Appendix A. Inventory and Visitor Impact Monitoring System

Field Data Forms / 33
Description of Procedures / 36
Variable Radial Transect Method / 44
Geometric Figure Method / 45
Photographs / 46

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

Revision Date: 6/91

1) Recreation Site Number: ___________ 2) Site Name: ___________

3) Site Designation: (D=designated  U=undeveloped) ___________

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

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

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

7) Tag Tree  8) Inventoryed by: ____________ 9) Date: _ _ / _ _ / _ _
   (Locate and label site on map)

Inventory Parameters

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

11) Shoreline Disturbance: ___________ feet

12) Height Above River: ___________ feet

13) Number of Other Recreation Sites Visible: ___________

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

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

16) Toilet:  (C=clivus  P=pl toilet  N=none) ___________

Impact Parameters (Begin with Recreation Site Boundary Determination)

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

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

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

20) Soil Exposure: (Use categories above) ___________

21) Tree Damage: None/Slight ___________  Moderate ___________  Severe ___________

22) Root Exposure: None/Slight ___________  Moderate ___________  Severe ___________

23) Number of Tree Stumps: ___________

24) Number of Trails: ___________

25) Number of Fire Sites: ___________

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

27) Human Waste: (N=None  S=Some  M=Much) ___________
28) Comments/Recommendations: 

29) Take Centerpoint and Recreation Site Photographs

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<thead>
<tr>
<th>Recreation Site Centerpoint References</th>
<th>Site Photo</th>
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Recreation Site Area from Program ______
+ Satellite Area ______
- Island Area ______ =

30) Total Recreation Site Area ______ (sq. ft.)

21)                                               22)                                               23)
Delaware Water Gap Recreation Site Monitoring Form B

Manual revision date: 6/91

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

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

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

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

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

________________________________________

________________________________________

7) Tag Tree 8) Inventoried by ________________________ 9) Date __ __ / __ __ / __ __

17) Condition Class (1 or 2) _____ 30) Recreation Site Size _______ (ft²)

(Locate and label site on map, photograph site)
DESCRIPTION OF PROCEDURES

Manual Revision Date: 6/91
Contact Jeff Marion for updated versions: jmarion@vt.edu

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

<table>
<thead>
<tr>
<th>CONDITION CLASS DEFINITIONS</th>
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<tr>
<td><strong>Class 1</strong>: Recreation site barely distinguishable; slight loss of vegetation cover and/or minimal disturbance of organic litter.</td>
</tr>
<tr>
<td><strong>Class 2</strong>: Recreation site obvious; vegetation cover lost and/or organic litter pulverized in primary use areas.</td>
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<tr>
<td><strong>Class 3</strong>: Vegetation cover lost and/or organic litter pulverized on much of the site, some bare soil exposed in primary use areas.</td>
</tr>
<tr>
<td><strong>Class 4</strong>: Nearly complete or total loss of vegetation cover and organic litter, bare soil widespread.</td>
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<tr>
<td><strong>Class 5</strong>: Soil erosion obvious, as indicated by exposed tree roots and rocks and/or gullying.</td>
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For recreation sites rated Condition Class 1 or 2, complete Form B; for recreation sites rated Class 3, 4, or 5, complete Form A. Form B is an abbreviated version of Form A and greatly reduces the amount of field time. The rationale for this approach is that detailed information on lightly impacted recreation sites is not as critical to management.

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

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

General Site Information

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

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

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

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

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

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

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

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

9. **Date**: Month, day, and year the recreation site was evaluated (e.g., June 12, 1989 = 06/12/89).
10. **Substrate of Landing Area**: The landing area is defined as the area of human disturbance extending from average water level up to the beginning of the recreation site access trail. Use your best judgment concerning where average water level is. Record the predominant substrate for this area using the coded categories below:
- B = bedrock - shelf bedrock
- C = cobbles - includes gravel size stone and up
- S = sand - includes sandy beach soils that do not form a surface crust in trampled areas
- O = soil - includes clays to loamy sands

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

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

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

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

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

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

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

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

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

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

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

Options: Some sites may lack the necessary permanent reference features enabling the centerpoint to be accurately relocated. If only one or two permanent reference features are available, use these and take additional photographs from several angles. If permanent features are unavailable, simply proceed with the remaining steps without permanently referencing the centerpoint. This option will introduce more error in comparisons with future measurements, particularly if the recreation site boundaries are not pronounced. Note your actions regarding use of these options in the Comments section.
Step 3. **Record Transect Azimuths and Lengths.** Standing directly over the centerpoint, identify and record the compass bearing (azimuth) of each recreation site boundary pin working in a clockwise fashion (in the exact order you would encounter them if you were walking the recreation site boundary). Be careful not to miss any pins hidden behind vegetation or trees. **Be extremely careful in identifying the correct compass bearings to these pins as error in these bearings will bias current and future measurements of recreation site size.** Next, anchor the end of your tape to the centerpoint stake, measure and record the length of each transect (nearest 1/10 foot), starting with the same boundary pin and in the same clockwise order as before. **Be absolutely certain that the appropriate pin distances are recorded adjacent to their respective compass bearings.** Leave boundary pins in place until you finish all other recreation site measurements.

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

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

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

These additional procedures are designed to eliminate much of the measurement error associated with different individuals making subjective judgments on those sites or portions of sites where boundaries are not pronounced. These procedures may only be used for sites whose centerpoints can be relocated.
17. **Condition Class**: Record the Condition Class you assessed for the site using the categories described earlier.

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

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

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

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

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

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

- **None/Slight**: No or slight damage such as broken or cut smaller branches, one nail, or a few superficial trunk scars.
- **Moderate**: Numerous small trunk scars and/or nails or one moderate-sized scar.
- **Severe**: Trunk scars numerous with many that are large and have penetrated to the inner wood; any complete girdling of tree (cutting through tree bark all the way around tree).
22. **Root Exposure:** Tally each live tree (>1 in. diameter at 4.5 ft.) within or on recreation site boundaries to one of the root exposure rating classes described below. **Include trees within undisturbed "islands" and exclude trees in disturbed "satellite" areas.** Assessments are restricted to all trees within the flagged recreation site boundaries in order to ensure consistency with future measurements. Where obvious, omit exposed roots that are clearly not human-caused (e.g., stream/river flooding).

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

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

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

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

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

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

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

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

28. **Comments:** An informal list of comments concerning the site: note any assessments that you felt were particularly difficult or subjective, problems with monitoring procedures or their application to this particular recreation site, suggestions for clarifying monitoring procedures, recommendations regarding site management, or any other comments.
29. **Recreation Site Photograph:** Select a good vantage point for viewing the entire recreation site, preferably one of the recreation site boundary flags, and take a picture of the recreation site. Note the compass bearing and distance from the centerpoint to the photo point and record in the space indicated on the back of the form (ASA 200 color print film and a 35mm wide angle lens is recommended). The intent is to obtain a photograph that includes as much of the site as possible to provide a photographic record of site conditions. The photo will also allow future workers to make a positive identification of the recreation site. Record the film type and ASA (or DIN), and photo description, recreation site number, and focal length in the photo log. At the earliest possible date label the backs of 3x5 prints with this information; also store and label the negatives. Staple the recreation site picture, the centerpoint location picture, and any others to a blank sheet of paper and attach to the recreation site form.

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

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

**Form B Procedures**

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

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

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

Step 3. Record Transect Azimuths and Lengths. Standing directly over the centerpoint, identify and record the compass bearing (azimuth) of each site boundary pin working in a clockwise fashion (in the exact order you would encounter them if you were walking the site boundary). Be careful not to miss any pins hidden behind vegetation or trees. Be extremely careful in identifying the correct compass bearings to these pins as error in these bearings will bias current and future measurements of site size. 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 site measurements.

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

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

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

![Geometric figures and their area calculations](image)

\[
A = 1 \times w \quad A = 0.5 \times b \times h \quad A = 3.14 \times r \times r
\]

\[
A = (8 \times 4) + (17 \times 10) + (5 \times 12) + (0.5 \times 4 \times 6) + (0.5 \times 5 \times 6)
\]

\[
A = 289
\]

\[
A = (0.5 \times 13 \times 14) + (13 \times 8) + (15 \times 25) + (3.14 \times 6 \times 6)
\]

\[
A = 683
\]
SITE BOUNDARIES

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

Yellow triangles indicate flagged pin locations which delineate site boundaries.

Site boundaries determined by pronounced changes in vegetation cover.

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

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

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

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

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

As organic litter is pulverized and eroded from sites the remaining materials often clump together, resulting in a patchwork of organic litter and bare soil which is difficult to evaluate. If patches of organic material are relatively thin and few in number, as illustrated in the photo above, the entire area should be assessed as bare soil. Otherwise, the patches of organic litter should be mentally combined and excluded from assessments.
NONE/SLIGHT: No or slight damage such as broken or cut smaller branches, 1 nail, or a few superficial trunk scars.

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

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

NONE/SLIGHT: No or slight root exposure such as is typical in adjacent offsite areas.
MODERATE: Top half of many major roots exposed more than 1 foot from base of tree.
SEVERE: Three-quarters or more of major roots exposed more than 1 foot from base of tree; soil erosion obvious.
Appendix B.
Data Analysis and Standards
Data Analysis and Standards

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

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

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

Percentiles

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

Using percentiles has several disadvantages, however. First, because percentiles are computed using only the ranks of the measured impact values, the relative “distances” between the original values are lost. To illustrate, consider the area of soil exposure for two pairs of campsites in Table 1. Soil exposure on site 3 is 2 ft² more than on site 2; the difference in percentiles is 4. Soil exposure on site 21 is 848 ft² more than on site 20, but the difference in percentiles is only 5. Dramatic and managerially important changes in resource conditions will be missed if percentiles are used for comparing amount of change. Their use should be restricted to ranking sites and for determining the percentage of sites below or above a specified rank. Percentiles also begin to “lose” information when the number of unique values for an impact parameter exceeds 100. When this happens, sites with different values are combined into common categories and given the same percentile rank.
Table 1. Two standardized measures computed from soil exposure measurements taken on 21 wilderness campsites in the Jefferson National Forest.

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Exposed Soil Actual (ft³)</th>
<th>Percentile</th>
<th>Z-Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31</td>
<td>5</td>
<td>-0.83</td>
</tr>
<tr>
<td>2</td>
<td>110</td>
<td>10</td>
<td>-0.71</td>
</tr>
<tr>
<td>3</td>
<td>112</td>
<td>14</td>
<td>-0.71</td>
</tr>
<tr>
<td>4</td>
<td>119</td>
<td>19</td>
<td>-0.69</td>
</tr>
<tr>
<td>5</td>
<td>127</td>
<td>23</td>
<td>-0.68</td>
</tr>
<tr>
<td>6</td>
<td>145</td>
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<td>-0.65</td>
</tr>
<tr>
<td>7</td>
<td>216</td>
<td>32</td>
<td>-0.54</td>
</tr>
<tr>
<td>8</td>
<td>236</td>
<td>37</td>
<td>-0.51</td>
</tr>
<tr>
<td>9</td>
<td>273</td>
<td>41</td>
<td>-0.46</td>
</tr>
<tr>
<td>10</td>
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<td>46</td>
<td>-0.43</td>
</tr>
<tr>
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<td>512</td>
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<td>960</td>
<td>82</td>
<td>0.60</td>
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<tr>
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<td>1096</td>
<td>87</td>
<td>0.82</td>
</tr>
<tr>
<td>20</td>
<td>1841</td>
<td>91</td>
<td>1.97</td>
</tr>
<tr>
<td>21</td>
<td>2689</td>
<td>96</td>
<td>3.28</td>
</tr>
</tbody>
</table>

Z-scores

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

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

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

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

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

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Site Size</th>
<th>Exposed Soil</th>
<th>Vegetation Loss</th>
<th>Damaged Trees</th>
<th>Shoreline Disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.95</td>
<td>-1.23</td>
<td>0.12</td>
<td>1.33</td>
<td>1.87</td>
</tr>
<tr>
<td>2</td>
<td>-0.04</td>
<td>-0.65</td>
<td>-0.71</td>
<td>0.27</td>
<td>0.09</td>
</tr>
<tr>
<td>3</td>
<td>2.03</td>
<td>1.95</td>
<td>1.45</td>
<td>2.51</td>
<td>1.27</td>
</tr>
</tbody>
</table>


Marion, Jeffrey L. 1991. Results from the application of a campsite inventory and impact monitoring system in eleven wilderness areas of the Jefferson National Forest. U.S. Department of Interior, National Park Service, Cooperative Park Studies Unit, Virginia Tech, Department of Forestry, Blacksburg, Virginia. 73 pp.


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 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.