

**APPENDIX I.**  
**Campsite Impact Assessment and Monitoring Manual**

# Campsite Impact Assessment and Monitoring Manual Great Smoky Mountains National Park

## *Description of Procedures*

For the purposes of this manual, campsites are defined as backcountry areas of disturbed vegetation, surface litter, or soils caused by overnight camping, although some day-use activities may also occur in the area. Both legal and illegal campsites are to be surveyed. Legal or designated campsites typically include more than one individual site, these will be distinguished by coding each site with a decimal point and additional three digit numbers as described under parameter 4 on page 2 of this manual. In areas with multiple sites there may not always be undisturbed areas between sites and an arbitrary decision may be necessary to define separate sites.

Three approaches will be used to assist in locating illegal campsites: 1) discussions with experienced backcountry rangers to identify potential camping areas, 2) hiking all park trails, however faint, and 3) searching areas identified on maps as likely camping locations (areas with low slopes, near water, or formal park trails).

For each site, monitoring begins with an assessment of Condition Class:

CONDITION CLASS DEFINITIONS	
<b>Form B</b>	
<b>Class 1:</b>	Campsite barely distinguishable; slight loss of vegetation cover and /or minimal disturbance of organic litter.
<b>Class 2:</b>	Campsite obvious; vegetation cover lost and/or organic litter pulverized in primary use areas. No bare soil other than fire scars.
<b>Form A</b>	
<b>Class 3:</b>	Vegetation cover lost and/or organic litter pulverized on much of the site, some bare soil exposed in primary use areas.
<b>Class 4:</b>	Nearly complete or total loss of vegetation cover and organic litter, bare soil widespread.
<b>Class 5:</b>	Soil erosion obvious, 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. Be conscientious in making Condition Class determinations. Do not allow the additional effort required by Form A procedures to influence your decision making!

**Materials:** Compass, peephole type (not corrected for declination)  
USGS topographic maps (1:24,000)  
Tape measure, 100 foot (marked in tenths)  
Flagged wire pins (25 minimum), one larger steel centerpoint stake  
Camera, 35mm SLR, 35mm lens and ASA 1000 color print film (store in freezer until used)  
Aluminum numbered tags, 4 inch galvanized steel nails  
Clipboard, monitoring manual, field forms (some on waterproof paper), pencils  
Magnetic pin locator (remeasurement only)  
Clinometer

*Form A Procedures*

**General Site Information**

1) Ranger Subdistrict: Refer to the park map and record the Ranger Subdistrict code:

AC	Abrams Creek	CC	Cades Cove
LR	Little River	LK	Lake
CB	Cosby OL	Oconaluftee	
CT	Cataloochee		

2) Maintenance Subdistricts: Refer to the park map and record the Maintenance Subdistrict code:

CC	Cades Cove	TM	Twentymile
LR	Little River	DC	Deep Creek
CB	Cosby OL	Oconaluftee	
CT	Cataloochee		

3) Park Trail Section: Office: Refer to the mapped Bratton study Trail Section's and record the correct number.

1	Appalachian Trail	6	LeConte	11	Forney Creek
2	Abram's Creek (west of #3)	7	Cosby	12	Deep Creek
3	Cades Cove	8	Boundary Trail	13	Smokemont
4	Tremont 9	Twenty Mile		14	Heintooga
5	Elkmont 10	Hazel Creek		15	Cataloochee
		16			Big Creek

4) Trail Code: Refer to the Trail Code Sheet and record the code for the closest formal park trail. In areas with two or more trails, record the trail which is most likely the primary source of use for the site, as evidenced by proximity or the most clearly defined access trail.

5) Campsite Number: Each site is to be numbered consecutively corresponding to numbered aluminum tags which will be buried at the campsite centerpoint. The tags are numbered 1000 through 2000 but we will use only the last three digits (ie. 001-999). For legal sites record the park campsite number, a decimal point, and the three digit campsite number (ie. 28.002 for one of the sites at campsite 28). For illegal sites record a 0, a decimal point and the three digit campsite number (ie. 0.002). When sites are reassessed, examine the mapped locations and field forms to determine if each site was present during the previous survey. Relocate campsite centerpoints with centerpoint references and the pin locator and verify campsite numbers by digging up the campsite number tags. Replace any missing tags and centerpoint nails only if you are absolutely certain of the campsite number and centerpoint location. Number new sites with any unique number larger than those used in previous surveys.

6) Inventoried by: Identify the one or two field personnel responsible for site assessment by listing the first initials of first and last names.

7) Date: Month, day, and year the campsite was evaluated (eg. June 12, 1993 = 06/12/93).

Site remeasurement - Due to phenological and site use changes which occur over the use season, it is critical that campsites be remeasured as close to the initial assessment month and day as possible, preferably within 1 to 2 weeks.

8) Campsite Location:

**Locate/Label Site on Map** - Mark the quad sheet with a dot precisely where the campsite is located and label with the campsite number. Draw a short line to the label in areas with a high density of campsites. Be as accurate as possible and supplement the quad map where necessary with either copier enlargements (note enlargement percentage) of the quad (for high density areas) or hand-written area maps.

Note that 1/4 inch on the map is equal to 500 feet on the ground.

**Describe Location** - Describe the campsite location using local geographic features (trail intersections, stream crossings, large boulders or trees) and paced distances. Record the distance of your pace in parentheses, for example:

18 paces (5.5'), each time you record a paced distance. Conversions will be done by computer. Verify your pace periodically. Accurate campsite location descriptions are critical to site relocation. Use sufficient descriptive detail and additional local area maps as necessary so that someone else five years later could relocate the site (see example at end of manual). When Global Positioning System (GPS) devices become available to the park it is recommended that the positions of all campsites be established and included in the park's Geographic Information System. This new technology will also significantly aid in relocating and tracking individual campsites over time.

**USGS Quad Code** - Record the code (following page) for the quad sheet on which the site is located:

BL	Blockhouse	GA	Gatlinburg	SI	Silers
BC	Bryson City	HA	Hartford	SM	Smokemont
BB	Bunches Bald	JC	Jones Cove	TA	Tapoco
CC	Cades Cove	KS	Kinzel Springs	TH	Thunderhead
CA	Calderwood	LK	Luftee Knob	TU	Tuskegee
CD	Clingman's Dome	MG	Mt. Guyot	WA	Waterville
CO	Cove Creek	ML	Mt. LeConte	WC	Wear Cove
DE	Dellwood	NC	Noland Creek	WH	Whittier
FO	Fontana RC		Richardson Cove		

### Inventory Parameters

- 9) Intersite Visibility: Record the number of other campsites in the area, which, if occupied, would be visible from the campsite. This is a social variable to assess site intervisibility, i.e., how visible are sites from each other. This information might be used to assess where visitors might experience solitude or camp with other visitors in a more social setting.
- 10) Aspect: Aspect is important in relation to solar radiation and the site's microclimate. With your back facing upslope, sight your compass downslope, perpendicular to the contour, and record the compass bearing on the form. When using the compass, avoid proximity to iron and steel objects.
- 11) Elevation: Elevation is important in relation to length of growing season, rainfall, and microclimate factors. From the map, determine the campsite's elevation to the nearest 40 feet. Note that each contour line is equal to 40 feet. If an altimeter is available, verify your determination. Altimeters respond to changes in barometric pressure and must be calibrated every few hours at known elevations such as an identifiable stream crossing or high point.
- 12) Site Position: Examine the map, relative to the ridge or mountain upon whose slope the campsite is located, record an "F" for "Foot" if the campsite is at the base of the slope along a permanent or intermittent stream, record a "U" for "Upper Slope" if the campsite is at or near the top of the slope (within 1/2 mile, 1 5/16 inch map distance). Record an "M" for "Midslope" for all others.
- 13) Distance to Formal Trail: Pace the distance, along a footpath if present, to the nearest formal park trail and record the number of paces. If over a 5 minute walk record a "-1".
- 14) Distance to Water: Using the following categories, indicate the distance from the closest boundary of the campsite to the closest water source:  
1=<25 ft 2=26-100 ft 3=101-200 ft 4=>201 ft
- 15) Water Source: Using the following codes, indicate the type of water source:  
S=Spring C=Creek/River I=Intermittent N=None within a 5 minute walk
- 16) Tree Species: Identify the campsite's dominant tree species (not individual tree) based on the extent of coverage (shading) of the ground within campsite boundaries. Use the tree identification references provided and list the common name on the form; codes will be developed and used for data entry following the field season. If you are unable to determine the specific species list the general group of trees i.e. pine, oak, or walnut.

- 17) Tree Canopy Cover: Estimate the percentage of tree canopy cover directly over the campsite. Imagine that the sun was directly overhead. What portion of the ground within campsite boundaries would be shaded by the current tree canopy? Code as shown below:  
 1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%
- 18) Campsite Expansion: Evaluate the adjacent off-site areas for their potential to restrict campsite expansion. Code as:  
 1=High expansion potential: site could easily expand, few constraining factors, 2=Moderate expansion potential: off-site areas moderately unsuitable for expansion due to steep slopes, rockiness, dense vegetation, and/or poor drainage, 3=Poor expansion potential: off-site areas are completely unsuitable for any expansion due to the factors listed above.
- 19) Campsite Slope: Use the clinometer to identify the "average" slope of the campsite. Pick a transect across the campsite which runs perpendicular to the slope and is "typical" of the campsite's general slope. Position your partner near the boundary at either the high or low end of the transect and yourself at the opposite end. Sight on a feature of your partner that is the same height above ground as your eyes. Read and record the percent slope on the form as a positive number.

## Impact Parameters

Assessment of site impacts begins with establishing the campsites' boundaries and measuring its size. For sites with shelters, refer to the Shelter Assessment Procedures at the end of this manual. The following procedures describe the use of the **Variable Radial Transect Method** for determining the sizes of campsites only. 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.

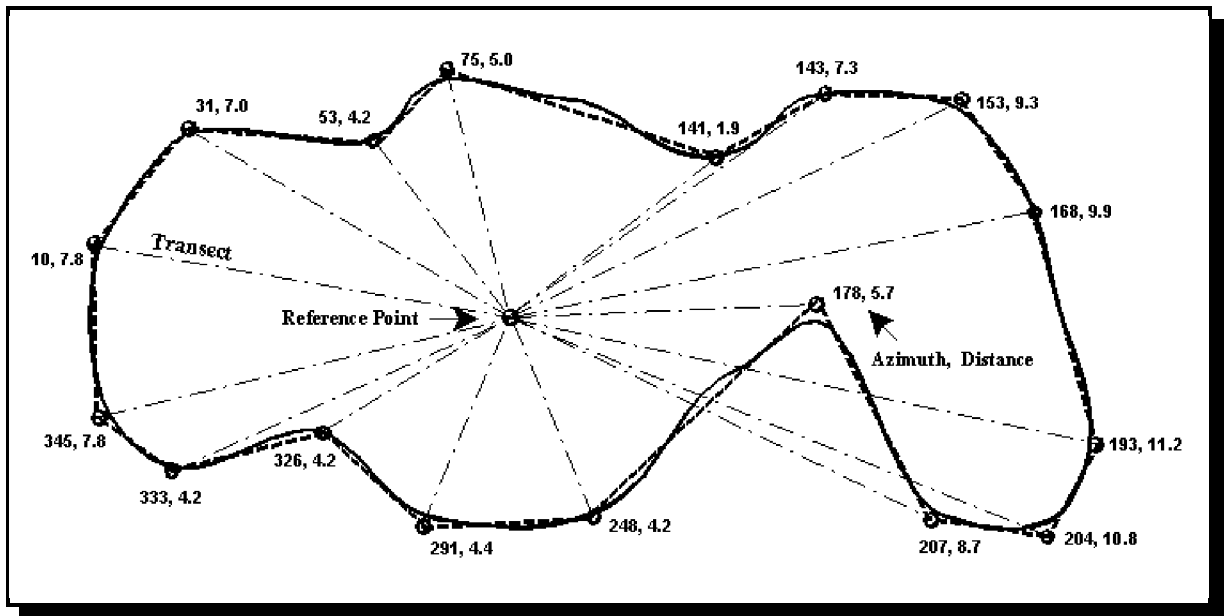
Step 2. Select and Reference Campsite Centerpoint. Select a campsite centerpoint that is preferably: a) visible from all the campsite boundary pins, b) close to and easily referenced by distinctive permanent features such as larger trees or boulders, and c) in a spot permitting the burial of the centerpoint nail and campsite tag. Embed a temporary 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.

Step 5. Soil Exposure Assessments. Exposed soil is 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, the decomposed product of organic litter, should be assessed as bare soil when its consistency resembles peat moss. Assessments of soil exposure may be difficult when organic litter 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 excluded from assessments.

a) If the campsite and satellite site(s) has one or more small areas of exposed soil use the **Geographic Figure Method** to determine their individual areas. This method involves superimposing one or more imaginary geometric figures (rectangles, circles, or triangles) on bare soil boundaries and measuring appropriate dimensions to calculate their areas

(refer to the diagrams following these procedures). 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.

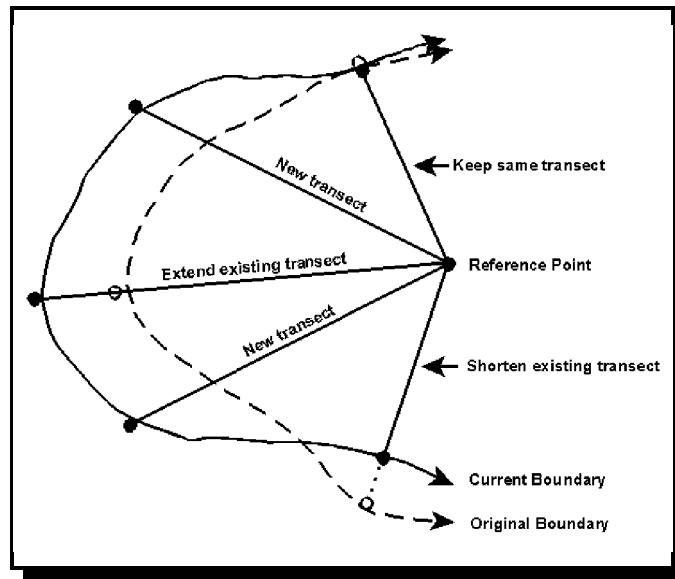
b) If the campsite has a large central core of exposed soil, use the **Variable Radial Transect Method** by repeating Step 1 to identify boundary points for this area. Repeat Step 3 to record transect lengths and bearings, and record data on the back of the form. If there are patches of organic soil within this core bare soil area they should be measured using the Geographic Figure Method; record their dimensions on the back of the form and label them "organic soil, subtract". Also, measure and record the dimensions of any additional exposed soil areas outside the core area but within campsite or satellite site boundaries.

Remove the centerpoint stake. Place a 4 inch long galvanized steel nail through the hole in the campsite number tag and bury at the centerpoint so that the tag is 2-3 inches underground.

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.



**Use of Peep Hole Compasses** Hold the compass level with the viewfinder close to your eye. The calibrated white floating scale should be kept level and in the bottom 1/3rd of the viewfinder. With your chin over the centerpoint, align the sighted object with the vertical black line in the center of the viewfinder. Allow the compass scale to come to a rest and read the bearing from the larger bottom set of numbers to the nearest degree. Be careful in reading the bearing from the scale, note that scale values decrease from left to right. Large scale interval is 5 degrees, smallest interval is 1 degree.

Practice and periodically compare compass readings with your partner by standing about 20 feet apart and sighting on each other's nose (one partner should read backazimuth bearings, the upper scale in the viewfinder). Compare your bearings to verify their accuracy. Beware that glasses, watches, and other metal objects may affect the compass. Our goal is to consistently achieve readings within one degree of each other.

- 20) Condition Class: Record the Condition Class you assessed, categories on front cover of manual.
- 21) 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 vegetation cover is either category 2 (6-25%) or category 3 (26-50%), you can simplify your decision by focussing on whether vegetative cover is greater than 25%.
- 1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%
- 22) Graminoid Cover Onsite: Follow the procedures for parameter 21 but assess only the coverage of grasses and sedges combined within campsite boundaries.
- 23) Vegetative Ground Cover Offsite: An estimate of the percentage of live non-woody vegetative ground cover (including herbs, grasses, and mosses and excluding tree seedlings, saplings, and shrubs) 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.
- 24) Graminoid Cover Offsite: Follow the procedures for parameter 22 but assess only the coverage of grasses and sedges combined.
- 25) Soil Exposure: A second assessment to permit an evaluation of two methods, direct measurement and categorical estimate, of assessing soil exposure, previously defined in Step 5 of the Variable Radial Transect Method procedures. This second method involves estimating the percentage of soil exposure within the campsite and satellite use area boundaries. Code as for vegetative cover above.
- 26-28) Tree Damage: Tally each live tree (>1 in. diameter at 4.5 ft.) 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 exclude trees in disturbed "satellite" areas. Assessments are restricted to all trees within the flagged campsite boundaries in order to ensure consistency with future measurements. 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. Where obvious, assess trees with scars from natural causes (e.g., lightning strikes) as None/Slight.
- 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.

- 29-31) Root Exposure: Tally each live tree (>1 in. diameter at 4.5 ft.) within or on campsite 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 campsite boundaries in order to ensure consistency with future measurements. Where obvious, assess trees with roots exposed by natural causes (e.g., stream/river flooding) as None/Slight.

**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.

- 32) Number of Tree Stumps: A count of the number of tree stumps (> 1 in. diameter at ground and less than 4.5 feet tall) within or on campsite boundaries. **Include trees within undisturbed "islands" and exclude trees in disturbed "satellite" areas.** Do not include windthrown trees with their trunks still attached or 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.

- 33) 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, always count questionable sites that are within site boundaries.

- 34) 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. Also do not count branches of trails that form outside campsite boundaries.

- 35) Human Waste: Conduct a quick search of likely "toilet areas" in adjacent off-site areas. Count the number of individual human waste sites: N=None, S=Some - 1 to 3 sites evident, M=Much - 4 or more sites evident.

- 36) Litter/Trash: Evaluate the amount of litter/trash within or easily visible from campsite boundaries: 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.

- 37) Total Campsite Area: Using the dBASE computer program, compute the campsite and exposed soil areas using the transect data. Using a calculator, compute and sum the area of each island, satellite, and exposed soil areas (see the Geometric Figure Method sheet for procedures and formulas). Record these values in the spaces provided on the back of Form A and calculate the Total Campsite Area. Record this value on the front of the form to facilitate computer data entry.

**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, descriptions of particularly significant impacts such as excessive litter, human waste, or horse impacts, or any other comments you feel may be useful.

**Campsite/Centerpoint Photograph:** Select a vantage point which provides the best view of the campsite and centerpoint location. Try to select a location which clearly shows the centerpoint location in relation to nearby trees or boulders. It may be necessary to take a separate centerpoint photograph in some instances. Place the tape measure against the centerpoint stake so that it is clearly visible in the camera viewfinder. Take a picture, pointing the camera down to include as much of the campsite groundcover as possible. Use the photo description space to write something unique about the photo which will allow you to recognize and label the photo for this campsite. Record the film roll and photo number(s) in the space provided. Label film rolls with your initials followed by a unique roll number. Also record the compass bearing and distance from the centerpoint to the photopoint. The intent is to obtain a photograph which 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 campsite and assist in centerpoint location. At the earliest possible time, label the backs of 3x5 prints with the campsite number and date, also label and store the negatives.

\* **If you haven't done so, bury the centerpoint nail and tag between 2-3 inches deep and compact the soil above it. Collect all campsite boundary pins, the centerpoint stake, and all other equipment.**

### *Form B Procedures*

This form is to be completed only for campsites rated as Condition Class 1 or 2, in place of Form A. Refer to the procedures described above for all parameters, with the following exceptions:

- ! Measure campsite size using the Geometric Figure Method (see instruction sheet at back of manual). Typically Class 1 and 2 campsites are quite small in size and this method should be both efficient and accurate. Record the types of figures used and all necessary dimensions on the back of the form. Total campsite area will be computed and recorded in the office.
- ! Bury the centerpoint nail and campsite number tag at the center of the site or near any distinctive features. Do not reference the centerpoint with compass bearings and distances. Do include centerpoint, location indicated by tape measure, in campsite photo.

### Legal Campsite Summary Form Procedures

This form is to be completed once for each numbered backcountry campsite following all individual site assessments. Refer to the procedures described above for parameters 1-8. Procedures for additional parameters are described below.

Campsite/Shelter Description Describe the following campsite characteristics:

**General Location** - relative to stream, trail, or other features

**Topography** - describe topographic features and slope

**Vegetation** - describe vegetation including type, structure (overstory, understory, groundcover), and density

**Soil** - describe the soil substrate (texture and stoniness)

**Shelter** - describe capacity, fencing, and other site facilities (fire places, hitching racks, bear poles or lockers, toilet)

**Impact** - describe the number of sites and the most significant types of impact

**Shelter Site Description Example:** This shelter site is located within sight of the trail with a stream approximately 50 yards behind the shelter. The area is generally level but slopes off more steeply near the stream. The forest is quite mature with mostly 2-4 foot diameter trees and a dense canopy. In adjacent offsite areas the understory is poorly developed with few small trees or shrubs. Groundcover vegetation is typically 10-25 percent. The soil texture is loamy with few stones evident. The three-sided shelter has a fence across the front and has 8 bunks with an inside fireplace. There is also an 8 foot hitching rail about 100 feet from the front of the shelter. No other legal sites were in the vicinity.

There is extensive exposed soil and some significant erosion in front of the shelter, in the horse hitching rail area, and on the stream embankments. There were also a large number of stumps in the area (54) and substantial damage to trees.

Comments/Recommendations List any additional comments on problems or clarifications applying assessment procedures, personal comments about the site, and personal recommendations about whether the site is good or bad or what might be done to better manage the site or minimize impacts.

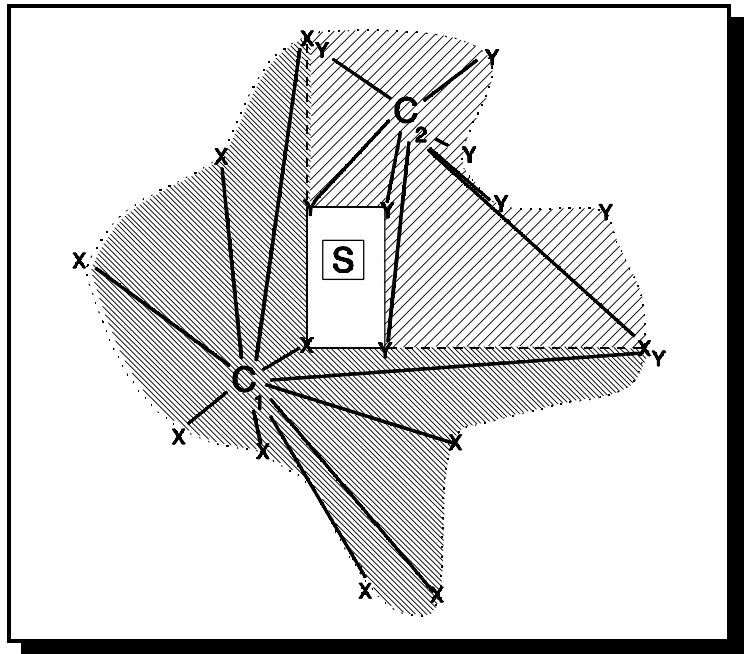
- 9) Tree Damage: Apply the same procedures and criteria used for assessing campsite trees to trees in adjacent offsite areas in the vicinity of the campsites you assessed individually. Walk through the entire area and tally trees with moderate and severe damage separately, do not include trees with no or slight damage. Limit your search to adjacent areas where individuals using this particular campsite would typically go to obtain firewood; do not conduct intensive searches far away from the area. Try your best to not double-count damaged trees which you assessed within or on campsite boundaries; however, include damaged trees in any satellite use areas (these should not have been included in campsite tree damage assessments).
- 10) Number of Tree Stumps: Apply the same procedures and criteria used for assessing campsite tree stumps to adjacent offsite areas. Follow search procedures and other recommendations as described above for tree damage. Conduct both searches simultaneously.
- 11) Number of Trails from Formal Trail to Campsites/Shelter: Walk the formal park trail(s) and count all easily recognizable campsite/shelter access trails. Some of these trails may join or split before reaching the campsite. This is unimportant. Record the number of trails leaving the formal trail(s).
- 12) Horse Use: Record the appropriate code: N=Horse use not permitted H=Horse use permitted
- 13) Toilet: Code as shown: N=None P=Pit toilet in the area
- 14) Firewood Availability: Looking offsite from campsite boundaries, code the amount of down and dead firewood (3-5 inch in size) as:  
N=None L=Very Little S=Some M=Much
- 15) Food Storage: Code as shown: B=Bearpoles S=Storage Lockers T=Suitable Trees N=Food Storage Needed

Campsite Area Map: Use the back of this form to sketch a map showing the location of each separate site in the area. Begin with the most heavily used core site and reference any other sites by recording the distances (measured or paced) and compass bearings from the centerpoint of this site to the centerpoints of all others. Label all sites with their site tag numbers. Also include the distance and bearing from the campsite sign or other more permanent and obvious feature to the centerpoint of the core site. Sketch in other features such as streams and steep slopes where appropriate.

**Comment:** Readers are referred to Marion (1991, pp. 46-51) for photographs illustrating campsite boundaries, boundary flag placement, vegetative ground cover classes, soil exposure, tree damage, and root exposure. These photographs are part of this manual to further assist field staff in making impact assessments. They are omitted here to conserve report production expenses as many are color photos that do not reproduce well in black and white.

## Shelter Assessment Procedures

The Variable Radial Transect Method must be modified for assessing shelter sites. Three separate areas must be measured and combined: two areas ( $C_1$  and  $C_2$ ) that are assessed with a modified variable radial transect method, and one area (S) that accounts for the shelter and is assessed with the geometric figure method. Figure 1 illustrates how these methods are applied to a typical shelter site. Unless specifically addressed below, procedures follow those described earlier for the standard Variable Radial Transect Method. A Shelter Assessment Form has been prepared for recording the following measurements.



**Figure 1.** Modified variable radial transect method applied to a shelter site. Note that three areas are measured ( $C_1$ ,  $C_2$ , and S).

**Step 1** Identify site boundaries and flag transect endpoints. Define the shelter site boundary with flags.

**Step 2** Select and reference two centerpoints.

Shown in Fig. 1 as points  $C_1$  and  $C_2$ , these centerpoints must be at least 8 feet from the shelter and firepit(s) so that magnetic interference will not affect the compass or magnetic pin locator. Each centerpoint will

account for the area on two sides of the shelter. However, note that the area for  $C_1$  will have two boundaries which parallel the shelter sides and extend out to the campsite boundary. Center point  $C_1$  should be permanently referenced with a nail with an aluminum tag, as on campsites. The other centerpoint,  $C_2$ , should be referenced only with a nail. Both centerpoints must be independently referenced to 3 permanent features and no more than one reference point should be a corner of the shelter in case it is moved or rebuilt in the future. Ideally the tagged centerpoint should be in the rear of the shelter to reduce the possibility that it may be discovered and removed by a visitor.

**Step 3** Establish boundary "joint" flags. Two additional flags must be placed on the boundary where the two figures "join" (shown as flags  $X_y$  in Fig. 1). These flags are aligned with the two shelter walls that bound the area associated with centerpoint  $C_1$ . Position the flags by standing on the boundary and sighting along each wall so that a straight line can be visualized that would connect the boundary to the near corner and on through to the far corner (i.e.,  $X_y$  to  $Y$  to  $X$ ).

**Step 4** Record transect azimuths and lengths. As for campsites, stand over the centerpoints and record the azimuth (bearing) and distance to each flag on the perimeter and to the relevant corners of the shelter (refer to Fig. 1). The  $C_1$  area will include a transect to 1 shelter corner; the  $C_2$  area will contain reference to each of the remaining three shelter corners.

**Step 5** Record the area of the shelter. The shelter is a rectangle with an area equal to the length of the long side multiplied by the length of the short side. Measure and record these two lengths.

Any modification of these procedures that may be necessitated by a unique shelter configuration must be noted clearly.

# Campsite Monitoring Form A: Great Smoky Mountains National Park

## General Site Information

- 1) Ranger Subdistrict \_\_\_\_\_ 2) Maintenance Subdistrict \_\_\_\_\_ 3) Trail Section \_\_\_\_\_  
 4) Trail Code \_\_\_\_\_ 5) Campsite No. \_\_\_\_\_ 6) Inventoried by \_\_\_\_\_  
 7) Date \_\_/\_\_/\_\_ 8) USGS Quad Code \_\_\_\_\_ Locate/Label Site on Map \_\_\_\_\_  
 Describe Location \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

## Inventory Parameters

- 9) Intersite Visibility \_\_\_\_\_  
 10) Aspect \_\_\_\_\_  
 11) Elevation \_\_\_\_\_ ft  
 12) Site Position (F=Foot M=Midslope U=Upper Slope) \_\_\_\_\_  
 13) Distance to Formal Trail (Code as -1 if over 5 min. walk) (1 pace = \_\_\_\_\_ ft) \_\_\_\_\_ paces  
 14) Distance to Water (1=<25 ft 2=26-100 ft 3=101-200 ft 4=>201 ft) \_\_\_\_\_  
 15) Water Source (S=Spring C=Creek/River I=Intermittent N=None= > 5 min. walk) \_\_\_\_\_  
 16) Tree Species: Common Name \_\_\_\_\_  
 17) Tree Canopy Cover (Use categories below) \_\_\_\_\_  
 18) Campsite Expansion (1=High 2=Moderate 3=Poor) \_\_\_\_\_  
 19) Campsite Slope \_\_\_\_\_ %

## Impact Parameters -- Apply Variable Radial Transect Method First --

- 20) Condition Class (3, 4, or 5) \_\_\_\_\_  
 21) 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%)  
 22) Graminoid Cover Onsite (Use categories above) \_\_\_\_\_  
 23) Vegetative Ground Cover Offsite (Use categories above) \_\_\_\_\_  
 24) Graminoid Cover Offsite (Use categories above) \_\_\_\_\_  
 25) Soil Exposure (Use categories above) \_\_\_\_\_  
 26-28) Tree Damage None/Slight \_\_\_\_\_ Moderate \_\_\_\_\_ Severe \_\_\_\_\_  
 29-31) Root Exposure None/Slight \_\_\_\_\_ Moderate \_\_\_\_\_ Severe \_\_\_\_\_  
 32) Number of Tree Stumps \_\_\_\_\_  
 33) Number of Fire Sites \_\_\_\_\_  
 34) Number of Trails \_\_\_\_\_  
 35) Human Waste (N=None S=Some M=Much) \_\_\_\_\_  
 36) Litter/Trash (N=None S=Some M=Much) \_\_\_\_\_  
 37) Total Campsite Area \_\_\_\_\_ ft<sup>2</sup>

Comments/Recommendations: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Campsite/Centerpoint Photo: Roll # \_\_\_\_ Photo # \_\_\_\_ Bearing \_\_\_\_ Distance \_\_\_\_ft  
 Photo Description \_\_\_\_\_

<u>Campsite Centerpoint References</u>	<b>Transect</b>	<b>Campsite</b>	<b>Exposed Soil</b>
	<b>Data</b>	<u>Deg.</u> <u>Ft.</u>	<u>Deg.</u> <u>Ft.</u>
1)			
2)	1)		
3)	2)		
Bury Nail/Tag ____	3)		
	4)		
<u>Satellite Site Dimensions</u> <u>Bearing</u> <u>Distance</u>	5)		
	6)		
	7)		
	8)		
	9)		
	10)		
<u>Island Site Dimensions</u> <u>Bearing</u> <u>Distance</u>	11)		
	12)		
	13)		
	14)		
	15)		
	16)		
<u>Exposed Soil Dimensions</u>	17)		
	18)		
	19)		
	20)		
	21)		
Campsite Area (dBASE): _____	22)		
+ Satellite Area: _____	23)		
-- Island Area: _____ =	24)		
<b>Total Campsite Area:</b> _____ <b>ft<sup>2</sup></b>	25)		

# Campsite Monitoring Form B: Great Smoky Mountains National Park

## General Site Information

- 1) Ranger Subdistrict \_\_\_\_ 2) Maintenance Subdistrict \_\_\_\_ 3) Trail Section \_\_\_\_  
4) Trail Code \_\_\_\_ 5) Campsite No. \_\_\_\_ 6) Inventoried by \_\_\_\_  
7) Date \_\_/\_\_/\_\_ 8) USGS Quad Code \_\_\_\_ Locate/Label Site on Map \_\_\_\_  
Bury Nail/Tag \_\_\_\_  
Describe Location \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Campsite/Centerpoint Photo: Roll # \_\_\_\_ Photo # \_\_\_\_ Bearing \_\_\_\_ Distance \_\_\_\_  
Photo Description \_\_\_\_\_

## Inventory Parameters

- 9) Intersite Visibility \_\_\_\_\_  
10) Aspect \_\_\_\_\_  
11) Elevation \_\_\_\_\_ ft  
12) Site Position (F=Foot M=Midslope U=Upper Slope) \_\_\_\_  
13) Distance to Formal Trail (Code as -1 if over 5 min. walk) (1 pace = \_\_\_\_ ft) \_\_\_\_\_ paces  
14) Distance to Water (1=<25 ft 2=26-100 ft 3=101-200 ft 4=>201 ft) \_\_\_\_\_  
15) Water Source (S=Spring C=Creek/River I=Intermittent N=None=> 5 min. walk) \_\_\_\_\_  
16) Tree Species: Common Name: \_\_\_\_\_

## Impact Parameters

- 20) Condition Class (1 or 2) \_\_\_\_\_  
26-28) Tree Damage None/Slight \_\_\_\_\_ Moderate \_\_\_\_\_ Severe \_\_\_\_\_  
32) Number of Tree Stumps \_\_\_\_\_  
33) Number of Fire Sites \_\_\_\_\_  
37) Total Campsite Area (office) \_\_\_\_\_ ft<sup>2</sup>

----- Campsite Dimensions -----

**Legal Campsite Summary Form: Great Smoky Mountains National Park**

- 1) Ranger Subdistrict \_\_\_\_\_ 2) Maintenance Subdistrict \_\_\_\_\_ 3) Trail Section \_\_\_\_\_
- 4) Trail Code \_\_\_\_\_ 5) Campsite Number \_\_\_\_\_ Site Numbers \_\_\_\_\_
- 6) Inventoried by \_\_\_\_\_ 7) Date \_\_/\_\_/\_\_ 8) USGS Quad Code \_\_\_\_\_

Campsite/Shelter Description (general location, topography, vegetation, soil, shelter, and impact:

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Comments/Recommendations: \_\_\_\_\_

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- 9) Tree Damage:      Moderate \_\_\_\_\_ (   )  
                              Severe     \_\_\_\_\_ (   )
- 10) Number of Tree Stumps \_\_\_\_\_ (   )
- 11) Number of Trails from Formal Trail to Campsites/Shelter \_\_\_\_\_
- 12) Horse Use (N=Not Permitted H=Horse Use Permitted) \_\_\_\_\_
- 13) Toilet (N=None P=Pit Toilet) \_\_\_\_\_
- 14) Firewood Availability (N=None/Little S=Some M=Much) \_\_\_\_\_
- 15) Food Storage (B=Bearpoles S=Storage Lockers T=Suitable Trees N=Food Storage Needed) \_\_\_\_\_



## Shelter Assessment Form

1) Campsite No. \_\_\_\_\_ 2) Shelter Name \_\_\_\_\_

Centerpoint Photo for C<sub>1</sub>: Roll # \_\_\_\_ Photo # \_\_\_\_ Bearing \_\_\_\_ Distance \_\_\_\_  
 Photo Description \_\_\_\_\_

Centerpoint Photo for C<sub>2</sub>: Roll # \_\_\_\_ Photo # \_\_\_\_ Bearing \_\_\_\_ Distance \_\_\_\_  
 Photo Description \_\_\_\_\_

<u>C<sub>1</sub> Centerpoint Ref.</u>	<u>C<sub>2</sub> Centerpoint Ref.</u>	<b>Transect</b>	<b>Shelter Areas</b>		<b>Exposed Soil</b>	
		<b>Data</b>	<b>C<sup>1</sup></b>	<b>C<sup>2</sup></b>	<b>C<sup>1</sup></b>	<b>C<sup>2</sup></b>
			<u>Deg/Ft</u>	<u>Deg/Ft</u>	<u>Deg/Ft</u>	<u>Deg/Ft</u>
1)	1)	1)				
2)	2)	2)				
3)	3)	3)				
Bury Nail/Tag ____	Bury Nail ____	4)				
		5)				
<u>Satellite Site Dimensions</u>	<u>Bearing/Distance</u>	6)				
		7)				
		8)				
		9)				
		10)				
<u>Island Site Dimensions</u>	<u>Bearing/Distance</u>	11)				
		12)				
		13)				
		14)				
		15)				
		16)				
<u>Exposed Soil Dimensions</u>		17)				
		18)				
		19)				
		20)				
		21)				
<u>Shelter Size Dimensions</u>		22)				
Length _____	Width _____	23)				

## 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.

+)))))) , *            w .)))))) -	* * h ))b) -	a    b  c	) r)
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$A = l \times w$	$A = 0.5 \times b \times h$	$A = \sqrt{s(s-a)(s-b)(s-c)}$ $s = 1/2(a+b+c)$	$A = 3.14 \times r \times r$
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+))5), *    *    * 12   *   * *   *   .))))))4))0)5)))) - .)))) -  * *	+))8)), *            4 +))2))))))2)17)), *            *            *            *            * 10            *            *            *            * .))))))4))0)5)))) - .)))) - 6 * *	))6)    +))))))2))))))1 15 * .))))25)))))) -	* * 14 * +))13))1 *            8 * * *
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$$A = (8 \times 4) + (17 \times 10) + (5 \times 12) + (.5 \times 4 \times 6) + (.5 \times 5 \times 6)$$

$$A = 289$$

$$A = (.5 \times 13 \times 14) + (13 \times 8) + (15 \times 25) + (3.14 \times 6 \times 6)$$

$$A = 683$$

**APPENDIX II.**  
**Trail Impact Assessment and Monitoring Manual**

# Great Smoky Mountains National Park Trail Impact Assessment and Monitoring Manual

## *Description of Procedures*

This manual describes trail assessment procedures designed to gather three general types of trail information. *Inventory Parameters* are included to provide general descriptive information about trail segments (e.g. tread width and trail use type). *Resource Condition Parameters* are included to provide standardized quantitative information about the type and extent of resource impacts on trails (e.g. soil erosion, wet soil, multiple treads). *Design and Maintenance Parameters* are included to document the number and effectiveness of trail maintenance features (e.g. drainage dips and water bars). An *Attraction Feature Parameter* is included to provide information about significant natural or cultural features. The objective of this manual is to describe a standardized set of procedures for assessing parameters under each of these categories using a rapid survey approach.

The trail survey approach described is designed to provide park managers with standardized, quantitative, and reliable information describing trail segments, their condition, and existing maintenance features. Such information can be used to characterize different trail segments in terms of a variety of attributes, resource condition (impact), and maintenance features. Managers may find this information valuable in preparing and justifying trail management actions and trail maintenance budget and staffing requests. Data on individual trails may also be used to direct trail maintenance activities or to set priorities for needed work. The trail survey information can also be analyzed to describe relevant environmental, managerial, and use-related factors influential to trail conditions. Managers may find this information valuable in trail management decision making, including use in Limits of Acceptable Change frameworks, and in the selection of resistant and resilient locations for new trails or trail re-routes. Finally, trail survey information can be compared to data from future assessments (using the same procedures) for monitoring purposes: identifying trends in trail condition and evaluating the effectiveness of implemented management actions.

Trail survey procedures were designed to be efficient, accurate, and precise. Efficiency refers to the ease of application and amount of staff time necessary. Accuracy refers to how close our measurements are to the "true" values, if we had unlimited time to take more careful or scientific measurements. And precision refers to our ability to get the same results if we had many different crews apply the same measurements to the same trail segment.

Only selected trail segments are assessed (the sample) but observations are made along the entire length of the surveyed trail segments. The rapid survey approach is conducted by two field staff who push a measuring wheel along the trail while observing and recording codes and measurements for all occurrences of the specified set of parameters. This manual provides detailed procedures describing each parameter and how it is to be assessed. Predefined codes are included to make field data recording and computer entry more efficient. A standard Trail Survey Form contains columns for recording parameter codes, cumulative distances from the beginning of the segment, and, where necessary, descriptive comments. Computer programs have been developed to enter, store and analyze the recorded information.

**Materials:** USGS topographic maps (1:24,000)  
Measuring wheel  
Clinometer  
Tape measure, 100 foot (marked in tenths)  
Camera, 35mm SLR, 35mm lens and ASA 1000 color print film (store in freezer until used)  
Clipboard, monitoring manual, field forms, pencils

## Trail Survey Procedures

### General Procedures and Inventory Parameters

Make photocopies of the complete trail segment from the USGS maps. Include some overlap of the segment if more than one copy is necessary. Do not reduce or enlarge the photocopies. Label all trail segments that are assessed with the segment names and codes from the attached trail listing sheets. Carry these photocopies as you assess the trail and verify, and where necessary revise, the segment's mapped alignment.

The following parameters apply to the entire trail segment and must be filled out at the top of each Trail Survey Form. Always begin new trail segments with a new form.

- 1) Trail Code: Record the trail segment code from the attached trail listing sheets.
- 2) Trail Name: Record the trail segment name from the trail listing sheets and trail name from park map if different.
- 3) Page Number: In the space provided record consecutive page numbers for the trail segment beginning with page 1 for each new trail segment.

All other parameters are recorded in the tabular section of the form. For each parameter record the capitalized 2 or 3 letter code in the Code column of the Trail Survey Form. In the Dist1 (Distance 1) column record the cumulative trail distance (nearest 1 foot) from the measuring wheel. Parameters which start with a "B" require "beginning" and "ending" distances; for these you will record the beginning distance under Dist1 and the ending distance under Dist2 (ending distance). Finally, some parameters require you to write additional comments. These should be brief, yet concise and complete. If comments require additional lines leave the first three columns blank. Each code, associated distance(s) and comment(s) must be an independent entry.

Whenever you record a code starting with the letter "B", record a dash (-) adjacent to the code in the left margin. These will serve as a visual aid to remind you to be looking for the "end" of this parameter. When you complete this entry by recording the "ending" distance in Dist2 make the dash into a plus (+). Parameters with beginning distances must have ending distances or the data will be incomplete and unusable in our analyses. Avoiding such missing data will require your undivided attention to this task, particularly to remembering which parameters are currently "incomplete" so that you will spot the locations where they end.

- 4) NEW - New Trail Segment: This parameter must be included beginning on the top line of a new form each time a new trail segment from the attached listing is started (more than one segment may be required to complete a red colored trail on the park map). Record the code "NEW" in the Code column, a "0" in the Dist1 column, and all of the following information in the Comments columns.

Trail Code: xx                      Trail Segment Name: xx    Date: xx  
Inventoried by: xx                Elevation: xx                      Begin Wheel: xx

Trail Code and Trail Segment Name: As for Parameters 1 and 2 above.

Date: Month, day, and year the trail segment was evaluated (eg. June 12, 1993 = 06/12/93).

Inventoried by: Identify the field personnel responsible for the trail segment assessment by first initials of first and last names; this is how we will know who is responsible for any mistakes found in the data!

Elevation: Record the elevation (nearest 20 feet) from a USGS map.

Begin Wheel: Select a location near the beginning of the trail segment which is easily identifiable for future reference. Begin the wheel at this location and write a brief description which will allow someone else to relocate precisely where to start the wheel in order to replicate the survey.

- 5) END - End Trail Segment: This parameter must be included to end each trail segment. Record the ending distance and the following information in the comments section.

Soil Moisture: xx            Elevation: xx                      End Wheel: xx

Soil Moisture: Record one of the following terms based on the current soil moisture conditions of the entire trail

segment: Wet, Intermediate, Dry

Elevation: Record the elevation (nearest 20 feet) from a USGS map.

End Wheel: Select a location near the end of the trail segment which is easily identifiable for future reference.

Write a brief description which will allow someone else to relocate precisely where to start their wheel if they replicate the survey in a reverse direction. This distance also reflects total trail segment length.

\* **Note**: Parameters 6 and 7 must be started now and will always be "incomplete" until the trail segment ends. You may need to record changes in the type of use and trail width over the course of the trail segment. When one of these parameters changes, record an ending distance for the former code and a new code with a begin distance.

6) **BUP, BUH - Use Type (begin/end)**: Record the type of use permitted on the trail: Pedestrian (Hiker only) or Horse (hikers are also permitted on horse trails). On the park trail map hiker trails are indicated by dashed lines, horse/hiker trails by solid lines.

**BUP - Pedestrian Use Only**

**BUH - Horse and Pedestrian Use**

7) **BT2, BTR, BT6 - Tread Width (begin/end)**: Record whether the tread is of trail width, generally 3-6 feet, or if the trail appears to be on an existing or former woods road (even if overgrown), with a width generally > 6 feet. When trail width changes record an ending distance for the former parameter and record a new parameter and begin distance to start the new trail width. Three trail width parameters are defined:

**BT2 - Trail**: 2-6 feet width and never used as a woods road

**BTR - Trail on Road**: 2-6 feet width but formerly a wider woods road (now overgrown/unmaintained)

**BT6 - Road**: > 6 feet and obviously a woods road

8) **REF - Reference Point**: Record the code and distance for this parameter periodically when you come across a permanent feature which can be used by future workers to compare and/or recalibrate their wheel readings to those you record. As wheels tend to be inaccurate over long distances, try to include a reference point approximately every 1/4 mile (1 mile = 5280 feet, 1/4 mile = 1320 feet or 264 revolutions of a 5 foot wheel [we may experiment with wheels which read in revolutions not feet]). Under Comments describe reference points with sufficient detail that someone else could relocate the precise point and reset their wheel reading to coincide with your own. Also try to select locations which can be identified on maps, for example: stream crossings, trail intersections, and high or low points (remember to describe specific points at these more general locations). As a general rule you should always reference intersections with formal park trails and roads. Examples: stream crossing, waters edge, right bank facing upstream *or* center of intersection with Parson Trail.

## Resource Condition Parameters

These parameters provide information on the condition of the trail as influenced by human use, environmental, and design/construction/maintenance factors. All parameters are of the begin/end type so be extremely careful to watch for and record beginning and ending distances. Record only those problems which exceed a lineal distance of 10 feet. Do not discontinue a parameter if the gap between two sections exhibiting the problem is less than 10 feet.

9) **BE1 -> BE? - Soil Erosion (begin/end)**: The intent of these two parameters is to identify trail sections which have experienced substantial soil erosion following trail construction. Careful attention to the general natural contour of the land in adjacent off-trail areas and to telltale clues regarding the surface of the original tread location and subsequent erosion is necessary. In particular, look for large rocks or boulders and tree roots whose tops were likely at the original trail surface but, through subsequent erosion, have been exposed more fully. Let us know of any suggestions for increasing the precision of this assessment as you gain more experience. Two soil erosion parameters are defined:

**BE1 - Soil Erosion 1**: 1 - 1.9 feet of soil lost since construction

**BE2 - Soil Erosion 2**: 2 - 2.9 feet of soil lost since construction

**BE3 - Soil Erosion 3**: 3 - 3.9 feet of soil lost since construction

... and so on for more highly eroded sections...

\* For each code above, record in the comments section the elevation for Dist1 (nearest 20 feet). Also record the most typical soil texture for the soil that has been eroded (examine the walls of the trench), a slash "/", followed

by the texture for the bottom of the trench. Use the codes and descriptions from the list below.

- TC:** Clayey - Soil high in clay, malleable when damp, sticky with wet, deep cracks appear in ground when dry, color is typically orange or red
- TS:** Sandy - Loose, coarse soil with high sand content
- TI:** Silty - Like flour or talcum powder when dry and only slightly plastic and sticky when wet
- TL:** Loamy - Combinations of the above, typically in roughly equal parts
- TO:** Organic - Dark organic soil, absorbs/retains water like peat moss and mucky when wet.
- TG:** Gravel - Record only when its obvious gravel was applied by park management
- TR:** Rocky - Natural gravel, rock, or bedrock covers at least 60% of the tread

- 10) **BRE - Root Exposure (begin/end):** Record for trail sections exhibiting severe tree root exposure such that the tops and sides of many roots are exposed.
- 11) **BW3, BW6 - Excessive Width (begin/end):** Record when the trail exhibits a greater than 3 foot expansion in width that is clearly attributable to recreational uses, such as walking/riding around tree falls, wet or muddy areas, eroded areas, multiple treads, etc. Be alert: this parameter will often be recorded in combination with the other resource problem parameters, i.e. excessive soil erosion, wet soils, and multiple treads often cause an excessive widening of the tread. Trail boundaries, like campsite boundaries, are indicated by pronounced changes in ground vegetation cover, composition, and height, or organic litter. Two expansion widths (actual expansion width, excluding normal trail width) are defined:
  - BW3:** 3 - 6 feet wider than normal
  - BW6:** > 6 feet wider than normal
- 12) **BWS - Wet Soil (begin/end):** Record for trail sections which exhibit temporary, seasonally, or permanently wet or boggy soils on more than half the width of the tread. Wet soils typically occur in low areas, depressions, or are associated with hillside seeps. Mudholes and other situations with standing water should be assessed with this parameter. If actual overground water flow is present record parameter **BWT - Running Water on Trail** instead. The objective is to record begin/end distances which reflect normal soil moisture conditions. If little or no rain has fallen in the previous few weeks, look more carefully for signs of seeps and damp soils and use your judgement in recording distances which would reflect more typical soil moisture conditions. The opposite is true if the assessment is conducted soon after rain. Use your judgement to deduce somewhat reduced begin/end distances.
- 13) **BWT - Running Water on Trail (begin/end):** Record whenever water from a large seep or small stream runs on the trail tread, potentially causing soil erosion and tread rutting (disregard water in lateral drains). Some degree of water flow must be present, otherwise record **BWS - Wet Soil.** Use your judgement as described for parameter 12 to record begin/end distances that reflect normal soil moisture conditions.
- 14) **BMT - Multiple Tread (begin/end):** Record the beginning and ending points where multiple treads diverge from a single tread. Record this parameter only when multiple treads are obvious, typically separated by some feature which divides the trail into two or more treads. Also record the maximum number of treads under Comments.

### Design and Maintenance Parameters

These parameters provide information on trail design, construction, and maintenance features. The first three parameters are of the begin/end type (follow previous directions), all other parameters are point features for which only a begin distance is recorded.

- 15) **BMG - Maintained Gravel (begin/end):** Record for trail sections which have been obviously graveled by park staff for either trails, maintained backcountry roads, or former woods roads.
- 16) **BEG - Excessive Grade (begin/end):** Record for trail sections with grades exceeding 20 percent (a 20-foot rise in 100 lineal feet). Using a clinometer, position your partner at the opposite end of the slope in question and sight on a feature of your partner that is the same height above ground as your eyes. Only record this parameter when the slope exceeds 20 percent. Record the soil texture code (see parameter 9) under Comments.

17) **BTC** - Trail Corduroy (begin/end): Trail corduroy is defined as any form of wooden or log bridging designed to traverse areas of wet soil (excluding stream bridges).

18) **DD**"?" - Drainage Dip: A drainage dip is defined as an obvious human-constructed dip or shallow trench, typically with an earthen berm built across the tread, configured in such a way that water is diverted off the trail. Replace the "?" with a letter code indicating the effectiveness of the drainage dip in diverting water from the trail tread. Effectiveness may be related to the quality of installation or current maintenance.

Use the following codes: **V**: Very Effective **P**: Partially Effective **I**: Ineffective

19) **WB**"?" - Water Bar: A water bar is defined as a wooden or rock structure partially buried in the trail tread for the purpose of diverting water off the trail. Replace the "?" with a letter code indicating the effectiveness of the water bar in diverting water from the trail tread. Effectiveness may be related to the quality of installation or current maintenance.

Use the following codes: **V**: Very Effective **P**: Partially Effective **I**: Ineffective

20) **LD**"?" - Lateral Drain: A lateral drain or ditch is defined as an obvious human-constructed trench dug along the up-slope side of the trail to collect and carry the water down-slope parallel to the trail until it can be shunted away from the trail at the end of a slope or across the trail at a water bar, drainage dip, or culvert. Record the distance for any point along the trail where the ditch is present. Replace the "?" with a letter code indicating the effectiveness of the lateral drain in diverting or carrying water from the trail tread. Effectiveness may be related to the quality of installation or current maintenance.

Use the following codes: **V**: Very Effective **P**: Partially Effective **I**: Ineffective

21) **RW** - Retaining Wall: A retaining wall is defined as an obvious human-constructed wall or cribbing constructed of rocks and/or logs to retain soil, typically on the downslope sides of trails. Record the distance for any point along the trail where this feature is present.

22) **CU** - Culvert: A culvert is defined as a metal, rock, or wooden structure which carries water from one side of the tread to the other; it may be open or enclosed. Be aware that some are buried and may not be easy to see.

23) **ST** - Step: A step is defined as an obviously human-placed rock or wooden structure which facilitates travel up a steep slope and/or prevents the erosion of soil or unconsolidated rock/gravel. Also include soil dams, rocks or wood embedded in the trail perpendicular to the tread to retain soil, often to cause eroded sections to fill in. Soil dams are distinct from water bars in that they are not angled and configured to shunt water off the tread.

### **Attraction Feature Parameter**

24) **AF** - Attraction Feature: Outstanding scenic natural or historical features directly or indirectly lead to increased concentrations of use and subsequent impacts. Record these features whenever they are notable or significant enough to attract the attention of visitors. Typically such "popular" features will have well-defined social trails leading to them. These are point features so record a distance under Dist1 for the point along the survey trail which is closest to the feature (do not wheel off the trail to the feature). Briefly describe the feature under comments eg. waterfall, vista, cliff, pond, or stone foundation.

### **Comments**

At the end of each trail segment please record some of your personal comments. Potential topics include specific problems in applying the trail assessment procedures or suggestions for their improvement, and personal observations regarding the trail segment, including: (1) the original layout, design and construction of the trail, (2) the amount, quality, and effectiveness of maintenance, (3) environmental attributes which make the trail either resistant or susceptible to resource impacts, and (4) the type and amount of use and its effects on the trail. This can be done in the evening when you have more time to



comfortably write. Write as many paragraphs or pages as necessary - we need more than codes and distances to appropriately evaluate these trail segments!

### **Photos**

Please take 1 or 2 representative photos of typical views of the trail as follows: turn camera to take a vertical format photo and compose picture to get a closer view of trail tread in bottom foreground with a more distant view of trail corridor in background. We can also use additional photos of "typical" trail features/conditions that might provide good illustrations for the trail manual and "extreme" examples of trail impacts. Where possible, try to take these latter photos when the sun is behind clouds - the lighting will be much more even. For each photo, record the trail name and a description for labelling purposes in a photo log or on the trail forms.



# Trail Survey Code Sheet

## Inventory Parameters

- NEW** - New Trail Segment (4)  
*Record Trail Code, Trail Name, Date, Inventory by, Elevation, and Begin Wheel location description*
- END** - End Trail Segment (5)  
*Record Soil Moisture, Elevation, and End Wheel location description*
- BUP** - Use Type: Pedestrian (6)
- BUH** - Use Type: Horse/Pedestrian (6)
- BT2** - Tread Width: Trail 2-6 ft (7)
- BTR** - Width: Trail on Road 2-6 ft (7)
- BT6** - Width: Road > 6 ft (7)
- REF** - Reference Point (8)  
*Describe to aid in relocation*

## Resource Condition Parameters

- BE?** - Soil Erosion:     1 = 1-1.9 ft  
                              2 = 2-2.9 ft  
                              3 = 3-3.9 ft  
                              ... and so on ... (9)

*Record Elevation for Dist1, Soil Texture: TC, TS, TI, TL, TO, TG, TR for eroded soil/remaining soil*

- BRE** - Root Exposure (10)
- BW3** - Excessive Width: 3-6 ft (11)
- BW6** - Excessive Width: > 6 ft (11)
- BWS** - Wet Soil (12)  
*Distances to reflect "normal" moisture*
- BWT** - Running Water on Trail (13)  
*Distances to reflect "normal" moisture*
- BMT** - Multiple Tread (14)  
*Record number of treads*

## Design and Maintenance Parameters

- BMG** - Maintained Gravel (15)
- BEG** - Excessive Grade: >20% (16)  
*Record Soil Texture: TC, TS, TI, TL, TO, TG, TR*
- BTC** - Trail Corduroy (17)
- DD?** - Drainage Dip, Effectiveness (?):  
**V** - Very, **P** - Partially,  
**I** - Ineffective (18)
- WB?** - Water Bar, Effectiveness (?):  
**V** - Very, **P** - Partially,  
**I** - Ineffective (19)
- LD?** - Lateral Drain, Effectiveness (?):  
**V** - Very, **P** - Partially,  
**I** - Ineffective (20)
- RW** - Retaining Wall (21)
- CU** - Culvert (22)
- ST** - Step (23)

## Attraction Feature Parameter

- AF** - Attraction Feature (24)  
*Record type of feature*

**APPENDIX III.**

**Summary Results: Campsite Impact Assessment**

Resource conditions on campsites and shelters by legal and rationing status<sup>1</sup>.

<b>Impact Indicator<sup>1</sup></b>		<b>Illegal Campsites</b>	<b>Legal Unrationed Campsites</b>	<b>Legal Rationed Campsites</b>	<b>Legal Rationed Shelters</b>
<b>Campsite Size (ft<sup>2</sup>)</b>	<b>Mean</b>	515	1311	2530	3218
	<b>Median</b>	382	876	1740	2895
	<b>Sum</b>	35,052	310,761	182,143	57,920
	<b>N</b>	68	237	72	18
<b>Vegetation Loss (ft<sup>2</sup>)</b>	<b>Mean</b>	273	814	1208	1522
	<b>Median</b>	159	521	653	1431
	<b>Sum</b>	8201	129,435	72,478	24,353
	<b>N</b>	30	159	60	16
<b>Exposed Soil (ft<sup>2</sup>)</b>	<b>Mean</b>	266	812	1489	1398
	<b>Median</b>	182	470	856	1361
	<b>Sum</b>	7970	129,064	89,352	22,365
	<b>N</b>	30	159	60	16
<b>Damaged Trees (#)</b>	<b>Mean</b>	0.7	2.9	5.6	2.1
	<b>Median</b>	0	1	2	0
	<b>Sum</b>	45	690	401	37
	<b>N</b>	68	237	72	18
<b>Trees w/Root Exposure (#)</b>	<b>Mean</b>	0.6	1.2	2.0	0.7
	<b>Median</b>	0	0	1	0
	<b>Sum</b>	18	186	120	11
	<b>N</b>	30	160	60	16
<b>Stumps (#)</b>	<b>Mean</b>	0.7	1.9	3.4	0.9
	<b>Median</b>	0	1	2	0
	<b>Sum</b>	47	460	247	17
	<b>N</b>	68	237	72	18
<b>Fire Sites (#)</b>	<b>Mean</b>	1.0	1.7	1.7	1.6
	<b>Median</b>	1	1	1	1
	<b>Sum</b>	69	409	125	29
	<b>N</b>	68	237	72	18
<b>Trails (#)</b>	<b>Mean</b>	2.8	4.4	4.9	5.7
	<b>Median</b>	3	4	5	6
	<b>Sum</b>	83	700	296	91
	<b>N</b>	30	159	60	16

<sup>1</sup> - N is the number of campsite values included in mean and median values; N values are smaller for some indicators because they were not assessed on lightly impacted campsites (see Methods section).

## **APPENDIX IV**

### **Summary Results: Trail Impact Assessment**

Summary of number of occurrences and total lineal distance of trail attributes for all surveyed trails (N=72, 328 miles). Dashed line separates lineal feature parameters from point feature parameters.

Trail Parameter	Occurrences		Total Lineal Distance <sup>1</sup>			
	Number	No./Mi	Miles	Percent	Ft/Mile	Mean (ft)
<b>Inventory</b>						
Use Type: Pedestrian	28	-	114.81	33.5	-	8,419
Use Type: Horse/Pedestrian	49	-	212.96	66.2	-	15,617
Tread Width: Trail 2-6 ft	68	-	277.62	84.4	-	20,359
Tread Width: Trail on Rd 2-6 ft	17	-	27.06	8.1	-	1,984
Tread Width: Road > 6 ft	14	-	20.79	7.1	-	1,525
<b>Resource Condition</b>						
Soil Erosion: 1-1.9 ft	634	1.90	12.10	3.5	185	887
Soil Erosion: 2-2.9 ft	84	0.26	1.92	0.7	35	141
Soil Erosion: >3.0 ft	16	0.06	0.59	0.4	19	43
Root Exposure	365	1.58	2.44	1.0	53	179
Excessive Width: 3-6 ft	150	0.50	1.90	0.6	32	140
Excessive Width: >6 ft	26	0.10	0.33	0.1	6	24
Multiple Tread	470	1.48	6.40	1.8	96	469
Wet Soil	752	2.33	11.30	3.5	184	829
Running Water on Trail	227	0.78	2.60	1.0	54	191
<b>Design and Maintenance</b>						
Graveled Tread	17	0.08	23.39	8.0	-	1,715
Excessive Grade: >20%	131	0.35	4.91	1.4	-	360
Trail Corduroy	19	0.04	0.11	<0.0	-	8
Drainage Dip: Very Effective	837	3.05				
Drainage Dip: Partially Effective	1,522	5.68				
Drainage Dip: Ineffective	1,778	5.99				
Water Bar: Very Effective	1,671	4.67				
Water Bar: Partially Effective	891	2.52				
Water Bar: Ineffective	1,242	3.40				
Lateral Drain	62	0.21				
Retaining Wall	235	0.64				
Culvert	208	0.77				
Step	414	0.79				

1 - **Miles** - Distance in miles, summed across all trails; **Percent** - Percent of each trail, averaged across all trails; **Ft/Mile** - Number of feet/mile for each trail, averaged across all trails, **Mean** - Distance in feet, averaged across all trails.

## **APPENDIX V.**

### **Additional Examples of Spatial Index for Recreation Impact Evaluation**



## References

- Plane, D. A. and Rogerson, P. A. (1994). *The Geographical Analysis of Population*. New York: John Wiley.
- Shaw, G. and Wheeler, D. (1994). *Statistical Techniques in Geographical Analysis*. New York: Halsted Press.
- Smith, S. L. J. (1995). *Tourism Analysis: A Handbook (2nd Ed.)*. Essex, England: Longman.
- Vogler, J. B. and Butler, D. R. (1996). Pedestrian- and bicycle-induced path erosion on a university campus. *Physical Geography* **17**, 485-494.

## List of Notations

Type	Term	Definition
<i>Subscripts</i>	<i>i</i>	<b>Trails:</b> 1, ..., m, ... , n occurrences (segments) of a trail impact problem. The <i>m</i> -th problem segment contains the median value; <b>Campsites:</b> 1, ... , n individual campsites (social trails) at a given campground area
	<i>j</i>	1, ... , k type of trail impact
<i>Symbols in parentheses</i>	(c)	Mid-point distance
	(e)	Ending distance
	(s)	Starting distance
<i>Major Symbols</i>	<i>A</i>	disturbed area on trails or campsites (m <sup>2</sup> )
	<i>d</i>	Distance readings from trail measuring wheel (m)
	<i>L</i>	Sum of problem segment lengths for a single impact type (m)
	<i>l</i>	Length of individual problem segment (m)
	<i>o</i>	number of observation unit (e.g., sectional evaluation in trail assessment)
	<i>T</i>	Total trail length (m)
	<i>t</i>	length of social trail at campground or campsite (m)
	<i>V</i>	Vegetation cover loss on a campsite (%)
<i>w</i>	Trail width (m)	

## I. Spatial Indices for Trails

### *Spatial Extent*

#### 1. Index of Lineal Extent (LE)

$$LE_j = \frac{\sum_{i=1}^n l_{ij}}{T}$$

**Unit:** %, or m/km (ft/mi).

**Range:** 0-100 %, or 0-1000 m/km (5280 ft/mi).

**Description:** Index of Lineal Extent is a simple sum of problem segment lengths for a given impact type expressed simply in meters, or in percentage of total trail length (see equation). For comparative purposes, LE can also be reported in m/km (by multiplying 1,000).

#### 2. Trail Area Index (TA)

$$TA_j = \frac{\bar{w} \sum_{i=1}^n l_{ij}}{T}$$

**Unit:** m<sup>2</sup> (ft<sup>2</sup>) or m<sup>2</sup>/km (ft<sup>2</sup>/mi).

**Range:** TA ≥ 0.

**Description:** Trail Area Index is a logical extension of LE by incorporating the trail width information. Similar applications can be found in Vogler and Butler (1996) and Cole et al. (1997). TA represents the areal extent of a given impact type. Similar to LE, TA can be expressed simply in areal units, or in ratio format such as m<sup>2</sup>/km (see equation) for comparative purposes. This index can also be used to quantify the extent of social trail development at campgrounds/campsites.

## *Spatial Distribution and Variation*

### 3. Impact Mean Center (MNC)

$$MNC_j = \frac{\sum_{i=1}^n l_{ij} d(c)_{ij}}{\sum_{i=1}^n l_{ij}}$$

**Unit:** m (ft).

**Range:** 0 to T (trail length).

**Description:** The Mean Center of a given impact type is essentially the weighted average of linear distance from the trailhead based on the length of individual problem segments. It is the linear equivalent of the mean center of points (Shaw and Wheeler 1994).

### 4. Impact Median Center (MDC)

$$MDC_j = d(s)_{mj} + \left( \frac{1}{2} L_j - \sum_{i=1}^{m-1} l_{ij} \right)$$

**Unit:** m (ft).

**Range:** 0 to T (trail length).

**Descriptions:** The Median Center of a given impact type is the location (distance from trailhead) where the sum of problem segment lengths is divided in two halves.

## 5. Proximity Index (PI)

$$PI_j = \frac{1}{T} \sum_{i=1}^{n-1} [d(s)_{i+1,j} - d(e)_{ij}]$$

**Unit:** m (ft).

**Range:** 0 to T (trail length).

**Descriptions:** The Proximity Index is basically the average distance between two occurrences of the same impact type along a trail. PI can range from zero (continuous existence) to approaching T (total trail length) if there are only two short occurrences located at either ends of the trail. This index requires at least two occurrences of a impact problem on a trail.

## 6. Concentration Index (CI)

$$CI_j = 100 \left( \frac{1}{2} \sum_{i=1}^o \left| \frac{l_{ij}}{L_j} - \frac{1}{o} \right| \right)$$

**Unit:** no unit.

**Range:** 0 to 100.

**Descriptions:** The Concentration Index is adapted from the Index of Dissimilarity and Hoover's Index in population geography (Plane and Rogerson 1994). This index can be used for summarizing the degree to which impact occurrences are concentrated along a trail. It is particularly useful if sectional evaluation (see Table 5.1) is adopted as trail assessment method, in which a trail is divided into sections (observation units, or "o" in the above formula) of equal length, and lineal extent of impact problems is measured or estimated for each section (e.g. Bratton et al. 1979). Values approaching zero indicate that impact segments is evenly distributed along the entire trail, while values approaching 100 indicate that impact segments are spatially concentrated.

## II. Spatial Indices for Campsites

### *Spatial Extent*

#### 7. Area of Vegetation Loss (AVL)

$$AVL_t = V_t A_t$$

**Unit:** m<sup>2</sup> (ft<sup>2</sup>).

**Range:** AVL ≥ 0.

**Description:** Introduced by Cole (1989), this index integrates spatial extent and intensity of impact of a campsite.

#### 8. Aggregate Campsite Area (ACA)

$$ACA = \sum_{i=1}^n A_i$$

**Unit:** m<sup>2</sup> (ft<sup>2</sup>).

**Range:** ACA ≥ 0.

**Description:** Aggregate Campsite Area is a simple sum of site size of all campsites within a campground area. It indicates the spatial extent of disturbance related to camping. The aggregation can also be performed on Area of Vegetation Loss (AVL).

## 9. Social Trail Index (STI)

$$STI = \frac{\sum_{i=1}^n w_i t_i}{\sum_{i=1}^n A_i}$$

**Unit:** no unit.

**Range:**  $STI \geq 0$ .

**Description:** Widespread existence of social trails (unofficial use-created trails) at campgrounds or campsites is indicative of the proliferation of camping impacts at these locations. STI is essentially a ratio between trail area (see Index No. 2 in this Appendix) and the aggregate campground area (ACA) (see Index No. 8 in this Appendix).

## Vita

Yu-Fai Leung was born July 11, 1967 in Hong Kong. He graduated from the Chinese University of Hong Kong with a Bachelor of Social Science degree (Second Class Honor, Upper Division) in Geography (Biology minor) in 1989, and a Master of Philosophy degree in Geography in 1992. He pursued further study in the United States and entered the M.S. program in Forestry at Virginia Tech, and was transferred to the Ph.D. program in 1993. He received his Ph.D. degree in Forestry from Virginia Tech in April 1998, specializing in outdoor recreation and park management.

He was previously employed by the Department of Geography, Chinese University of Hong Kong, as a Graduate Teaching Assistant. During his doctoral study at Virginia Tech he was employed by the Department of Forestry as a Graduate Research Assistant, participating in various research projects in national parks, forests, and rivers throughout the southeastern region of the United States. He also served as a Graduate Teaching Assistant and laboratory instructor for a forest soils and hydrology course. Upon completion of his degree, he was employed as a postdoctoral research associate with the Forestry Department and the Virginia Tech Cooperative Park Studies Unit, and worked as principal investigator in a visitor use and impact assessment and monitoring project in Denali National Park, Alaska.

His primary teaching and research interests focus on recreation ecology and visitor impact assessment, nature-based recreation and tourism (including ecotourism), and protected area management. He is particularly interested in pursuing these interests from a spatial perspective, and with a regional emphasis in East Asia. He also has a strong academic interest in the application of geographic information and Internet technologies for research and instructional purposes.

He is married to Laura Suet-Lai Lam, and owns a cat named Dong-Dong.