abundant, although an effort was made to quantify these terms in the 1991 survey (see Appendix A). Results indicate that improperly disposed human waste was not evident in the vicinity of three-quarters of the sites (Table 6). However, waste was rated abundant (≥ 4 occurrences) on eight (11%) of the sites. Additional evaluations for this parameter are provided in the relational analysis section.

Litter/Trash

The amount of litter or trash on campsites was assessed in three categories: none, some, or abundant. As with human waste, an effort was made to quantify these terms in the 1991 survey (see Appendix A). Littering appears to not be a problem on the river campsites. Litter was not found on 72 sites (95%) and was rated as abundant (volume $> 2\frac{1}{2}$ gallon bucket) on only one campsite (Table 6). This represents a significant improvement from the previous survey. This finding may simply document the effectiveness of litter cleanup crews, who visit most sites on a weekly or bi-monthly basis. However, in 1989 the park initiated a litter bag program and in 1990 required all commercial canoe liveries to distribute mesh litter bags to their clients. Monitoring by litter cleanup crews has revealed a significant and permanent reduction in the amount of litter removed from campsites after the initiation of this action.

Tree Canopy Cover

The percentage of tree canopy cover directly over campsite boundaries was assessed using four categories: 0-25%, 26-50%, 51-75%, and 76-100%. Survey results show that nearly all of the campsites are forested; only one site has tree cover of 25% or less (Table 6). Most campsites have very dense forest canopies; 68 sites (88%) have canopy cover in excess of 75%.

Campsite Condition Parameters

The presentation and analysis of campsite condition data are focussed primarily on designated campsites, due to the relatively small number of illegal sites and the greater importance of the designated sites to management. Where necessary, assessment procedures and data transformations are presented for each parameter. Refer to Appendix A for the detailed field procedures. Data on campsite conditions from the 1986 and 1991 surveys are presented using two methods, described below.

The first method compares results from the two campsite assessments for all designated campsites. As previously noted, in 1991, ten of the most lightly impacted designated campsites were assessed using the shortened Form B procedures. With the exception of campsite size, the 1991 data therefore includes 77 rather than 87 designated campsites. However, river use levels have remained fairly constant since the earlier survey and the ten omitted campsites account for a very small proportion of overall use. It is therefore presumed that the 77 designated sites for which full data are available accommodate roughly the same amount of use that was spread among the 116 designated campsites that existed in 1986.

Under this first method, data from both surveys are presented in a two-part table for each parameter. Included are general descriptive statistics and the number and percent of campsites by several categories of amount of change. Discussions include a summary of campsite conditions for the 1991 survey and comparison of the results from both surveys.

The second method presents data only for designated campsites for which complete data were available from both surveys. Positive identification and pairing between campsite numbers from the two surveys was not possible for four of the 77 campsites with complete data sets so maximum sample sizes are 73. This method presents data from a large sample of campsites common to both surveys, but readers are cautioned that the assumption of equivalent use is not as valid as for the first method. In particular, we may assume that the 73 campsites were likely used less intensively during the time of the 1986 survey than they were in 1991 because of the additional designated sites over which use was spread, i.e. 116 designated sites accommodated approximately the same amount of use in 1986 as is now accommodated on only 87 sites. In other words, we might expect the greater intensity of use in 1991 to be reflected in additional resource impacts on the campsites.

Under this second method, data are again presented in two-part tables, though the sample size is held constant by including only those campsites with complete data common to both surveys. Additionally, the second table presents the number and percent of campsites that remained unchanged, increased, and decreased, by several categories of amount of change. Campsites rated as "unchanged" were those for which the differences measured were less than the estimated error percentages presented in Table 3. These results are also graphically illustrated with bar charts for each parameter in which bars with positive values reflect deteriorating conditions and bars with negative values reflect improving conditions. All figures are placed at the end of the section to facilitate their direct comparison.

Campsite Size

Research Methods: Campsite sizes were assessed in the 1986 survey by measuring the necessary dimensions of one or more geometric figures superimposed over campsite boundaries (see Geographic Figure Method, Appendix A). Campsite sizes in 1991 were assessed by measuring the lengths and azimuths of transects radiating from a center point to campsite boundaries (see Variable Radial Transect Method, Appendix A). Campsite boundaries in both surveys were identified using the same procedures (see Appendix A for procedures and photos). Areas were determined with a calculator for the Geometric Figure Method and with a dBASE computer program for the Variable Radial Transect Method. No data transformations were performed.

Comparison of All Designated Campsites, 1986 to 1991: In 1991, designated campsites ranged in size from 120 ft² to 8,316 ft² with a median size of 1,302 ft² (Table 7a). The median site would thus cover an area of approximately 36 x 36 feet. Nearly three-quarters of the sites (73%) were under 2000 ft² in size (45 x 45 feet) (Table 7b). Comparison with 1986 survey data reveals essentially no change in the median campsite size although some significant changes do occur in the distribution of campsite sizes. Specifically, from 1986 to 1991 there is a marked reduction in the percentage of larger sites (compare 14% vs. 6% of sites >4000 ft²) and an increase in the percentage of smaller sites (compare 65% vs 73% of sites <2000 ft²) (Table 7b). The change of greatest managerial significance is the dramatic reduction in the overall area of disturbance associated with camping, as obtained by summing the campsite sizes from each survey. The sum of all campsite sizes was 302,784 ft² in 1986 and 150,859 ft² in 1991, a 50% reduction in the total area of disturbance.

Table 7a. General statistics of designated campsites assessed in 1986 and 1991 for campsite size.

Statistic	Campsite Size (ft ²)	
	1986 N=116	1991 N=85
Median	1,362	1,302
Mean	2,610	1,775
St. Dev.	4,007	1,551
Minimum	108	120
Maximum	33,056	8,316
Sum	302,784	150,859

Table 7b. Number and percent of designated campsites assessed in 1986 and 1991 by campsite size categories.

Campsite Size (ft ²)	Number		Percent		Cumulative Percent	
	1986	1991	1986	1991	1986	1991
<1000	39	29	33	34	33	34
1001-2000	37	33	32	39	65	73
2001-3000	16	11	14	13	79	86
3001-4000	8	7	7	8	86	94
4001-5000	2	0	2	0	88	94
5001-6000	5	0	4	0	92	94
6001-7000	1	4	1	5	93	99
7001-8000	0	0	0	0	93	99
8001-9000	2	1	2	1	95	100
>9000	6	0	5	0	100	100
Totals	116	85	100	100	100	100

Comparison of Designated Campsites Common to Both Surveys: The median campsite size declined 12% from 1986 to 1991, 1,582 ft² to 1,399 ft² (Table 7c). More significantly, the sum of the campsite sizes declined 71,948 ft², a 37% reduction. Given the constant number of campsites (N=73) and an increase in the amount of use per site, this reduction in size can be attributed only to increased concentration of use within each campsite. Results in Table 7d (illustrated in Figure 9) reveal that 21 (29%) of the sites increased in size while 35 (48%) of the sites decreased in size from 1986 to 1991. Accounting for an estimated 20% measurement error, approximately 17 (23%) of the sites remained unchanged. In other words, the sizes of these campsites in 1991 were within 20% (larger or smaller) of their 1988 sizes. Finally, while 11 sites increased more than 500 ft², 28 sites decreased more than this amount.

Discussion: The total area of disturbance resulting from river camping was reduced by over 150 thousand square feet, a 50% reduction from the 1986 survey. This reduction was achieved by concentrating use on each individual site through the establishment of anchored firegrates and by reducing the total number of designated sites available. Establishment of firegrates served to informally define individual campsites and to concentrate camping activities in their vicinity. Such concentration resulted in campsite sizes that remained the same or decreased slightly in spite of an estimated 25% increase in the intensity of individual site use. However, the reduction in designated campsite numbers, from 116 in 1986 to 87 in 1991, was the primary factor responsible for this marked decline in the total area of disturbance. These findings offer strong support for the management strategy of use concentration or containment in reducing visitor impacts, both with respect to number of sites and use at individual sites.

Table 7c. General statistics of designated campsites common to both the 1986 and 1991 surveys for campsite size.

Statistic	Campsite Size (ft ²)	
	1986 N=73	1991 N=73
Median	1,582	1,399
Mean	2,695	1,710
St. Dev.	3,064	1,279
Minimum	258	201
Maximum	15,392	8,316
Sum	196,739	124,791

Table 7d. Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in size.

Absolute Change in Campsite Size (ft ²) 1986 → 1991	Designated Campsites Assessed in 1986 and 1991 (N=73)			
	Increased		Decreased	
	Number	Percent	Number	Percent
≤500	10	14	7	10
501-1000	5	7	8	11
1001-2000	6	8	7	9
2001-3000	0	0	5	7
3001-4000	0	0	2	3
>4000	0	0	6	8
Totals	21	29	35	48
Unchanged *	6	8	11	15

* - Absolute change was ≤ 20% of the 1986 values.

Non-Woody Vegetation Loss

Research Methods: Vegetative groundcover was assessed both within campsite boundaries and in adjacent undisturbed offsite areas with similar environmental attributes. Workers estimated the percent of live non-woody vegetation ground cover (herbs, grasses, and mosses) in each location and recorded the most appropriate vegetation coverage class from pre-defined categories. The 1986 survey employed four 25% vegetation coverage categories; the 1991 survey employed a modified approach with 6 categories following Daubenmire (1968). See Appendix A for specific procedures and photos illustrating each vegetation cover class. Regardless, coverage class midpoints were used to estimate the percentage of vegetation cover lost on campsites by subtracting onsite values from offsite values. The area of vegetation loss (ft²), reported below, was calculated by multiplying percentage loss by campsite size.

Comparison of All Designated Campsites, 1986 to 1991: The area of vegetation loss ranged from 55 ft² to 7,942 ft² in 1991 with a median loss of 902 ft² (Table 8a). The majority of sites, 81%, lost less than 2000 ft² of vegetation cover, although four sites lost over 5000 ft² (Table 8b). Median vegetation cover was 15% on campsites and 98% in adjacent undisturbed areas; the typical site therefore lost approximately four-fifths of its vegetation cover. In comparison to 1986 survey data, the median area of vegetation loss increased 187 ft² or 26%. However, the total area of vegetation loss was reduced by 21% (29,056 ft²), as determined by summing vegetation loss across all campsites for survey.

Table 8a. General statistics of designated campsites assessed in 1986 and 1991 for vegetation loss.

Statistic	Vegetation Loss (ft ²)	
	1986 N=111	1991 N=77
Median	715	902
Mean	1,230	1,395
St. Dev.	2,656	1,466
Minimum	0	55
Maximum	24,957	7,942
Sum	136,508	107,452

Table 8b. Number and percent of designated campsites assessed in 1986 and 1991 by area of vegetation loss categories.

Vegetation Loss (ft ²)	Number		Percent		Cumulative Percent	
	1986	1991	1986	1991	1986	1991
<1000	73	41	66	53	66	53
1001-2000	26	21	23	28	89	81
2001-3000	5	6	5	8	94	89
3001-4000	1	4	1	5	95	94
4001-5000	2	1	2	1	97	95
>5000	4	4	3	5	100	100
Totals	111	77	100	100	100	100

Comparison of Designated Campsites Common to Both Surveys: The median area of vegetation loss declined from 928 ft² in 1986 to 808 ft² in 1991, a decline of 15% (Table 8c). Total vegetation loss, summed across all campsites, declined only slightly. Fewer campsites increased in size (24 or 34%) than decreased in size (32 or 46%) (Table 8d and Figure 10). Fourteen campsites (20%) remained unchanged, based on an error estimate of 20%. The distributions of data for vegetation loss were similar for the two surveys.

Discussion: The total area of vegetation loss on campsites is estimated to have declined by 29,056 ft², a 21% reduction from the 1986 survey. This reduction was achieved largely from a reduction in the total number of campsites. The median area of vegetation loss increased from 1986 to 1991, likely in response to the increased use intensity which the reduced number of campsites received. The anchored firegrates would also tend to concentrate activities on campsites, resulting in more intensive vegetative trampling but over a smaller total area. Thus, while campsites are generally the same or smaller in size than in 1986, the percentage of vegetation loss on individual campsites is higher due to the increased intensity of use. Curiously, median vegetation loss for the sites common to both surveys decreased 15%, although total vegetation loss was only slightly lower. The latter finding supports the conclusion that concentrating use by reducing campsite size is also the most effective approach for minimizing vegetation loss.

Table 8c. General statistics of designated campsites common to both the 1986 and 1991 surveys for vegetation loss.

Statistic	Vegetation Loss (ft ²)	
	1986 N=70	1991 N=70
Median	928	808
Mean	1,336	1,230
St. Dev.	1,615	1,264
Minimum	0	55
Maximum	9,565	7,942
Sum	93,541	89,757

Table 8d. Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in vegetation loss.

Absolute Change in Vegetation Loss (ft ²) 1986 → 1991	Designated Campsites Assessed in 1986 and 1991 (N=70)			
	Increased		Decreased	
	Number	Percent	Number	Percent
≤500	8	11	12	10
501-1000	8	11	8	17
1001-2000	5	7	7	10
2001-3000	1	1	2	3
>3000	2	3	3	4
Totals	24	34	32	46
Unchanged *	7	10	7	10

* - Absolute change was ≤ 20% of the 1986 values.

Exposed Soil

Research Methods: Exposed soil, areas with little or no organic litter or vegetative cover, was assessed using the same procedures as for vegetation loss. Computations for determining the area of exposed soil (ft²) were also identical.

Comparison of All Designated Campsites, 1986 to 1991: The area of exposed soil ranged from 11 ft² to 8,149 ft² in 1991 with a median area of 917 ft² (Table 9a). As for vegetation loss, the majority of sites, 78%, have less than 2000 ft² of exposed soil, although four sites have over 5000 ft² of their soil exposed (Table 9b). Exposed soil comprises 85% of the area for the median campsite in 1991. Due to annual flooding of river campsites, an organic litter layer is typically absent. Therefore, the loss of vegetation cover immediately results in exposed soil. Comparison of the data from both surveys reveals that median soil exposure has nearly doubled, from 463 ft² to 917 ft². However, the total area of exposed soil has declined approximately 10%, as determined by summing exposed soil across all campsites for each survey.

Table 9a. General statistics of designated campsites assessed in 1986 and 1991 for exposed soil.

Statistic	Exposed Soil (ft ²)	
	1986 N=116	1991 N=77
Median	463	917
Mean	1,034	1,407
St. Dev.	1,713	1,507
Minimum	0	11
Maximum	11,216	8,149
Sum	119,929	108,322

Table 9b. Number and percent of designated campsites assessed in 1986 and 1991 by area of exposed soil categories.

Exposed Soil (ft ²)	Number		Percent		Cumulative Percent	
	1986	1991	1986	1991	1986	1991
<1000	74	41	64	53	64	53
1001-2000	25	19	21	25	85	78
2001-3000	10	7	9	9	94	87
3001-4000	1	6	1	7	95	94
4001-5000	1	1	1	1	96	95
>5000	5	4	4	5	100	100
Totals	116	77	100	100	100	100

Comparison of Designated Campsites Common to Both Surveys: The median area of exposed soils for campsites common to both surveys declined slightly from 1986 to 1991. (Table 9c). The sum of exposed soil (ft²) also declined, from 98,984 ft² to 90,007 ft², a 9% reduction. Approximately equal numbers of campsites increased as decreased in exposed soil area and 12 sites remained unchanged (given a 20% error estimate) (Table 9d and Figure 11).

Discussion: Total area of exposed soil was reduced 11,607 ft² from 1986 to 1991, a 10% reduction. Most of this reduction, which is not large, appears to have occurred as a result of further concentration of use on individual campsites, as opposed to a reduction in the number of campsites. Approximately 9,000 ft² of the 11,607 ft² reduction in the area of exposed soil occurred on the sites common to both surveys (Table 9c).

Table 9c. General statistics of designated campsites common to both the 1986 and 1991 surveys for exposed soil.

Statistic	Exposed Soil (ft ²)	
	1986 N=73	1991 N=73
Median	861	822
Mean	1,356	1,233
St. Dev.	1,988	1,323
Minimum	0	11
Maximum	11,216	8,150
Sum	98,984	90,007

Table 9d. Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in exposed soil.

Absolute Change in Exposed Soil (ft ²) 1986 → 1991	Designated Campsites Assessed in 1986 and 1991 (N=73)			
	Increased		Decreased	
	Number	Percent	Number	Percent
≤500	13	18	7	10
501-1000	5	7	11	15
1001-2000	10	14	6	8
2001-3000	2	3	4	5
3001-4000	1	1	1	1
>4000	0	0	1	1
Totals	31	43	30	40
Unchanged *	7	10	5	7

* - Absolute change was ≤ 20% of the 1986 values.

Shoreline Disturbance

Research Methods: The width of shoreline vegetation exhibiting pronounced disturbance from boats and visitor activities was measured as a lineal distance to the nearest foot (see Appendix A). No data transformations were performed.

Comparison of All Designated Campsites, 1986 to 1991: Shoreline disturbance ranged from 0 to 48 ft with a median value of 3 ft in 1991 (Table 10a). The distribution of values is fairly broad; 78% of the sites have shoreline disturbance of less than or equal to 10 ft, 12% at 11 to 20 ft, and 10% at greater than 25 ft (Table 10b). It is interesting to note that shoreline disturbance did not exceed 5 ft for approximately half the campsites, some of which must receive at least moderate levels of use. A large amount of shoreline disturbance is clearly "avoidable" and such disturbance is not essential for site use. Furthermore, multiple boat landing areas for a single site were quite rare and do not seem to be the problem. In comparison to 1986 survey data, the amount of shoreline disturbance declined significantly, from a median value of 16 ft to 3 ft, an 81% reduction. More significantly, the sum of shoreline disturbance was reduced from 3,096 ft to 671 ft, a 78% reduction. A good portion of this reduction occurred on sites with extensive shoreline disturbance in 1986. Thirty-one sites (27%) had shoreline disturbance in excess of 35 ft in 1986 while only two sites (3%) had shoreline disturbance to this extent in 1991.

Table 10a. General statistics of designated campsites assessed in 1986 and 1991 for shoreline disturbance.

Statistic	Shoreline Disturbance (ft)	
	1986 N=116	1991 N=77
Median	16	3
Mean	27	9
St. Dev.	32	10
Minimum	0	0
Maximum	187	48
Sum	3,096	671

Table 10b. Number and percent of designated campsites assessed in 1986 and 1991 by shoreline disturbance categories.

Shoreline Disturbance (ft)	Number		Percent		Cumulative Percent	
	1986	1991	1986	1991	1986	1991
0-5	45	41	39	53	39	53
6-10	8	19	7	25	46	78
11-15	2	2	2	3	48	81
16-20	11	8	9	9	57	90
21-25	3	0	3	0	60	90
26-30	6	3	5	4	65	94
31-35	10	2	8	3	73	97
>35	31	2	27	3	100	100
Totals	116	77	100	100	100	100

Comparison of Designated Campsites Common to Both Surveys: The median shoreline disturbance declined from 23 ft in 1986 to 3 ft in 1991 (Table 10c). Summed across all sites, shoreline disturbance declined 1,683 ft, a 71% reduction. Only 11 campsites (15%) increased in shoreline disturbance from 1986 to 1991, while 55 sites (75%) had less shoreline disturbance (Table 10d and Figure 12). Twenty-two sites decreased by more than 30 ft. Additionally, the change for 6% of the sites fell within the estimated 20% measurement error and 4% of the sites had identical values for both surveys.

Discussion: Shoreline disturbance was dramatically less in 1991 than in 1986. Median shoreline disturbance declined from 16 ft to 3 ft while riverwide, the sum of shoreline disturbance fell from 3,096 ft to 671 ft. It is difficult to attribute specific causes for this 78% reduction. However, during the site selection and firegrate establishment program in 1988/89, River Rangers considered the adequacy of canoe landings and trails as a factor in site selection. They also used weed eaters to establish one canoe landing area for each designated campsite; previously, landing areas were shared by several sites, at least in areas with high campsite densities. Moreover, managers have continued this practice in the spring on some sites where landing areas and trails are overgrown by dense grass growth. It seems likely that the additional spacing and traffic necessary in using shared landings contributed to the exceptionally large landings that were more common in 1986.

Measurement methods appear to be uniform although in 1991 the location for taking the lineal measurement was more clearly specified. In 1991, the measurement was taken one foot beyond or above the leading edge of adjacent undisturbed vegetation bordering the river. No location was specified in the earlier survey and some workers may have taken measurements closer to the water, where vegetation is more variable due to river level fluctuations.

Table 10c. General statistics of designated campsites common to both the 1986 and 1991 surveys for shoreline disturbance.

Statistic	Shoreline Disturbance (ft)	
	1986 N=73	1991 N=73
Median	23	3
Mean	32	9
St. Dev.	34	10
Minimum	0	0
Maximum	187	48
Sum	2,360	677

Table 10d. Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in shoreline disturbance.

Absolute Change in Shoreline Disturbance (ft) 1986 → 1991	Designated Campsites Assessed in 1986 and 1991 (N=73)			
	Increased		Decreased	
	Number	Percent	Number	Percent
≤9	7	10	9	12
10-19	4	5	16	22
20-29	0	0	8	11
30-39	0	0	9	12
≥40	0	0	13	18
Totals	11	15	55	75
Unchanged * Same: 3 (4%) of sites	0	0	4	6

* - Absolute change was ≤ 20% of the 1986 values, including sites with same values from both assessments.

Tree Damage

Research Methods: Assessments for tree damage were refined in 1991 by assessing all campsite trees using three discrete categories: none/slight, moderate, and severe (see Appendix A for definitions and photos). Category definitions were defined so that trees rated as moderate or severe would be comparable to those simply assessed as "damaged" in the 1986 survey. Other revisions were added to further specify which trees should be assessed. However, comparability is reduced because damaged trees are only counted within campsite boundaries, which have changed between surveys (no permanent reference points were defined in the 1986 survey). If a campsite expanded in size, a damaged tree located offsite and excluded from assessments in the 1986 survey might be counted in the 1991 survey (and vice versa). Additional site remeasurement procedures have been added to the 1991 manual to resolve this problem in the future. For data presented below this problem was lessened by transforming tree damage data from the number of damaged trees/site to the number of damaged trees/1000 ft². This area (1000 ft²) was selected because it is close to the median campsite size and therefore more easily interpreted. This conversion standardizes the data to make it more comparable for campsites of different sizes.

Comparison of All Designated Campsites, 1986 to 1991: In 1991, designated campsites had between zero and six damaged trees/1000 ft²; the median site had 2.3 damaged trees/1000 ft² (Table 11a). [The actual number of damaged trees on the median site was three, with a range from zero to 20 trees. In 1986 the actual number of damaged trees on the median site was four, with a range from zero to 17 trees.] Although six sites in 1991 had no damaged trees, 66% of the sites had between one and four damaged trees/1000 ft² (Table 11b). In comparison to 1986 data, the median site had a somewhat greater degree of tree damage. Furthermore, changes in the data distributions reveal an increased percentage of 1991 campsites with larger numbers of damaged trees. For example, in 1991, 32% of the campsites had more than three damaged trees/1000 ft² while in 1986, only 11% of the sites had more than this number. However, when summed across all sites, tree damage declined 41%, from 324 to 191 damaged trees/1000 ft², clearly due to a decrease in the number of designated campsites.

Table 11a. General statistics of designated campsites assessed in 1986 and 1991 for damaged trees.

Statistic	Damaged Trees (#/1000 ft ²)	
	1986 N=116	1991 N=77
Median	2.0	2.3
Mean	2.8	2.5
St. Dev.	2.8	1.6
Minimum	0	0
Maximum	15	6
Sum	324	191

Table 11b. Number and percent of designated campsites assessed in 1986 and 1991 by tree damage categories.

Damaged Trees (#/1000 ft ²)	Number		Percent		Cumulative Percent	
	1986	1991	1986	1991	1986	1991
0	18	6	16	8	16	8
0.1-1.0	17	7	28	9	44	17
1.1-2.0	24	20	30	26	74	43
2.1-3.0	12	19	15	25	89	68
3.1-4.0	15	12	7	16	96	84
4.1-5.0	11	5	1	6	97	90
>5.0	19	8	3	10	100	100
Totals	116	77	100	100	100	100

Comparison of Designated Campsites Common to Both Surveys: For the median site, the number of damaged trees/1000 ft² increased 0.2 or 10% (Table 11c). Furthermore, although roughly the same number and percent of campsites increased as decreased in the number of damaged trees (Table 11d and Figure 13) the sum of damaged trees/1000 ft² declined from 204 to 174. Twelve campsites changed with the estimated 30% measurement error while two sites had identical values for tree damage.

Discussion: Although median tree damage values increased slightly, the sum of damaged trees declined, even when the number of sites was held constant. However, changes were not dramatic and, given problems with data comparability with this parameter, we may conclude only that tree damage changed little from 1986 to 1991.

Table 11c. General statistics of designated campsites common to both the 1986 and 1991 surveys for damaged trees.

Statistic	Damaged Trees (#/1000 ft ²)	
	1986 N=73	1991 N=73
Median	2.0	2.2
Mean	2.8	2.4
St. Dev.	2.9	1.7
Minimum	0	0
Maximum	15	6.4
Sum	204	174

Table 11d. Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in damaged trees.

Absolute Change in Damaged Trees (#/1000 ft ²) 1986 → 1991	Designated Campsites Assessed in 1986 and 1991 (N=73)			
	Increased		Decreased	
	Number	Percent	Number	Percent
≤1	7	10	4	5
1.1-2	8	11	7	10
2.1-3	8	11	8	12
3.1-4	5	7	3	4
>4	2	3	6	8
Totals	30	42	28	39
Unchanged * Same: 2 (3%) of sites	4	5	8	11

* - Absolute change was ≤ 30% of the 1986 values., including sites with same values from both assessments.

Root Exposure

Research Methods: All comments described under the Research Methods section for tree damage are equally applicable to the assessment of root exposure.

Comparison of All Designated Campsites, 1986 to 1991: In 1991, the number of trees/1000 ft² with root exposure ranged from zero to 6.4 with median of zero (Table 12a). The *actual* number of trees/site with root exposure ranged from zero to eight with a median of zero. These values are identical to those in 1986. In comparison to the 1986 survey, the median number of trees/1000 ft² with root exposure remained the same but the sum of all trees with root exposure declined from 77 to 25 trees/1000 ft², a 68% reduction. Furthermore, 78% of the campsites had no trees with root exposure in 1991, in comparison to 58% of the sites with no root exposure in 1986 (Table 12b).

Table 12a. General statistics of designated campsites assessed in 1986 and 1991 for trees with exposed roots.

Statistic	Trees with Root Exposure (#/1000 ft ²)	
	1986 N=116	1991 N=77
Median	0	0
Mean	0.7	0.3
St. Dev.	1.2	0.9
Minimum	0	0
Maximum	6.8	6.4
Sum	77	25

Table 12b. Number and percent of designated campsites assessed in 1986 and 1991 by root exposure categories.

Trees with Root Exposure (#/1000 ft ²)	Number		Percent		Cumulative Percent	
	1986	1991	1986	1991	1986	1991
0	67	60	58	78	58	78
0.1-1.0	20	10	17	13	75	91
1.1-2.0	16	2	14	3	89	94
2.1-3.0	8	3	7	4	96	98
>3.0	5	2	4	2	100	100
Totals	116	77	100	100	100	100

Comparison of Designated Campsites Common to Both Surveys: The median number of trees/1000 ft² with exposed roots remained at zero for both 1986 and 1991 (Table 12c). The sum of trees with exposed roots declined from 40 to 28 trees/1000 ft², a 30% reduction. Nearly three times as many campsites decreased in root exposure as increased, 31 campsites compared to 11 campsites (Table 12d and Figure 14) respectively. Only one site changed within the 30% estimated measurement error while 30 sites (41%) retained identical values for root exposure.

Discussion: Although the median site had no trees with exposed roots in both 1986 and 1991, the data indicates that root exposure did decline over the five year period. The 68% reduction in the sum of trees/1000 ft² with root exposure seems large enough to support this conclusion. One factor explaining why campsites had so few trees with root exposure is that field workers were instructed to rate trees with exposed roots from natural causes (e.g. river flooding) in the none/slight category, excluding them from this analysis. This procedure was somewhat subjective, requiring workers to carefully examine the level of natural root exposure in adjacent undisturbed areas, at the same height above the river. Most trees which naturally occur along riverbanks appeared to be unaffected by fairly significant levels of root exposure. Furthermore, the additional exposure caused by camping appears to be small in comparison to that caused by river flooding. For these reasons, it is recommended that this parameter be omitted in future assessments.

Table 12c. General statistics of designated campsites common to both the 1986 and 1991 surveys for trees with exposure roots.

Statistic	Trees with Root Exposure (#/1000 ft ²)	
	1986	1991
	N=73	N=73
Median	0	0
Mean	0.6	0.4
St. Dev.	0.8	1.0
Minimum	0	0
Maximum	3.1	6.4
Sum	40	28

Table 12d. Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in root exposure.

Absolute Change in Root Exposure (#/1000 ft ²) 1986 → 1991	Designated Campsites Assessed in 1986 and 1991 (N=73)			
	Increased		Decreased	
	Number	Percent	Number	Percent
≤ 1	5	7	20	27
1.1-2	3	4	7	10
2.1-3	1	1	4	6
>3	2	3	0	0
Totals	11	15	31	43
Unchanged * Same: 30 (41%) of sites	0	0	1	1

* - Absolute change was ≤ 20% of the 1986 values, including sites with same values from both assessments.

Tree Stumps

Research Methods: Most comments described under the Research Methods section for tree damage are equally applicable to the assessment of tree stumps. The only exception is that stumps were assessed in both surveys by presence only, not by severity.

Comparison of All Designated Campsites, 1986 to 1991: In 1991, the number of stumps/1000 ft² ranged from zero to five with a median value of 0.3 (Table 13a). The *actual* number of stumps ranged from zero to eight with a median of one. In 1986 the actual number of stumps, ranged from zero to 35 with a median of one. In comparison to 1986 data, the median number of stumps/1000 ft² declined slightly but the number of stumps/1000 ft² riverwide declined from 88 to 42, a 52% reduction. Few changes occurred in the distribution of values (Table 13b).

Table 13a. General statistics of designated campsites assessed in 1986 and 1991 for tree stumps.

Statistic	Stumps (#/1000 ft ²)	
	1986 N=116	1991 N=77
Median	0.3	0.3
Mean	0.8	0.6
St. Dev.	1.1	0.8
Minimum	0	0
Maximum	7.1	5.0
Sum	88	42

Table 13b. Number and percent of designated campsites assessed in 1986 and 1991 by tree stump categories.

Stumps (#/1000 ft ²)	Number		Percent		Cumulative Percent	
	1986	1991	1986	1991	1986	1991
0	52	38	45	48	45	48
0.1-1.0	31	27	27	35	72	83
1.1-2.0	19	10	16	13	88	96
2.1-3.0	9	3	8	4	96	100
>3.0	5	0	4	0	100	100
Totals	116	77	100	100	100	100

Comparison of Designated Campsites Common to Both Surveys: The median number of stumps/1000 ft² for campsites common to both surveys declined from 0.2 to zero (Table 13c). The sum for this parameter remained essentially unchanged. More campsites increased than decreased in the number of stumps/1000 ft² but differences were not dramatic (Table 13d and Figure 15). The change for 6% of the sites fell within the estimated 20% measurement error and 20 (27%) of the sites retained identical values.

Discussion: Few changes appear to have occurred with respect to the number of tree stumps/1000 ft² on campsites. Furthermore, the majority of campsites (83%) had one or fewer tree stumps/1000 ft² and the maximum number of stumps/1000 ft² was five, indicating that tree cutting is not a significant problem on the river campsites.

Table 13c. General statistics of designated campsites common to both the 1986 and 1991 surveys for tree stumps.

Statistic	Stumps (#/1000 ft ²)	
	1986 N=73	1991 N=73
Median	0.2	0
Mean	0.6	0.5
St. Dev.	0.9	0.8
Minimum	0	0
Maximum	5.3	5.0
Sum	44	39

Table 13d. Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in stumps.

Absolute Change in Tree Stumps (# stumps/1000 ft ²) 1986 → 1991	Designated Campsites Assessed in 1986 and 1991 (N=73)			
	Increased		Decreased	
	Number	Percent	Number	Percent
≤1	22	30	7	10
1.1-2	5	7	6	8
2.1-3	0	0	6	8
>3	2	3	1	1
Totals	29	40	20	27
Unchanged * Same: 20 (27%) of sites	2	3	2	3

* - Absolute change was ≤ 20% of the 1986 values, including sites with same values from both assessments.

Trails

Research Methods: Procedures for assessing the number of access and social trails leading away from the campsite boundary were essentially identical for both surveys. No data transformations were performed.

Comparison of All Designated Campsites, 1986 to 1991: In 1991, the median number of trails was three, with a range of one to five (Table 14a). One-quarter of the campsites had one to two trails while nearly three-quarters had three to four trails (Table 14b). In comparison to the 1986 survey, the median remained unchanged but the total number of trails summed across all designated sites declined 37%, from 364 to 229.

Table 14a. General statistics of designated campsites assessed in 1986 and 1991 for trails.

Statistic	Trails (#)	
	1986 N=116	1991 N=77
Median	3	3
Mean	3.1	3.0
St. Dev.	1.6	0.8
Minimum	0	1
Maximum	9	5
Sum	364	229

Table 14b. Number and percent of designated campsites assessed in 1986 and 1991 by trails categories.

Trails (#)	Number		Percent		Cumulative Percent	
	1986	1991	1986	1991	1986	1991
0	5	0	4	0	4	0
1-2	35	20	30	26	34	26
3-4	59	55	51	71	85	97
5-6	13	2	11	3	96	100
7-8	3	0	3	0	99	100
9-10	1	0	1	0	100	100
Totals	116	77	100	100	100	100

Comparison of Designated Campsites Common to Both Surveys: The median number of trails remained unchanged at three for the campsites common to both surveys (Table 14a). The sum of trails declined from 248 to 209, a 16% reduction. Fourteen more sites (19%) decreased than increased in the number of trails (Table 14d and Figure 16). Finally, while only one site changed within the estimated 20% measurement error, 22 or 30% of the sites had identical values for both surveys.

Discussion: No significant changes occurred in the number of access or social trails on the median campsite, although the data indicate a 37% reduction in the number of such trails riverwide. This reduction is attributed to both a reduction in the number of campsites and in the number of trails/site. Excessive trail formation in the areas of campsites is not a significant problem, although most campsites have more trails (three to four) than are really essential (one or two).

Table 14c. General statistics of designated campsites common to both the 1986 and 1991 surveys for trails.

Statistic	Trails (#)	
	1986 N=73	1991 N=73
Median	3	3
Mean	3.4	2.9
St. Dev.	1.5	0.9
Minimum	1	1
Maximum	7	5
Sum	248	209

Table 14d. Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in trails.

Absolute Change in Trails (#) 1986 → 1991	Designated Campsites Assessed in 1986 and 1991 (N=73)			
	Increased		Decreased	
	Number	Percent	Number	Percent
1	12	16	14	19
2	5	7	11	15
3	1	1	3	4
>3	0	0	4	6
Totals	18	25	32	44
Unchanged * Same: 22 (30%) of sites	0	0	1	1

* - Absolute change was ≤ 20% of the 1986 values, including sites with same values from both assessments.

Fire sites

Research Methods: Procedures for assessing the number of fire sites were essentially identical for both surveys. No data transformations were performed.

Comparison of All Designated Campsites, 1986 to 1991: In 1991, the median number of fire sites was one, with a range of one to four (Table 15a). All campsites had NPS established steel firegrates in 1991 whereas only 33 campsites had cement or steel firegrates in the 1986 survey (the remainder had stone firepits). Most campsites (87%) had only the provided firegrate, with no evidence of fires being built in other locations (Table 15b). In comparison to the 1986 data, the median remained unchanged but the sum of fire sites riverwide declined from 133 to 92, a 31% reduction.

Table 15a. General statistics of designated campsites assessed in 1986 and 1991 for fire sites.

Statistic	Fire Sites (#)	
	1986 N=116	1991 N=77
Median	1	1
Mean	1.1	1.2
St. Dev.	0.8	0.6
Minimum	0	1
Maximum	6	4
Sum	133	92

Table 15b. Number and percent of designated campsites assessed in 1986 and 1991 by fire site categories.

Fire Sites (#)	Number		Percent		Cumulative Percent	
	1986	1991	1986	1991	1986	1991
0	10	0	9	0	9	0
1	87	67	75	87	84	87
2	16	7	14	9	98	96
3	0	1	0	1	98	97
4	2	2	1	3	99	100
5	0	0	0	0	99	100
6	1	0	1	0	100	100
Totals	116	77	100	100	100	100

Comparison of Designated Campsites Common to Both Surveys: Both the median number of fire sites and sum of fire sites remained essentially unchanged from 1986 to 1991 for the sites common to both surveys (Table 15c). Virtually the same number of campsites (15) increased in number of fire sites as decreased (14), while 44 sites (60%) had an identical number of fire sites (Table 15d and Figure 17).

Discussion: The number of fire sites was reduced by 31%, approximately by the same percentage accounted for by the reduction in campsite numbers from 1986 to 1991. Compliance with the regulation requiring that fires be built only within NPS-provided firegrates appears high, with only ten sites (13%) having an additional fire site evident.

Table 15c. General statistics of designated campsites common to both the 1986 and 1991 surveys for fire sites.

Statistic	Fire Sites (#)	
	1986 N=73	1991 N=73
Median	1	1
Mean	1.2	1.3
St. Dev.	0.8	0.6
Minimum	0	1
Maximum	6	4
Sum	90	91

Table 15d. Number and percent of designated campsites common to both the 1986 and 1991 surveys which remained unchanged, increased, and decreased in fire sites.

Absolute Change in Fire Sites (#) 1986 → 1991	Designated Campsites Assessed in 1986 and 1991 (N=73)			
	Increased		Decreased	
	Number	Percent	Number	Percent
1	12	16	11	15
2	1	1	1	1
3	2	3	2	3
Totals	15	21	14	19
Unchanged * Same: 44 (60%) of sites	0	0	0	0

* - Absolute change was ≤ 20% of the 1986 values, including sites with same values from both assessments.

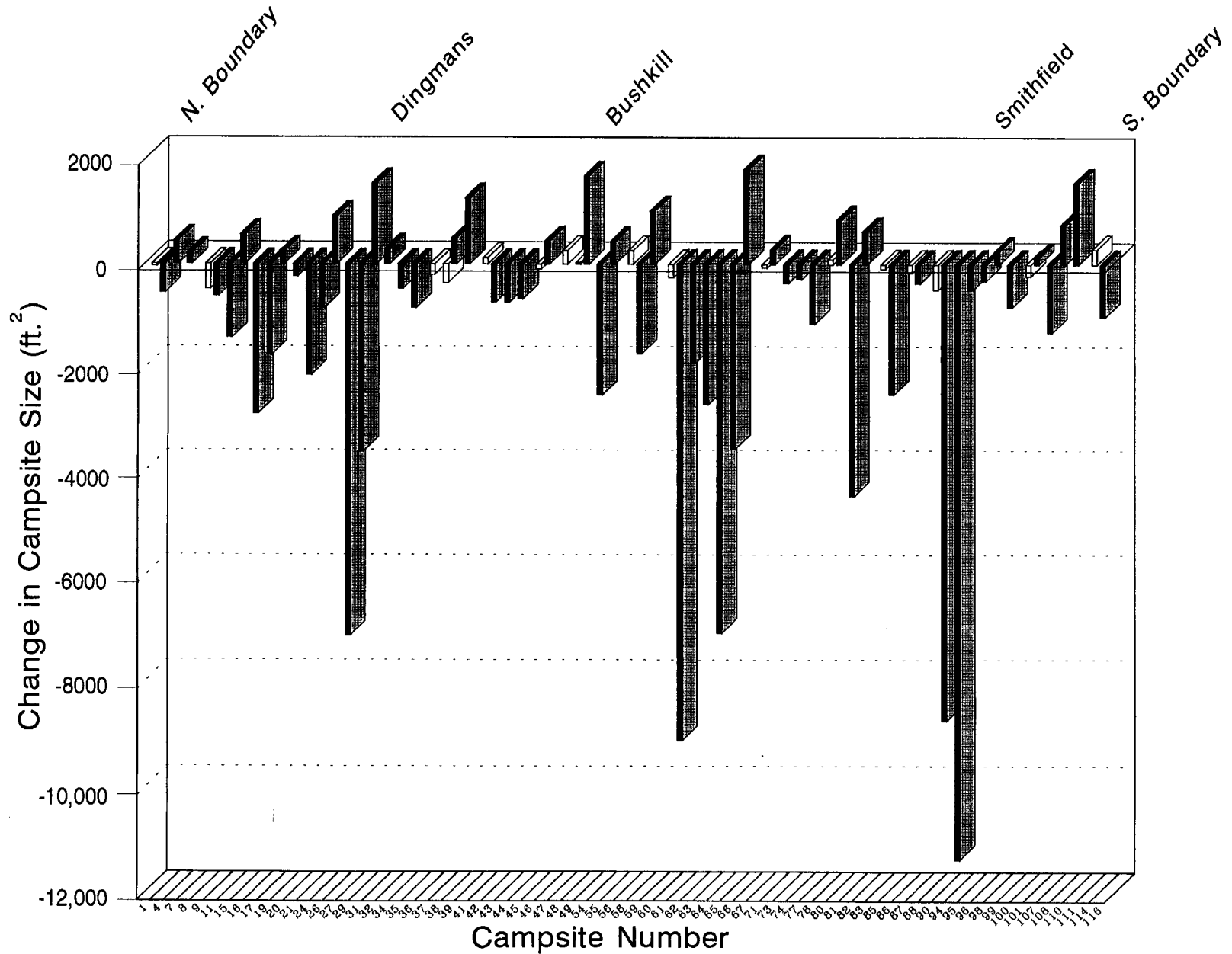


Figure 9. Change in campsite size (ft²) from 1986 to 1991 for designated campsites common to both surveys. Campsites with positive bar values have increased in size, those with negative bar values have decreased in size. Bars that are not shaded represent values that are less than or equal to the 20% estimated measurement error, i.e. when the absolute value of $[(1991 \text{ value} - 1986 \text{ value})/1986 \text{ value}]$ is $\leq 20\%$.

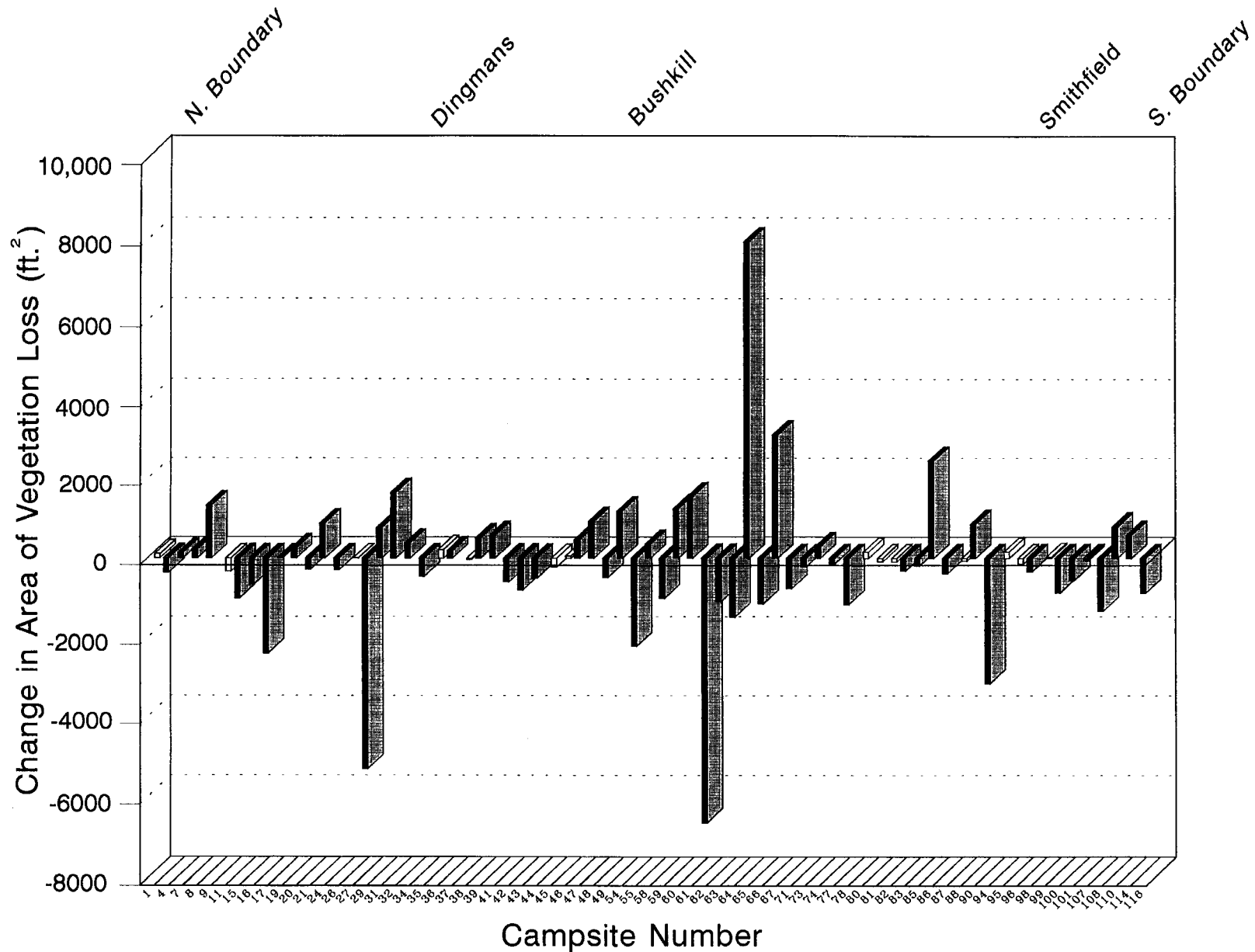


Figure 10. Change in area of vegetation loss (ft²) from 1986 to 1991 for designated campsites common to both surveys. Campsites with positive bar values have increased in area of vegetation loss, those with negative bar values have decreased. Bars that are not shaded represent values that are less than or equal to the 20% estimated measurement error, i.e. when the absolute value of $[(1991 \text{ value} - 1986 \text{ value}) / 1986 \text{ value}]$ is $\leq 20\%$.

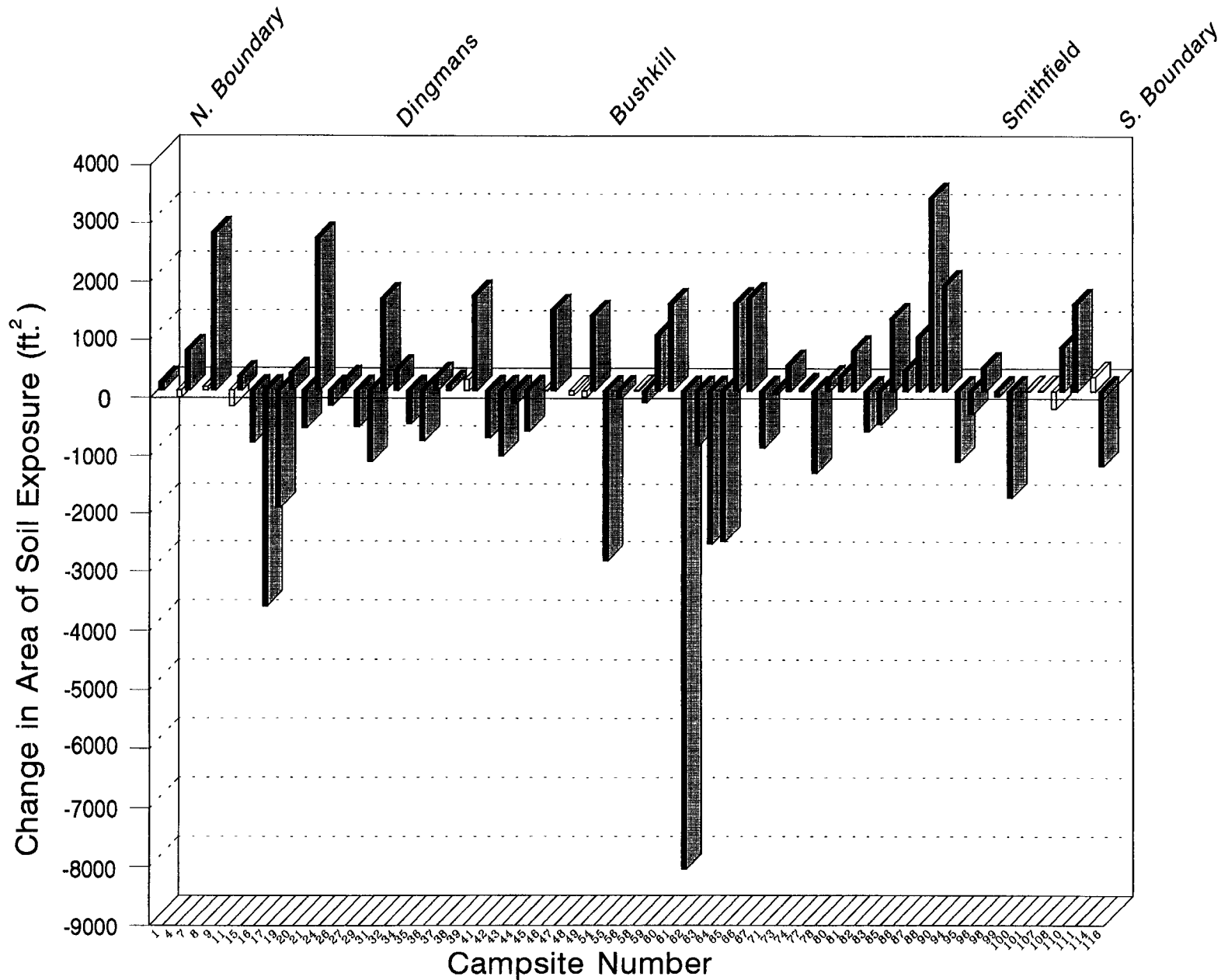


Figure 11. Change in area of soil exposure (ft²) from 1986 to 1991 for designated campsites common to both surveys. Campsites with positive bar values have increased in area of soil exposure, those with negative bar values have decreased in size. Bars that are not shaded represent values that are less than or equal to the 20% estimated measurement error, i.e. when the absolute value of $[(1991 \text{ value} - 1986 \text{ value}) / 1986 \text{ value}]$ is $\leq 20\%$.

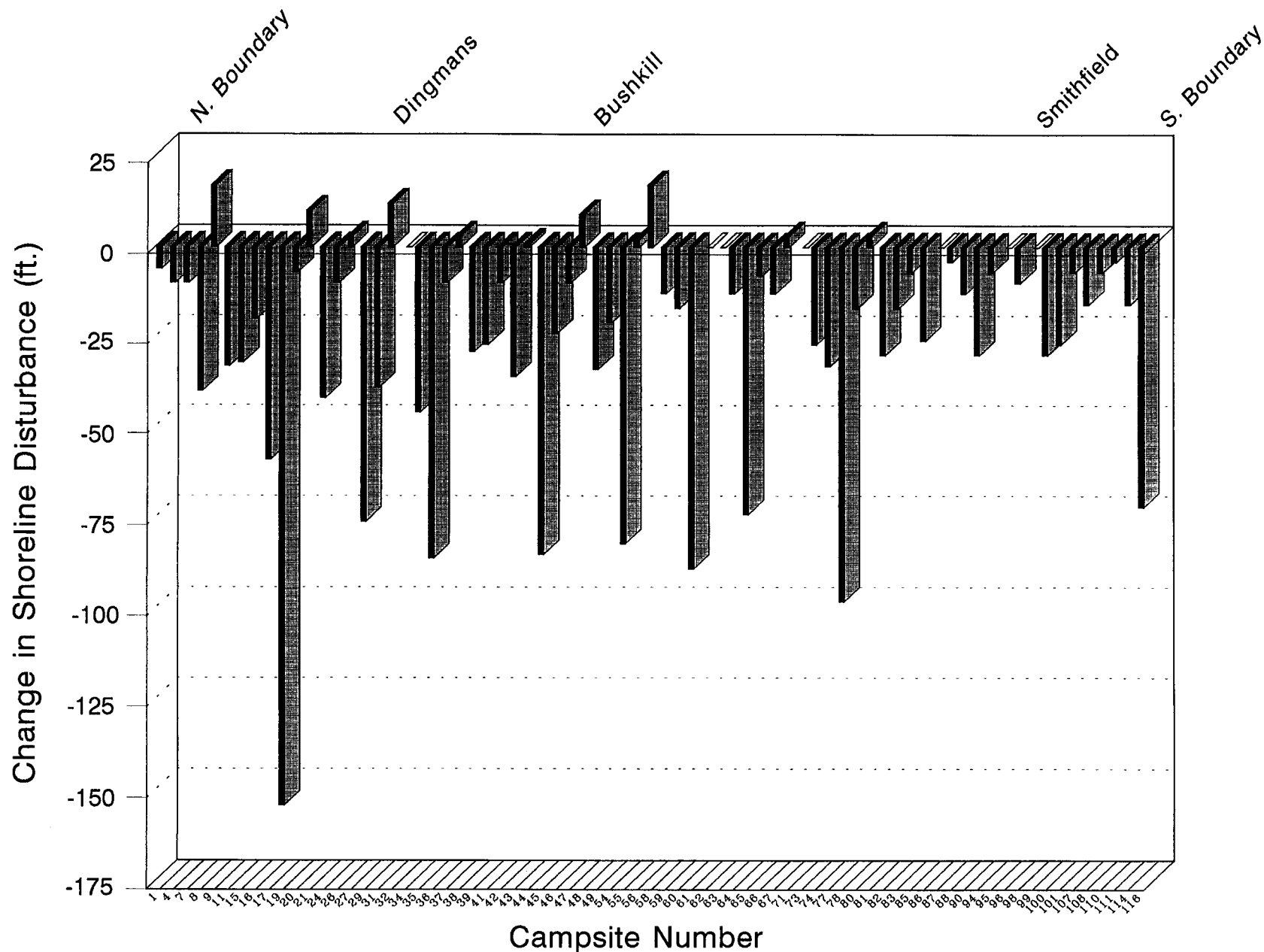


Figure 12. Change in shoreline disturbance (ft) from 1986 to 1991 for designated campsites common to both surveys. Campsites with positive bar values have increased in shoreline disturbance, those with negative bar values have decreased. Bars that are not shaded represent values that are less than or equal to the 20% estimated measurement error, i.e. when the absolute value of $[(1991 \text{ value} - 1986 \text{ value}) / 1986 \text{ value}]$ is $\leq 20\%$.

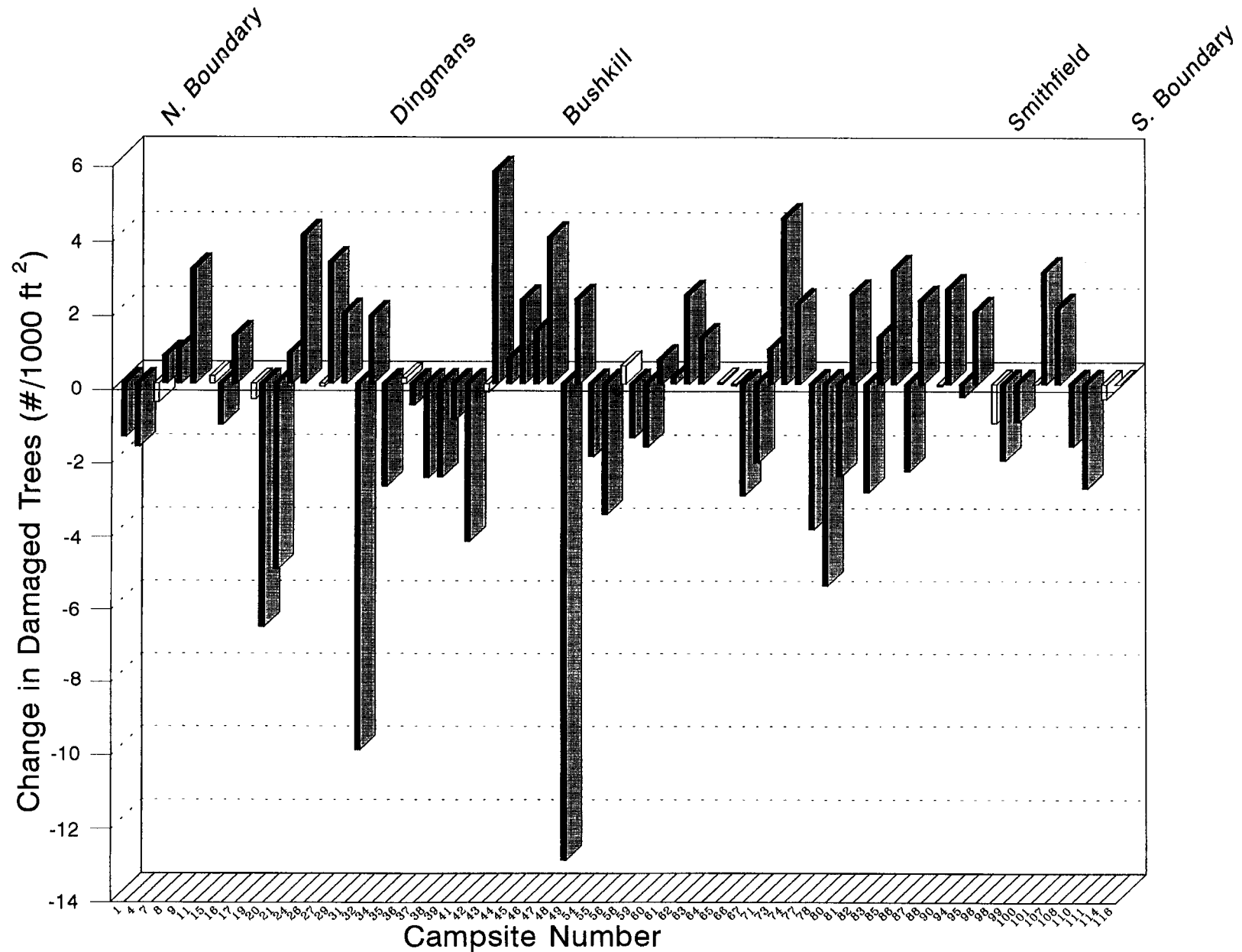


Figure 13. Change in damaged trees (#/1000 ft²) from 1986 to 1991 for designated campsites common to both surveys. Campsites with positive bar values have increased in number of damaged trees, those with negative bar values have decreased. Bars that are not shaded represent values that are less than or equal to the 30% estimated measurement error, i.e. when the absolute value of $[(1991 \text{ value} - 1986 \text{ value})/1986 \text{ value}] \leq 30\%$.

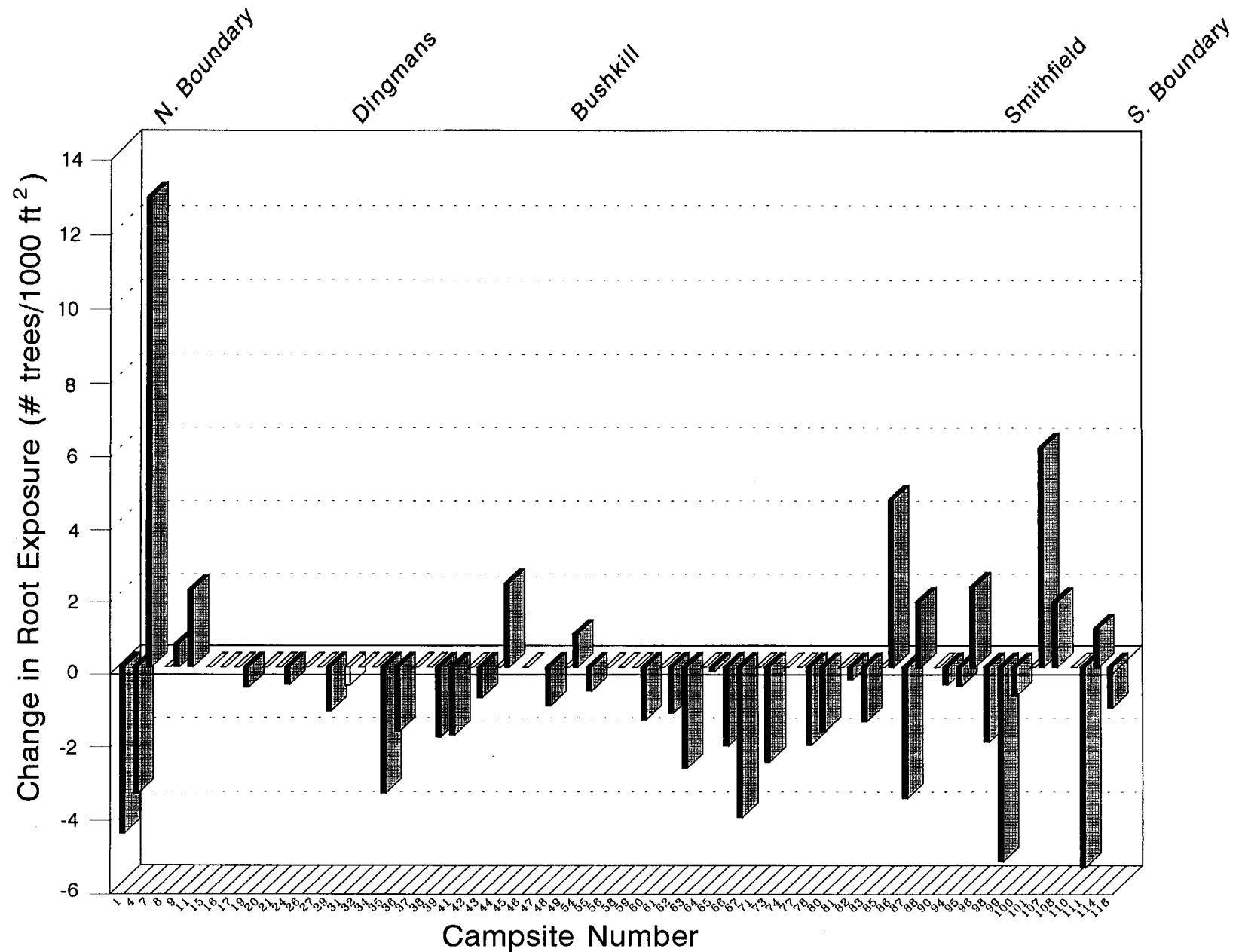


Figure 14. Change in trees with root exposure (#/1000 ft²) from 1986 to 1991 for designated campsites common to both surveys. Campsites with positive bar values have increased in number of trees with root exposure, those with negative bar values have decreased. Bars that are not shaded represent values that are less than or equal to the 30% estimated measurement error, i.e. when the absolute value of $[(1991 \text{ value} - 1986 \text{ value})/1986 \text{ value}]$ is $\leq 30\%$.

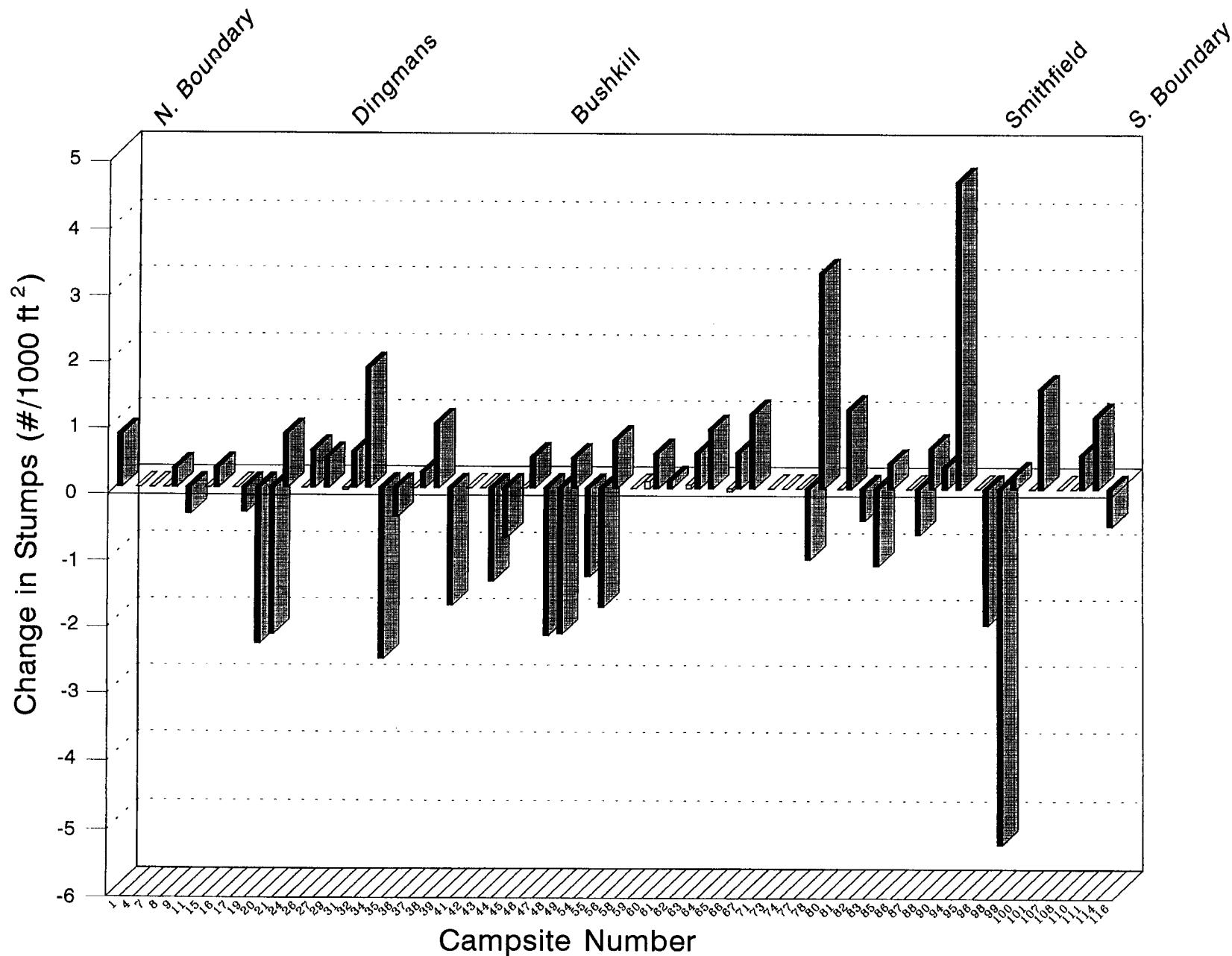


Figure 15. Change in tree stumps (#/1000 ft²) from 1986 to 1991 for designated campsites common to both surveys. Campsites with positive bar values have increased in number of tree stumps, those with negative bar values have decreased. Bars that are not shaded represent values that are less than or equal to the 20% estimated measurement error, i.e. when the absolute value of $[(1991 \text{ value} - 1986 \text{ value}) / 1986 \text{ value}] \leq 20\%$.

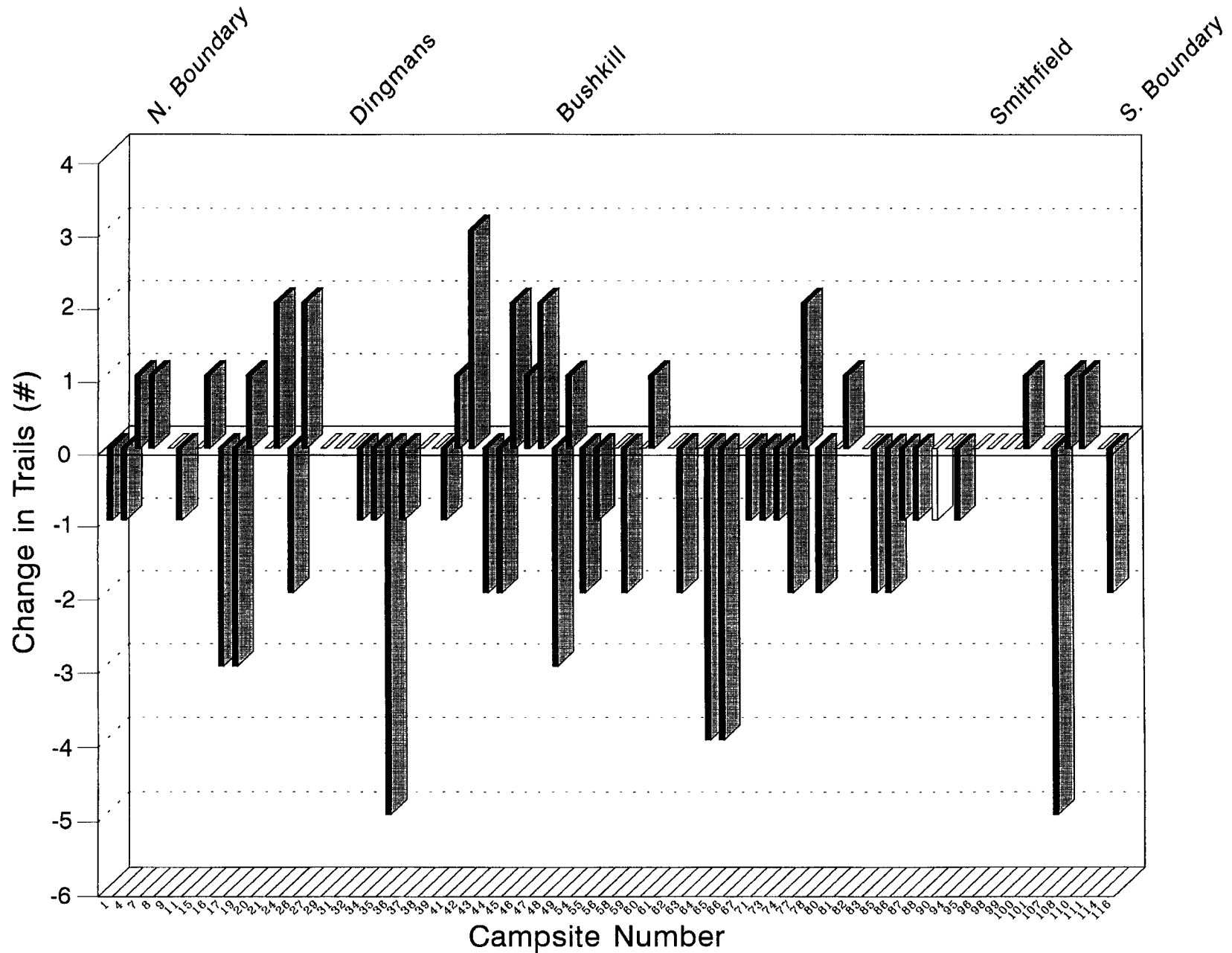


Figure 16. Change in trails (#) from 1986 to 1991 for designated campsites common to both surveys. Campsites with positive bar values have increased in number of trails, those with negative bar values have decreased. Bars that are not shaded represent values that are less than or equal to the 20% estimated measurement error, i.e. when the absolute value of $[(1991 \text{ value} - 1986 \text{ value}) / 1986 \text{ value}]$ is $\leq 20\%$.

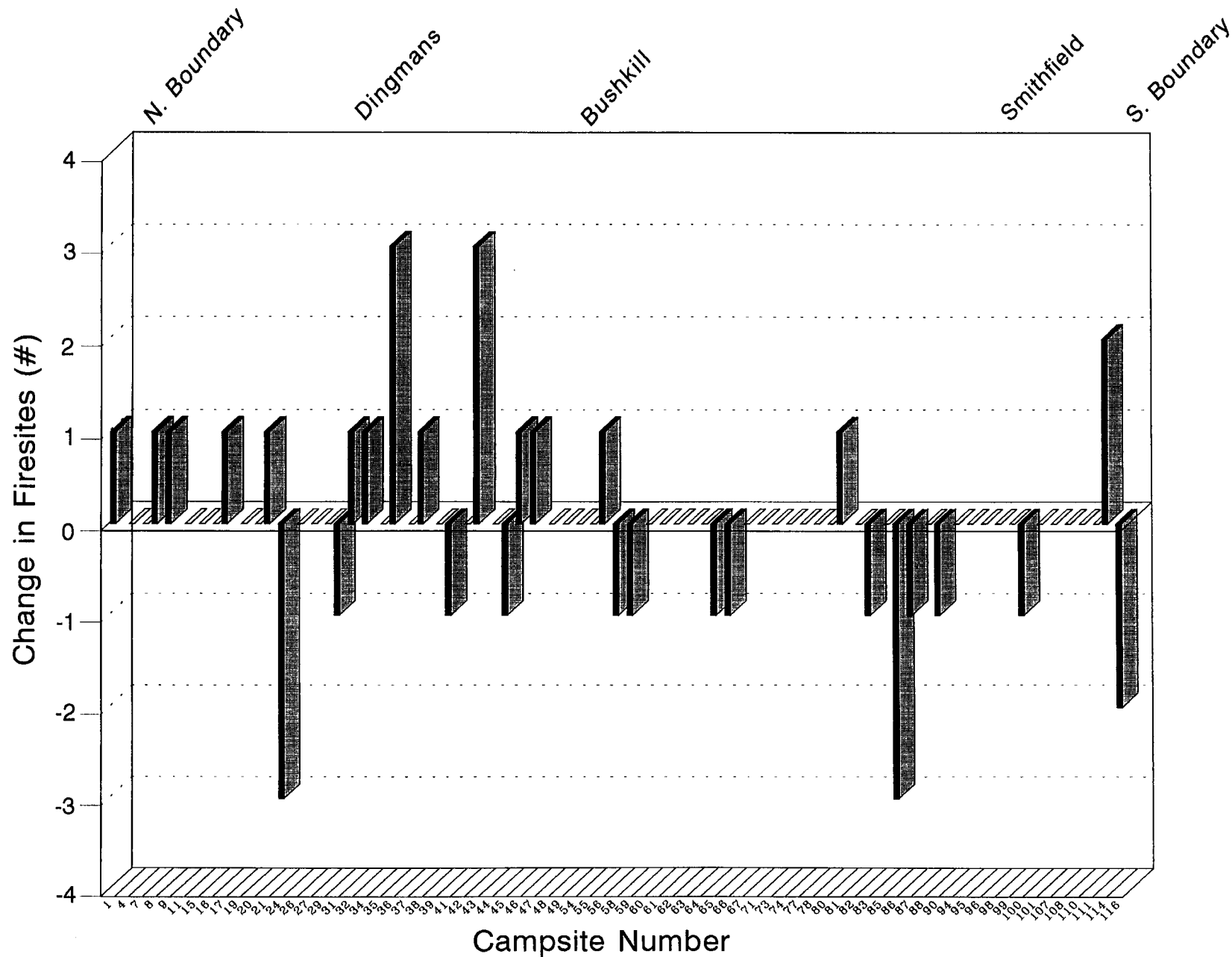


Figure 17. Change in fire sites (#) from 1986 to 1991 for designated campsites common to both surveys. Campsites with positive bar values have increased in number of fire sites, those with negative bar values have decreased. Bars that are not shaded represent values that are less than or equal to the 20% estimated measurement error, i.e. when the absolute value of $[(1991 \text{ value} - 1986 \text{ value}) / 1986 \text{ value}]$ is $\leq 20\%$.

Condition Class

Condition class ratings for all designated campsites assessed in 1991 are presented in Table 16. No sites were rated condition class 1 (refer to Figure 6, page 12), indicating that all campsites are receiving sufficient use to make them readily discernable. Only ten sites (11%) were rated condition class 2, indicating that disturbance to vegetation cover and organic litter occurs only in primary use areas. These sites were assessed using the shortened Form B but a review of their photographs reveals that seven of the sites were located in open grassy vegetation types that research has shown to be highly resistant to trampling. The other three sites were forested sites that appeared to be receiving relatively little use.

Table 16. Condition class ratings for designated campsites in 1991.

Condition Class	Designated Campsites	
	Number	Percent
1	0	0
2	10	11
3	30	34
4	47	54
5	0	0

The majority of sites were rated condition class 3 (34%) or 4 (54%), indicating a complete or near complete loss of onsite vegetation cover but little or no obvious soil erosion. These findings reflect the moderate use levels that the majority of these campsites receive (primarily weekend use over a 12 week use-season). Findings also reflect the relatively fragile nature of the largely herbaceous groundcover common to the majority of these campsites, most of which are situated under rather dense forest canopies. Interestingly, no sites received a condition class rating of 5, indicative of obvious soil erosion. Field staff were instructed to discount erosion caused by river flooding, as evidenced when erosion was also obvious in similar adjacent offsite areas. Soil erosion on campsites clearly occurs, most commonly on the more uneven and sloping campsites closest to the river. The removal of vegetation cover through recreational use likely accelerates erosion during periods of flooding. However, indications of erosion in such environments are common; nearly all trees close to the river have obvious root exposure. Furthermore, most upland sites, which are relatively unaffected by river flooding, are located on flat river benches that are not as susceptible to erosion. Finally, erosion was only evaluated within campsite boundaries; erosion on access trails was common, though not assessed.

Undesignated (Illegal) Campsites

The management actions implemented by park staff have resulted in significant reductions in both the number and extent of change of undesignated campsites. In 1986 the locations of designated campsites were not well-defined and camping regulations were poorly communicated to visitors. Significant progress has been made in resolving this problem through a variety of management actions: wide distribution of information describing camping locations and regulations, increased visitor contact and law enforcement, campsite identification by firegrate placement, and posting of "No Camping" signs on undesignated sites receiving repeated use. The number of illegal campsites has been reduced 64%, from 63 (35% of all 1986 campsites) to 23 (21% of all 1991 campsites) (Table 4).

It is important to note that the reduction in number of illegal campsites occurred with the reclassification of 29 campsites as illegal when the number of designated campsites was

reduced during firegrate placement in 1988-89. By 1991, only three of the illegal campsites were former designated campsites, indicating remarkable compliance with the new designated site camping regulations. Most of the 29 reclassified campsites were located under closed overstories that support limited ground vegetation. However, a single year's leaf fall, if undisturbed by continued use, might obliterate all traces of their existence. Campsite monitoring staff also noted untrampled herbaceous vegetation growing on the former designated campsites with more open overstories. Where recognized, all such campsites were assessed only when there was evidence of continued use. In addition, the 1991 survey was conducted in mid-June, when the full effects of that year's use, including any illegal use, were not yet evident.

The total area of disturbance associated with illegal camping, determined by summing campsite sizes, was reduced 83%, from 97,712 ft² in 1986 (N=63) to 16,578 ft² in 1991 (N=23). Average site sizes declined from 1,551 ft² to 721 ft² while median site sizes declined from 1,044 ft² to 368 ft². A positive correspondence was established for 17 of the 23 illegal campsites. For these campsites common to both surveys, two campsites increased in size and 15 campsites decreased in size. The sizes of these 17 campsites summed to 27,544 ft² in 1986 and 12,166 ft² in 1991, a 56% reduction in the total area of disturbance. Average sizes for these sites are 1,620 ft² in 1986 and 716 ft² in 1991.

Only eight of the 23 illegal campsites in 1991 were condition class 3 or greater and therefore were assessed using the more comprehensive Form A (campsite size is the only condition parameter assessed on Form B). Therefore, comparisons for vegetation loss or other campsite condition parameters are inappropriate.

Relational Analyses

Relational analyses were conducted to summarize differences in the conditions of designated campsites among river segments and landform positions and to evaluate the influence of environmental and managerial factors. This information describes the spatial distribution of site impacts and highlights factors that, when addressed through site selection and management decision making, could help to minimize site degradation.

River Segment

Resource conditions varied considerably among river segments and among individual parameters within segments (Table 17). In general, campsite impacts were highest within the Milford to Dingman's and Bushkill to Smithfield river segments, similar to the 1986 findings. The uppermost and lowermost segments, which have the fewest sites, had relatively good campsite conditions, with the exception of root exposure and trails for the segment upstream from Milford. Surprisingly, campsites in the most central river segment, Dingman's to Bushkill, were generally rated good, excepting shoreline disturbance and fire sites.

Table 17. Mean designated campsite conditions for five river segments.

Resource Parameter	River Segment ¹				
	N-M	M-D	D-B	B-S	S-S
----- average -----					
Sample Size:	N=4	N=18	N=20	N=42	N=3
Condition Class Rating	3.5	3.6	3.4	3.3	3.7
Campsite size (ft ²)	1066	1771	1522	1882	1749
Sample Size:	N=4	N=17	N=17	N=36	N=3
Vegetation Loss (ft ²)	737	1374	1137	1607	1328
Exposed Soil (ft ²)	689	1419	1259	1553	1379
Shoreline Disturbance (ft)	11	11	13	6	9
Damaged Trees (#)	2.3	5.4	3.3	4.8	4.3
(#/1000 ft ²)	2.0	3.2	2.1	2.4	2.2
Trees w/Root Exposure (#)	2.3	0.4	0.8	0.4	0.7
(#/1000 ft ²)	1.9	0.2	0.3	0.2	0.3
Stumps (#)	0.5	1.0	0.5	1.6	0.3
(#/1000 ft ²)	0.4	0.5	0.2	0.8	0.2
Trails (#)	3.3	3.3	2.9	2.9	2.0
Fire Sites (#)	1.0	1.3	1.5	1.0	1.0

¹ - River segments: N-M = Northern park boundary to Milford, M-D = Milford to Dingman's, D-B = Dingman's to Bushkill, B-S = Bushkill to Smithfield, S-S = Smithfield to Southern park boundary.

Site Location

For five of the nine parameters, resource conditions were poorest for campsites on the New Jersey shoreline, intermediate for sites on the Pennsylvania shoreline, and best for island sites (Table 18). Areal measures are greater for the New Jersey sites because of their heavy use, often by large groups, and the presence of large flat benches that offer little resistance to site expansion. Few differences were statistically significant, however, due to considerable variation among sites within each grouping.

Table 18. Analysis of designated campsite conditions by site location: New Jersey shoreline, Pennsylvania shoreline, and islands.

Resource Parameter	Site Location			One-Way ANOVA
	New Jersey Shoreline	Pennsylvania Shoreline	Islands	F Ratio/ Significance
	----- average -----			
Sample Size:	N=40	N=21	N=25	
Condition Class Rating	3.4	3.4	3.5	0.03 / .947
Campsite size (ft ²)	1998	1597	1483	0.98 / .381
Sample Size:	N=35	N=18	N=24	
Vegetation Loss (ft ²)	1745	1278	974	2.10 / .129
Exposed Soil (ft ²)	1772 ^I	1318	942 ^N	2.28 / .110
Shoreline Disturbance (ft)	7	9	11	1.84 / .166
Damaged Trees (#)	5.1	3.9	3.9	0.90 / .412
(#/1000 ft ²)	2.4	2.4	2.7	0.21 / .812
Trees w/Root Exposure (#)	0.5	0.4	0.8	0.54 / .587
(#/1000 ft ²)	0.3	0.1	0.5	1.00 / .372
Stumps (#)	1.6 ^I	0.8	0.7 ^N	3.19 / .047
(#/1000 ft ²)	0.7	0.4	0.4	1.85 / .165
Trails (#)	2.9	2.7	3.2	2.19 / .119
Fire Sites (#)	1.0 ^P	1.5 ^N	1.2	4.18 / .019

Superscripts refer to results from a Duncan test ($p=.05$) for multiple comparisons between group means:

N - This value is significantly different from the value for New Jersey shoreline sites,

P - This value is significantly different from the value for Pennsylvania shoreline sites,

I - This value is significantly different from the value for island sites.

Overstory Density

The density of tree canopies over campsites is important due to its influence on the composition and density of groundcover vegetation. A number of studies, including campsite and experimental trampling studies conducted at DEWA, have demonstrated a significantly greater trampling resistance for grasses and sedges (graminoids) as opposed to broad-leaved herbaceous plants. The flexible leaves and other morphological characteristics of graminoids make them highly resistant to trampling, unlike the broad leaves and brittle stems of most herbs. Unfortunately, most graminoids are shade intolerant, limiting their cover to less than 15% in most closed canopy forests along the river. Therefore, trampling from even low levels of use typically removes most herbaceous ground vegetation on densely forested campsites.

Data presented in Table 19 provide an illustration of these relationships. Onsite ground vegetation cover for sites with more open tree canopies (0 to 75% cover) averaged 45% as compared to 27% for sites with more complete canopies (75-100%). Offsite vegetation cover was only slightly more under open canopies than closed canopies (compare 98% to 95%). Differences are not as pronounced and are not statistically significant, however, for the absolute difference and areal measures of vegetation loss (Table 19). This is likely due to the omission of data on vegetation cover for the ten designated sites assessed with Form B (condition class 1 and 2 sites), due to their excellent conditions. A review of the site photographs reveal that seven of these sites occur in very open overstories and have 90-100% grass cover onsite. These sites are the most trampling resistant of all sites surveyed as evidenced by their condition class 1 and 2 ratings.

Table 19. Analysis of vegetative changes on designated campsites in relation to tree canopy cover: open (0-75%), and closed (75-100%).

Resource Parameter ¹	Tree Canopy Cover		One-Way ANOVA
	Open: 0-75% (N=9)	Closed: 76-100% (N=68)	F Ratio / Significance
Vegetation Cover Onsite (%)	45	27	N.A.
Vegetation Cover Offsite (%)	98	95	N.A.
Vegetation Cover Loss, A.D. (%)	53	68	2.29 / .134
Vegetation Cover Loss (ft ²)	655	1493	2.66 / .107

1 - Vegetation cover on- and offsite are averages of vegetation cover class midpoints (six classes were used, see Appendix A); vegetation cover loss, absolute difference (A.D.), is computed by subtracting onsite from offsite values, providing an estimate of the percentage of original vegetation cover that has been lost on campsites; vegetation cover loss, ft², is computed by multiplying the absolute difference value by the total campsite size, providing an estimate of the area, in square feet, of vegetation loss.

Site Height Above River

For most resource parameters, campsite conditions declined with increasing height above average river water level (Table 20). These differences, many of which are statistically significant, are related to both topographic and vegetative characteristics of the riparian environment. Campsites situated in lowland positions are typically constrained in size by river embankments and the river itself. Trampling resistant grasses and some sedges dominate the ground vegetation on and around these sites, as river flooding prevents the formation of dense tree cover. The rich riparian soils also promote rapid recovery. The disadvantages of these sites is their greater shoreline disturbance (Table 20) and visibility to visitors travelling on the river. Additionally, the loss of vegetation cover immediately exposes bare soil as leaves and other organic debris is absent from these sites due to annual flooding.

Table 20. Analysis of designated campsite conditions by site height above the river: low (0-6 ft), intermediate (7-16 ft), and high (17-40 ft).

Resource Parameter	Site Height Above River			One-Way ANOVA
	Lowland: 0-6 ft	Intermediate: 7-16 ft	Upland: 17-40 ft	F Ratio/ Significance
	----- average -----			
Sample Size:	N=36	N=25	N=26	
Condition Class Rating	3.2	3.6	3.6	2.75 / .070
Campsite size (ft ²)	1141 ^U	1642 ^U	2644 ^{L,I}	8.31 / .001
Sample Size:	N=26	N=25	N=26	
Vegetation Loss (ft ²)	997 ^U	1158 ^U	2023 ^{L,I}	3.96 / .023
Exposed Soil (ft ²)	1031 ^U	1180 ^U	2000 ^{L,I}	3.30 / .042
Shoreline Disturbance (ft)	13 ^U	6 ^L	7 ^L	3.61 / .032
Damaged Trees (#)	3.8	4.5	5.1	0.75 / .474
(#/1000 ft ²)	2.8 ^U	2.9 ^U	1.8 ^{L,I}	3.68 / .030
Trees w/Root Exposure (#)	0.5	0.9	0.4	0.84 / .434
(#/1000 ft ²)	0.3	0.5	0.2	0.67 / .516
Stumps (#)	0.7 ^U	0.8 ^U	1.7 ^{L,I}	5.97 / .004
(#/1000 ft ²)	0.4	0.4	0.8	2.16 / .122
Trails (#)	2.9	3.0	3.0	0.23 / .795
Fire Sites (#)	1.1	1.2	1.3	0.81 / .450

Superscripts refer to results from a Duncan test (p=.05) for multiple comparisons between group means:

L - This value is significantly different from the value for Lowland sites,

I - This value is significantly different from the value for Intermediate sites,

U - This value is significantly different from the value for Upland sites.

The upland sites typically occur on large flat river benches under closed, often dense, overstories. The placement of permanently anchored firegrates in these areas has been highly successful in identifying and concentrating use at each designated campsite. However, site expansion remains a problem due to the lack of topographic or vegetative barriers. All of these sites occur under closed tree canopies which, depending on their density, have lost nearly all ground vegetation. Offsite vegetation is typically not very tall or dense and offers little resistance to site expansion. An advantage of these sites is the presence of organic litter, though this is easily pulverized and lost through trampling and is occasionally lost in major floods.

Installation of Pit Toilets

Managers installed pit toilets on all New Jersey and island campsites in 1987 and 1988. Enclosed Clivus Multrum composting toilets had previously been placed in areas with particularly dense concentrations of sites in the early 1980's. Monitoring data from both surveys is examined to evaluate the effectiveness of these management actions. The evaluations have significant limitations, however, due to the difficult (and unpleasant) task of accurately locating and counting all occurrences of improperly disposed human waste associated with the use of each campsite and the fact that findings are based on single assessments.

Evaluations begin by reexamining the results in Table 6 (page 19). Comparison of data on the occurrence of improperly disposed human waste between surveys reveal mixed findings. A smaller number of sites were rated "some" or "abundant" for occurrences of human waste in the 1991 survey than in the 1986 survey, (19 sites vs. 26 sites). However, a greater *percentage* of the 1991 sites (25%) received these ratings than in the 1986 survey (22%). Such results suggest no significant changes in the relative occurrence of this problem over time.

The occurrence of improperly disposed human waste in 1991 was also examined with respect to toilet presence and type (Table 21). Results indicate that the Clivus Multrum toilets were the most effective, with no occurrences of human waste. For those campsites with pit toilets, ten (31%) had evidence of improperly disposed human waste but only two of these had numerous occurrences (>4). In contrast, for campsites lacking toilets, nine (28%) had evidence of human waste but six of these had numerous occurrences. A Pearson's Chi-Square test revealed these differences to be statistically significant (Value = 10.29, sig = .036).

SUMMARY AND RECOMMENDATIONS

Monitoring Results

The campsite monitoring surveys have yielded a considerable amount of information about changes in the number and distribution of DEWA river campsites, their condition, and the influence of environmental factors and management actions. These findings and their implications for management are reviewed by posing and answering several questions of concern to management.

- *What is the current status of river campsites with respect to their numbers, distribution, characteristics, and resource conditions?*

Survey staff in 1991 located and assessed 110 river campsites, 87 (79%) were designated and 23 (21%) were undesignated (illegal). There are an average of 2.2 designated and 0.6 undesignated campsites per river mile. The largest number and density of designated campsites are in the Bushkill to Smithfield river segment (42 sites, 4.2 sites/mile). The smallest number and density of designated campsites are in the above Milford (4 sites, 1.0 sites/mile) and below Smithfield (3 sites, 0.4 sites/mile) river segments.

All designated campsites are river accessed; nearly half (35 sites, 45%) are situated on low river banks less than 11 feet above average river level while the remainder are located on higher embankments and river benches ranging from up to 40 feet above the river. Most sites (68, 88%) occur under a closed forest overstory. Campsite facilities include a steel firegrate and, on most New Jersey and island campsites (N=45), either a composting or pit toilet. Nearly half the campsites (42 sites, 48%) have no other sites visible from the campsite or its shoreline access, indicating good potential for visitor solitude while camping. In contrast, opportunities for groups to camp together for more social experiences are also possible: two to four other campsites are visible from the boundaries or shorelines of 20 sites. Finally, litter was rarely evident on campsites but some problems with improper disposal of human waste were evident on 19 sites.

Designated campsites ranged in size from 120 to 8,316 ft² with a median size of 1,302 ft² (about 36 by 36 feet). The median campsite had about 900 ft² of ground devoid of both vegetation cover and organic litter, though the latter is often absent due to frequent river flooding. The median campsite also had only three lineal feet of shoreline disturbance, two trees with moderate to severe human-caused tree damage, no trees with human-caused root exposure, and no stumps. Finally, the median site had three access or social trails and only one fire site.

- *How have the number, distribution, and resource conditions of river campsites changed over a five year period?*

Total campsite numbers have decreased 39%, from 179 in 1986 to 110 in 1991. More specifically, the number of designated campsites declined by 25%, from 116 to 87, while the number of illegal campsites declined by 64%, from 63 to 23. The greatest reduction in the number of designated campsites occurred in the central Dingman's to Bushkill to Smithfield river segments. The greatest reduction in the number of illegal campsites occurred in the Dingman's to Bushkill segment, though the reduction in the Milford to Dingman's segment was also large.

Campsite intervisibility has declined; two or more sites were visible from 32% of the campsites or their shore accesses in 1986 but only 23% of the current campsites have this degree of intersite visibility. In 1986, 28% of the campsites had either cement or steel firegrates, while in 1991, all designated sites had permanently anchored steel firegrates. Similarly, in 1986, 26% of the sites had access to composting toilets, while in 1991, at least 59% of the campsites had access to either composting or pit toilets. The occurrence of litter appears to have declined substantially; 39% of the sites in 1986 had no litter while 95% of the 1991 sites lacked litter. Assessments of improperly disposed human waste suggest that this was and remains a problem for about one-quarter of the campsites. However, the reliability of single assessments for these last two parameters are likely to be low due to large temporal variation.

Nearly all resource condition assessments indicated substantial improvements in resource conditions on designated campsites. The sizes of designated campsites declined from an average of 2,610 ft² in 1986 to 1,775 ft² in 1991. More significantly, the total area of disturbance, summing across all sites, declined 50%, from 302,784 ft² to 150,859 ft². The average area of ground vegetation loss on campsites increased by 165 ft², likely in response to a greater concentration of use caused by the installation of firegrates. However, the total area of vegetation loss for all designated campsites declined by 21% (29,056 ft²), largely due to the reduction in site numbers. In a similar fashion, the area of exposed soil increased 36% on the median campsite but declined by 10% overall. Average lineal shoreline disturbance declined 66% while the sum of shoreline disturbance declined from 3,096 ft² to 671 ft², a 78% reduction.

The number of damaged trees on designated campsites declined from an average of 2.8 to 2.3, with total numbers reduced from 324 to 191. Assessments of trees with human-caused root exposure revealed a decline from 0.7 to 0.3 trees per site and from 75 to 25 across all sites. Similarly, the average number of tree stumps declined from 0.8 to 0.5 on campsites, and from 88 to 42 across all sites. The mean number of campsite access and social trails were similar, though trail numbers declined due to the reduction in site numbers. Finally, the average number of fire sites were also comparable, but overall, their numbers were reduced from 133 to 92.

- *How effective have management actions been in minimizing the resource impacts associated with river camping?*

A number of recommended management actions from the 1986 survey were implemented by park staff. These included a review of all designated and illegal campsites to evaluate their potential for remaining or becoming designated campsites. Site selection guidelines were provided to help identify campsites with the best potential for sustaining use with minimal impact. This review was completed by river district staff and 87 campsites were selected and formally designated in 1988/89. In many instances this reduction, from 116 to 87 sites, occurred by selecting only one or a few of the many pre-existing campsites at the individual locations where camping was previously permitted. Where possible, campsites were selected to increase camping solitude by maximizing intersite distances and to decrease resource impacts by applying the site selection guidelines.

A second principal recommendation was that permanently anchored steel firegrates be installed on each designated campsite. Signs were also posted on each site instructing visitors to camp only on sites with firegrates. "No Camping" signs were also posted on sites that did not receive firegrates whenever repeated use occurred. A third recommendation was for the development and wider distribution of educational materials. The park developed a high quality river guide pamphlet that includes a map showing all designated campsite locations, listing all camping regulations, and recommending low impact camping practices. Beginning in 1990, this pamphlet was widely distributed at all park visitor centers, river accesses, and offices and by commercial river outfitters. A final action, initiated by River District staff in 1988, was an increased emphasis on ranger patrols to enforce the designated site camping regulations. In particular, a 5 AM patrol was initiated to catch offenders.

As described in this report and summarized above, monitoring data indicate that campsite conditions have dramatically improved between 1986 and 1991. These changes are the product of a combination of many different environmental and use-related factors, as influenced by the management actions highlighted above. The interrelationships between these factors and actions are complex and difficult to measure even in controlled experimental studies. Statistical testing and definitive statements regarding cause and effect are therefore not possible with existing data. Rather, the likely influence of management actions on principal use-related and environmental factors will be discussed and their significance will be inferred.

Principal use-related factors include type of use, amount of use, and visitor behavior. There are no indications that type of campsite use has changed and so this factor will not be considered. Rough estimates of river campsite use suggest that use has remained constant or declined slightly between the two monitoring assessments. River rangers concur, reporting that the level of campsite use has been relatively constant for some time. User behavior has not been directly observed and its relative influence must be inferred.

All of the management actions have the potential of changing user behavior. Increased campsite spacing and firegrate installation more clearly define individual campsites, both attracting and concentrating use in the immediate vicinity of the firegrate. A result would be smaller, more well-defined, campsites. Posted signs and the new widely distributed river guide

pamphlet communicate the regulation that camping must occur only on campsites with steel firegrates. The pamphlet's river map showing campsite locations also helps visitors plan their trips so that legal campsites can be used, and indicates locations of alternatives when intended campsites are occupied. Low impact practices recommended in the pamphlet (see text box) may also have been adopted by some visitors, possibly resulting in fewer damaged trees or less litter. "No Camping" signs posted on the most persistent illegal campsites and increased law enforcement efforts reinforced these messages.

Principal environmental factors include vegetation and soil types and their relative resistance to the effects of camping, resilience (ability to recover), vegetative growing conditions, and the effects of river flooding. There are no indications that growing conditions or patterns of river flooding have changed significantly or that they are responsible for improved campsite conditions. Improved site selection in the designation of campsites may have excluded campsites that were most susceptible to degradation and retained or substituted campsites with greater resistance. However, only a few sites were converted from fragile settings (areas with dense herbaceous cover) to resistant settings (areas with dense grassy cover). Finally, differences between the campsite assessment dates may have influenced findings. During the initial survey, campsites were assessed throughout the summer, in contrast to the 1991 survey when all campsites were assessed in mid-June. Experience has shown that campsite degradation does increase over the course of the summer, though differences are not highly pronounced.

We may conclude from this discussion that the management actions were the principal agent of change contributing to the improvement in site conditions. We can only speculate about the relative contributions of the various management actions. The elimination of 29 designated campsites in 1988/89 is likely responsible for a good portion of the reduction in cumulative or summed measures of change. For example, the total area of disturbance (sum of campsite sizes) declined from 302,784 ft² in 1986 (N=116 sites) to 150,859 ft² in 1991 (N=87 sites), a 50% reduction (Table 22). However, the total area of disturbance was still reduced by 37% for the 73 campsites common to both the 1986 and 1991 surveys (Table 22). In fact, reductions occurred in eight of the nine parameters for the 73 campsites common to both surveys, suggesting that factors in addition to the elimination of campsites led to the improvements in site conditions.

Low Impact Practices
(recommended in River Guide)

- Use a campstove rather than a fire. If a fire is necessary, it must only be built in the steel firegrate provided at each site. Use only dead, fallen wood. (That dead tree is part of the scenery and a home for owls.) Keep the fire small. Be sure it is out before you leave.
- Leave rocks and flowers where you find them, so others can enjoy them as you do.
- Carry out your litter, including leftover food. Pick up litter left by others; there will always be thoughtless people for us to clean up after. Leave the site as you would like to find it.
- Latrines, if not present, should be dug five to six inches deep and should be at least 300 feet away from water...

... and including messages on washing and noise...

The principal factor likely responsible for reducing the area of disturbance associated with each campsite was the establishment of permanently anchored firegrates. This action specifically identifies camping locations and provides a focal point for camping activities. As predicted in models presented in Cole (1992), any increase in the degree of activity concentration leads to a decrease in campsite area. Increased trampling intensities would occur near the firegrates, where all vegetation is lost, and decreased trampling intensities would occur toward the perimeter, where surviving vegetation cover is greatest. Reductions in the mean and median values for the areal measures of change (site size, vegetation loss, and exposed soil [Tables 7c - 9c]) for the 73 campsites common to both surveys, provide supporting evidence that firegrate placement was effective in reducing campsite sizes.

Table 22. Comparison of cumulative change (sum) values for all designated campsites and those designated campsites common to both surveys.

Campsite Condition Parameter	Designated Campsites (1986, N=116) (1991, N=77)			Designated Campsites Common to 1986 & 1991 Surveys (N=73)		
	1986 Sum	1991 Sum*	Percent Change	1986 Sum	1991 Sum	Percent Change
Campsite Size (ft ²)	302,784	150,859**	-50%	196,739	124,791	-37%
Vegetation Loss (ft ²)	136,508	107,452	-21%	93,541	89,757	-4%
Exposed Soil (ft ²)	119,929	108,322	-10%	98,984	90,007	-9%
Shoreline Disturbance (ft)	3,096	671	-78%	2,360	677	-71%
Damaged Trees (#/1000 ft ²)	324	191	-41%	204	174	-15%
Trees w/Root Expos. (#/1000 ft ²)	77	25	-68%	40	28	-30%
Stumps (#/1000 ft ²)	88	42	-52%	44	39	-11%
Trails (#)	364	229	-37%	248	209	-16%
Fire Sites (#)	133	92	-31%	90	91	1%

* - Excluding data from 10 campsites assessed with the abbreviated Form B due to their good condition.

** - Sample size (N) in 1991 = 87.

- *What are the most salient problems that require current management attention?*

The number and locations of designated campsites are now under the control of management. Furthermore, the number of illegal campsites has declined from 63 to 23 and existing measures should be sufficient to continue this trend. Therefore, management attention should now focus on the resource conditions of the 87 designated campsites. While firegrate establishment has helped to concentrate use, site expansion remains a primary concern. For example, 73% of the designated campsites are less than 2000 ft² (45 x 45 ft), certainly large enough to accommodate most groups of campers (Table 7b). Yet, 23 sites are larger and five sites are over 6000 ft² in size. Given the fragility of the vegetation and organic litter, large campsites also mean excessive vegetation loss and exposed soil.

Damage to trees is a common problem in most protected areas that permit campfires. Though the median and mean number of damaged trees on campsites is not excessive (about two trees), 13 campsites (15%) had more than twice this number.

Problems with improperly disposed human waste also remain a concern. However, monitoring surveys conducted once each five years cannot reliably document the extent of this problem or temporal trends. More frequent assessments by park staff who routinely visit campsites are needed.

Recommendations

Campsite Monitoring Program

The 1991 campsite survey demonstrated the efficiency of the river campsite monitoring program at DEWA. Only two field staff working ten days were required to canoe the river and assess all campsites. Training, field work preparation, and computer data entry added another ten days, for a total of one month's time for two seasonal workers. Revision of field procedures, data analysis, and report writing by the author required an additional month. The continuation of the monitoring program, with assessments at five year intervals, is recommended. According to this schedule, campsites should be reassessed in 1996.

Campsite remeasurement procedures have been incorporated into the monitoring manual in Appendix A. These procedures should be field tested and revised where necessary prior to application. The relocation of campsite centerpoints and additional measurements will lengthen assessment times an estimated 10 to 15 minutes per campsite. Several changes in the 1991 procedures are also recommended. In 1991, ten designated campsites were rated as condition class 2 campsites and assessed with the abbreviated Form B. This created numerous problems in the analysis and interpretation of data. In the future, all designated sites should be assessed with the more comprehensive Form A. An expanded information base is not necessarily required for the illegal campsites, however, which might all be assessed with Form B to reduce field time. Finally, for reasons previously discussed, it is recommended that root exposure, litter, and human waste parameters be omitted from future surveys. Excessive root exposure from river flooding is commonplace throughout the riparian zone, making this assessment difficult and unreliable. The amount of litter removed from campsites is already being

monitoring by litter cleanup crews, and human waste assessments could be added, perhaps on a monthly basis.

Additionally, river rangers should maintain a dated record of all management actions relating to the management and condition of the designated and undesignated river campsites. This would include changes in visitor contact and law enforcement efforts, literature content and distribution, posting of signs, site maintenance or rehabilitation work, and opening and closure of designated campsites.

Management Actions

All existing management actions implemented to reduce illegal campsite use should be continued. Many of these sites are the result of repeated day use activities such as fishing or lunch stops. For those sites receiving repeated overnight use, a more permanent alternative to a "No Camping" sign (which is often torn down) is a 4x4 post embedded in the center of each site with "No Camping" routed on its sides. Such posts have been highly effective in deterring illegal site use in Shenandoah National Park. Other potential actions include various forms of site restoration work; consult the author for literature and more specific recommendations on this topic. Appendix B lists the site numbers and other information on all 23 undesignated campsites. Site numbers can be located on the 1/400 scale river maps provided to the park to aid river rangers in locating and patrolling the undesignated campsites.

Appendix B also lists all designated campsites larger than 2000 ft² (N=23). These sites are unnecessarily large. It is recommended that river managers visit these sites to determine why they are so large and to evaluate alternative options for decreasing their size. Several options are offered for consideration:

- 1) Revise camping regulations, literature, and signs to encourage concentration of camping activities close to the firegrates. Vegetative groundcover is quickly lost on campsites under forest canopies. Therefore the objective for a designated site camping policy should be to contain use to the smallest possible area. An indirect, educational, approach might be stated as a minimum impact recommendation to "concentrate your camping activities within existing campsite boundaries and close to firegrates". A more direct, regulatory, approach might be stated as "all tents and tarps must be located within 20 feet of established firegrates".
- 2) Close and restore some or all of the existing large campsites that occur on flat benches lacking barriers to site expansion. Establish replacement campsites only in areas with effective natural topographical barriers that limit site expansion. Favor the selection of campsites under either very open or very dense forest canopies. Open overstories support dense grassy vegetation cover which is highly resistant to trampling. Though even grass cover will be lost above moderate trampling intensities, the area of vegetation loss is small when compared to forested campsites that have more fragile groundcover comprised of broad-leafed herbs. In forested settings, most ground vegetation is lost above low trampling intensities so vegetation loss can be minimized by selecting campsites with very dense forest canopies that support relatively little ground vegetation.

3) Establish a group size limit for camping. Large groups can significantly expand campsite boundaries in as little as one night of use. Management experience in the Boundary Waters Canoe Area Wilderness and other areas has shown group size restrictions to be effective in constraining campsite sizes. A group size limit of eight to ten is recommended. An option could be provided for larger groups to use a limited number of specially designated group campsites. Such sites could be signed to prohibit their use by smaller groups or could be managed through a reservation system. Close cooperation with river outfitters will be necessary to inform large overnight groups of any new park group-camping policies.

4) Evaluate large campsites to determine if their size might be caused by a lack of adequate tenting sites in the vicinity of the firegrate. To reduce incentives for site expansion, where necessary, relocate firegrates to areas with more numerous tenting locations or conduct site maintenance work to improve existing tent sites in the vicinity of firegrates. Use of attractive "off-site" areas can be discouraged by partially burying large rocks or by digging shallow pits and mounding soil to ruin potential tenting sites. Compliance and restoration can be enhanced by naturalizing such areas with dead tree limbs, organic duff, and vegetative plantings. However, experience in other parks has shown these actions alone are often ineffective.

Excessive tree damage also remains a concern. At the earliest opportunity, it is recommended that relevant camping regulations, literature, and signs be revised to reduce or eliminate the use of axes and saws. An indirect, educational, approach might be added to the existing minimum impact recommendation relating to firewood "... Use only dead, fallen wood that can be broken by hand. Axes and saws are unnecessary and damage live trees, please leave them behind...". A more direct, regulatory, approach might be stated as "... Use only dead, fallen wood that can be broken by hand. Axes and saws are prohibited...".

It is better to remove the right to carry an axe and saw than the right to build a campfire, an integral part of many campers' outdoor experience. If such actions fail to resolve problems with tree damage, as evidenced by objective monitoring data, the action of prohibiting campfires may then be justified and defensible.

No significant changes were documented for improperly disposed human waste, though more frequent assessments are necessary to improve and ensure reliability. It is recommended that park litter cleanup crews or other staff monitor the extent of human waste disposal problems. Improved maintenance and/or signing of trails to toilets may lessen human waste problems on those sites with pit toilets.

Finally, it is recommended that park staff consider the development of a backcountry management plan that incorporates a Limits of Acceptable Change (LAC) management framework (see discussion and Figure 2 on page 6). Such a plan is needed to provide a vision, specific objectives, and a decision making framework for the management of backcountry resources with DEWA. The river campsite monitoring program has demonstrated its capabilities in documenting changes in campsite conditions, an essential component for LAC management. However, the lack of management objectives and standards describing acceptable conditions will continue to limit management efforts to interpret and act upon the results of monitoring.

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APPENDIX A

1991 Campsite Monitoring Manual

Note: Photographs illustrating campsite boundaries, boundary flag placement, vegetative ground cover classes, soil exposure, tree damage, and root exposure are part of this manual but have been omitted from this Appendix. High quality reproductions of these photographs, some of which are in color, may be found in Marion 1991, on pages 46-51.

**DELAWARE WATER GAP NATIONAL RECREATION AREA
RIVER CAMPSITE MONITORING MANUAL**

DESCRIPTION OF PROCEDURES

Manual Revision Date: 6/91

For the purposes of this manual, campsites 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 in comparison to offsite areas, as indicated by exposed tree roots and rocks and/or gullying.

For campsites rated Condition Class 1 or 2, complete Form B, for campsites 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 campsites is not as critical to management.

During subsequent surveys an attempt should be made to relocate and assess all sites from the preceding survey. Former designated sites which 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.
1=designated 2=undesignated (illegal)
- 4) River Segment: Indicate the river segment within which the site is located:
1=North Boundary-Milford 2=Milford-Dingman's 3=Dingman's-Bushkill 4=Bushkill-Smithfield 5=Smithfield-South Boundary
- 5) Site Location: Code as below.
1=Island 2=PA shoreline 3=NJ shoreline
- 6) Describe Site Location: Describe the location of the campsite 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 campsite 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 which 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 campsite was evaluated (eg. June 12, 1989 = 06/12/89).

INVENTORY PARAMETERS

- 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 campsite access trail. Use your best judgement concerning where average water level is. Record the predominant substrate for this area using the coded categories below.
- 1=bedrock - shelf bedrock
 - 2=cobble - includes gravel size stone and up
 - 3=sand - includes sandy beach soils which do not form a surface crust in trampled areas
 - 4=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 campsite. 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 will provide a sufficiently accurate site height.
- 13) Number of Other Campsites Visible: Record the number of other campsites, which if occupied, would be visible from the campsite 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 campsite:
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: Any NPS provided toilet. Code as below.
- 1=present, visible - toilet is present and visible from the campsite
 - 2=present, not visible - toilet is present nearby or within a set of group sites but is not visible
 - 3=not present - toilet is not present

IMPACT PARAMETERS

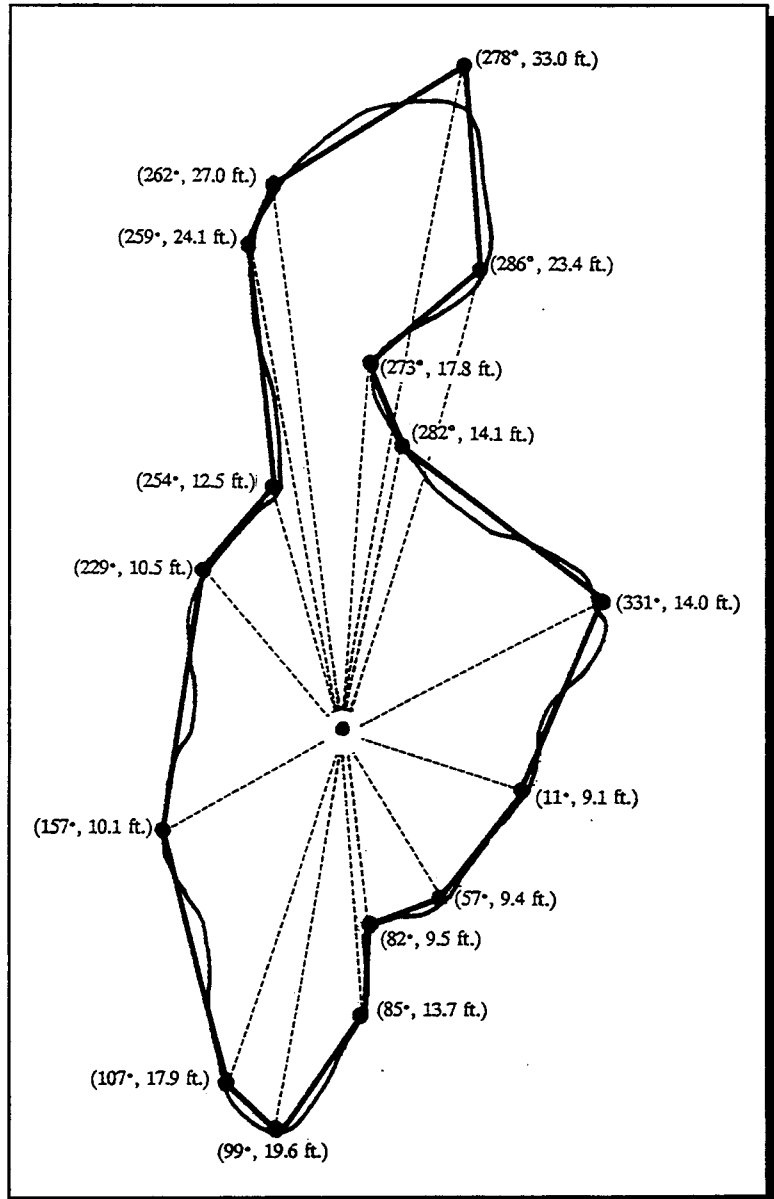
Assessment of site impacts begins with establishing the campsites' boundaries and measuring its size. The following procedures describe the use of the **Variable Radial Transect Method** for determining the sizes of campsites. This is accomplished by measuring the lengths of linear transects radiating to the campsite boundary from a permanently defined centerpoint.

Step 1. Identify Campsite Boundaries and Flag Transect Endpoints.

Walk the campsite boundary and place flagged wire pins at locations which, when connected with straight lines, will define a polygon whose area approximates the campsite area. Use as few pins as necessary, typical campsites can be adequately flagged with 10-15 pins. Look both directions along campsite boundaries as you place the flags and try to balance areas of the campsite which fall outside the lines with offsite (undisturbed) areas which fall inside the lines. Pins do not have to be placed on campsite boundaries, as demonstrated in the diagram following these procedures. Project campsite boundaries straight across areas where trails enter the site.

Identify campsite 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, ie.

areas where leaves are untrampled and intact vs. areas where leaves are pulverized or absent. When defining the campsite boundaries, be careful to include only those areas which 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 Campsite Centerpoint. Select a campsite centerpoint that is preferably: a) visible from all the campsite boundary pins, b) close to and easily referenced by distinctive permanent features such as larger trees or boulders, and c) approximately 5 feet from the steel firegrate (any closer will result in electromagnetic interference with the pin locator). Embed a temporary 10 inch stake through the eyelet on the tape measure at the centerpoint location. Reference the centerpoint to at least three relatively permanent and distinctive 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 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. Periodically review and practice the procedures on compass use at the end of this section. Record the center point identification information on the back of the form.

Examples: 1) Red Maple, 3.2 ft dbh, 23.2 ft at 195° (largest tree on campsite)
 2) Boulder, 17.9 ft at 312°, (distance and bearing to highest point)
 3) Sycamore, 1.4 ft dbh, 29.5 ft at 78°, (only sycamore in area)

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 campsite boundaries are not pronounced. Note your actions regarding use of these options in the Comments section of the survey form.

Step 3. Record Transect Azimuths and Lengths. Standing directly over the centerpoint, identify and record the compass bearing (azimuth) of each campsite boundary pin working in a consistent direction (in the exact order you would encounter them if you were walking the campsite 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 campsite 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 campsite measurements.

Step 4. Measure Island and Satellite Areas. Identify any undisturbed "islands" of vegetation inside campsite boundaries (often due to clumps of trees or shrubs) and disturbed "satellite" use areas outside campsite boundaries (often due to tent sites, cooking sites, or horse use areas). Use campsite boundary definitions for determining the boundaries of these areas. Use the **Geographic Figure Method** to determine the areas of these islands and satellites. 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. Also, record the compass bearing and distance from the center of each island or satellite site to the campsite centerpoint. Replace the centerpoint stake with a 5 inch galvanized nail embedded so that its head is 3-4 inches below the ground surface.

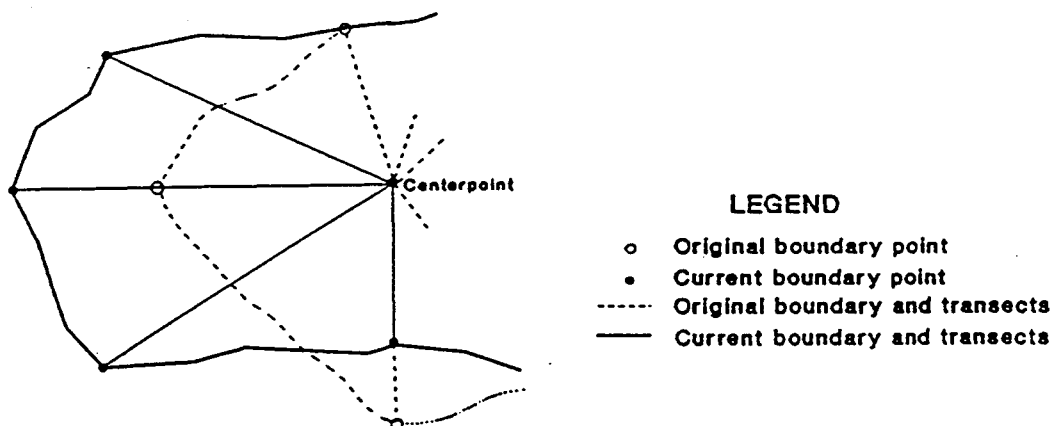
Site Remeasurement - Relocate the centerpoint using centerpoint references, photos, and a magnetic pin locator. Reestablish campsite boundary pins using the transect data compass bearings and distances. Reassess boundary pin locations based on the following procedures:

- 1) Keep the same transect length if that length still seems appropriate, ie. there is no compelling reason to alter the initial boundary determination.
- 2) Record a new transect length if the prior length is inappropriate, ie. 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.

- 3) Repeat Steps 1 and 3 from above to establish additional transects where necessary to accommodate any changes in the shape of campsite boundaries (diagram below). Also repeat Step 4.

These additional procedures are designed to eliminate much of the measurement error associated with different individuals making subjective judgements 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 above.

- 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 campsite boundaries using the coded categories listed below (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 vegetative 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 above. The control site should be similar to the campsite in slope, tree canopy cover (amount of sunlight penetrating to the forest floor), and other environmental conditions. The intent is to locate an area which would closely resemble the campsite area had the campsite 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 campsite 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 above.

- 21) Number of Trees with Damage: Tally each live tree (>1 inch diameter at 4.5 feet) within or on campsite boundaries to one of the tree damage rating classes described below (refer to the photographs following these procedures). Include trees within undisturbed "islands" and disturbed "satellite" areas. Multiple tree stems from the same species which 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 which are clearly not human-caused (eg. lightning strikes).

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).

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 which 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 which 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.

- 22) Number of Trees with Root Exposure: Tally each live tree (>1 inch diameter at 4.5 feet) within or on campsite boundaries to one of the root exposure rating classes described below. Include trees within undisturbed "islands" and disturbed "satellite" areas. Omit exposed roots which are clearly not human-caused (eg. stream/river flooding).

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.

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 which 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 which 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.

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

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 which 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 which 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 campsite boundaries. Do not count extremely faint trails which 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 campsite 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: 1=None or less than a handful, 2=Some - a handful up to enough to fill a standard 2 1/2 gallon bucket, 3=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 campsite. 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: 1=None, 2=Some - 1 to 3 sites evident, 3=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 campsite, suggestions for clarifying monitoring procedures, recommendations regarding site management, or any other comments.
- 29) Campsite Photograph: Select a good vantage point for viewing the entire campsite, preferably one of the campsite boundary flags, and take a picture of the campsite. 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 400 color print film and a 35mm wide angle lens is recommended). The intent is to obtain a photograph which includes as much of the site as possible to provide a photographic record of site conditions. It will also allow future workers to make a positive identification of the campsite. Record the film type and ASA (or DIN), focal length, and photo description, campsite 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 campsite picture, the center point location picture, and any others to a blank sheet of paper and attach to the campsite form.
- * Collect all campsite boundary pins, the centerpoint stake, and all other equipment.
- 30) Total Campsite Area: A computer program will be used to calculate campsite 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 Campsite Area.

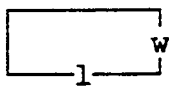
FORM B PROCEDURES

Refer to the procedures described above, all procedures are the same with the exception of campsite size. Measure campsite size using the Geometric Figure Method. Typically Class 1 and 2 campsites 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.

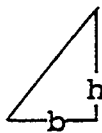
Geometric Figure Method

This method for determining the area of recreation sites, disturbed "satellite" sites, and interior undisturbed "island" sites is relatively rapid and can be quite accurate if applied with good judgement. 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.

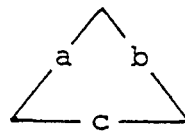
Good judgement is required in making the necessary measurements of each geometric figure. As boundaries will never perfectly match the shapes of geometric figures, you will have to mentally balance disturbed and undisturbed areas included and excluded from the geometric figures used. For example, in measuring an oval site with a rectangular figure, you would have to exclude some of the disturbed area along each side in order to balance out some of the undisturbed area included 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.



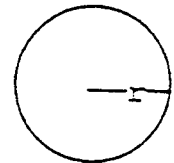
$$A = l \times w$$



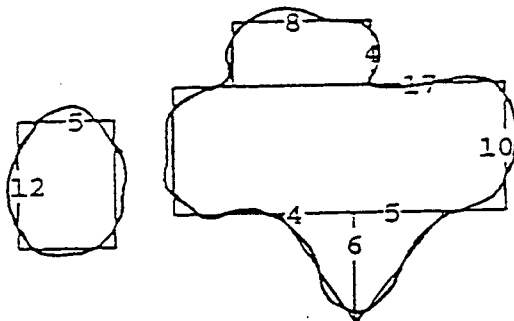
$$A = 0.5 \times b \times h$$



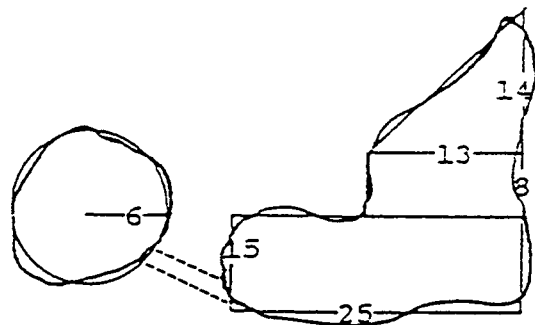
$$A = \frac{\sqrt{s(s-a)(s-b)(s-c)}}{s = 1/2(a+b+c)}$$



$$A = 3.14 \times r \times r$$



$$\begin{aligned} A &= (8 \times 4) + (17 \times 10) + (5 \times 12) + \\ &\quad (.5 \times 4 \times 6) + (.5 \times 5 \times 6) \\ A &= 289 \end{aligned}$$



$$\begin{aligned} A &= (.5 \times 13 \times 14) + (13 \times 8) + \\ &\quad (15 \times 25) + (3.14 \times 6 \times 6) \\ A &= 683 \end{aligned}$$

DELAWARE WATER GAP CAMPSITE MONITORING FORM A

- 1) Campsite Number: _____ 2) Site Name: _____
 3) Site Designation: (1=designated 2=undesignated) _____
 4) River Segment: (1=North Boundary-Milford Beach 2=Milford Beach-Dingman's
 3=Dingman's-Bushkill 4=Bushkill-Smithfield 5=Smithfield-South Boundary) _____
 5) Site Location: (1=Island 2=PA shoreline 3=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: (1=bedrock 2=cobble 3=sand 4=soil) _____
 11) Shoreline Disturbance: _____ ft.
 12) Height Above River: _____ ft.
 13) Number of Other Campsites 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: (1=clivus 2=pit toilet 3= none) _____

IMPACT PARAMETERS (Begin with Campsite 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: (1=None 2=Some 3=Much) _____
 27) Human Waste: (1=None 2=Some 3=Much) _____

28) Comments/Recommendations: _____

29) Take Center Point and Campsite Photographs

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

Manual revision date: 6/91

DELAWARE WATER GAP CAMPSITE MONITORING FORM B

- 1) Campsite Number: _____ 2) Site Name: _____
- 3) Site Designation: (1=designated 2=undesignated) _____
- 4) River Segment: (1=North Boundary-Milford Beach 2=Milford Beach-Dingman's
3=Dingman's-Bushkill 4=Bushkill-Smithfield 5=Smithfield-South Boundary) _____
- 5) Site Location: (1=Island 2=PA shoreline 3=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) Campsite Size _____ (ft²)
(Locate and label site on map, photograph site)

Manual revision date: 6/91

APPENDIX B

Listings for Large Designated Campsites and Undesignated Campsites

Listing of designated campsites greater than 2000 ft².

SITE #	RIVERSEG	SITELOC	CONDCLAS	TOTAREA
65	4	3	4	8316
50	3	2	4	6822
92	4	3	4	6362
24	2	1	4	6132
70	4	3	3	6032
94	4	3	4	3918
30	2	3	4	3899
67	4	3	3	3763
19	2	1	4	3708
62	4	3	4	3568
90	4	3	4	3394
91	4	3	4	3217
64	4	3	4	2793
86	4	3	4	2584
48	3	2	4	2507
58	4	3	4	2409
60	4	2	4	2407
41	3	2	4	2379
54	3	3	4	2196
108	5	1	3	2191
47	3	2	4	2114
39	3	1	4	2038
66	4	3	4	2013

Site # = 1991 campsite number, refer to river map for campsite locations.

Riverseg = River Segment: 1 = N. boundary - Milford Beach, 2 = Milford B. - Dingman's, 3 = Dingman's->Bushkill, 4 = Bushkill - Smithfield, 5 = Smithfield - S. boundary

Siteloc = Campsite Location: 1 = Island, 2 = PA shoreline, 3 = NJ shoreline

Condclas = Condition Class Rating

Totarea = Campsite Size (ft²)

Listing of all undesignated campsites.

SITE #	RIVERSEG	SITELOC	CONDCLAS	TOTAREA
9	1	2	4	3502
106	5	2	4	2858
114	5	1	4	1839
38	3	2	3	1581
107	5	1	3	660
116	5	2	3	774
2	1	3	2	782
3	1	3	2	406
5	1	3	2	202
6	1	3	2	280
10	2	3	2	528
12	2	3	2	368
14	2	3	2	28
28	2	3	2	804
22	2	2	2	143
40	3	3	2	314
57	4	2	2	346
76	4	2	2	120
84	4	2	2	255
102	4	2	2	450
115	5	2	2	120
13	2	1	1	154
23	2	3	1	64

Site # = 1991 campsite number, refer to river map for campsite locations.

Riverseg = River Segment: 1 = N. boundary->Milford Beach, 2 = Milford B.->Dingman's, 3 = Dingman's->Bushkill, 4 = Bushkill->Smithfield, 5 = Smithfield->S. boundary

Site loc = Campsite Location: 1 = Island, 2 = PA shoreline, 3 = NJ shoreline

Condclas = Condition Class Rating

Totarea = Campsite Size (ft²)



As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.