Research to Support Development of Resource Indicators and Standards for Visitor Experience and Resource Protection (VERP) Implementation in Boston Harbor Islands, A National Park Area

Final Report (Review Draft)

by

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I. INTRODUCTION

A. Background

The enabling legislation for Boston Harbor Islands (BOHA) (P.L. 104-333) requires that park managers protect and maintain the natural and scientific values of the islands, while at the same time, the law mandates that the managers improve access to BOHA and enhance public outdoor recreation. Thus, in addition to the balance between resource protection and visitor use typical at all units of the National Park Service (NPS) system, there is the added legislated requirement at BOHA to increase use while protecting resources. It is projected that park visitation to the islands could double over the next few years and quadruple in the foreseeable future (BOHA 2002). In other words two million people would have access the islands via public transportation in the near future.

The National Parks and Recreation Act of 1978 (P.L. 95-625) requires that BOHA and other NPS units address the visitor carrying capacity issue in their general management planning process through the "identification of and implementation commitments for visitor carrying capacities for all areas of the unit" (NPS 2000). In response, the park's General Management Plan identifies a process for protecting park resources and providing quality visitor experiences through zoning and the application of carrying capacities to each zone or use area. The analysis of carrying capacity is defined as "the character of use that can be supported over a specified time by an area developed at a certain level without causing excessive damage to either the environment or the experience" (Lime and Stankey 1971).

Establishing both a social and ecological carrying capacity is essential to providing guidance on acceptable visitor use management from closure (to protect rare species, wildlife habitat, or other sensitive areas), or use dispersal (such as hiking and camping) to concentrating use (such as high density visitation with developed facilities) for the long-term protection and preservation of the natural characteristics of the islands.

B. Boston Harbor Islands National Recreation Area

Established in 1996, Boston Harbor Islands National Park Area (BOHA) consists of 30 islands within Boston Harbor, Massachusetts. The primary significance of the park resides in:

1) The only drumlin field in the United States that intersects a coast, formed by the glaciers some 15,000 years ago
2) Opportunities for solitude and land-and water-based education and recreation within an urban area
3) An island complex composed of 500 hectares (1,200 acres) of land, archeological resources, historic sites, open space, wildlife habitats, and 35 miles of relatively undeveloped shoreline; all inside an area of 50 square miles and within view of downtown Boston and other harbor communities

The park is known to provide habitat for nesting seabirds, harbor seals, more than 70 species of terrestrial birds, and state-listed plants. By its configuration, assemblage of natural, geologic, cultural, and historic features, and proximity to a major metropolitan area, the Boston Harbor Islands system offers a resource that has no parallel in the United States.

The park is administered in partnership by the Secretary of the Interior, the Commonwealth of Massachusetts, City of Boston and others, always in accordance with the laws applicable to units of the National Park System. The NPS is one of the 13 members of the Boston Harbor Islands Partnership that manages the park. A 28-member Advisory Council provides valuable public involvement.

The park has recently gone through the first general management planning process (BOHA 2002). Part of the GMP process required that the visitor carrying capacity issue be addressed. Accordingly, this study was developed to provide research support for carrying capacity determination, particularly in development of indicators and standards.

C. Visitor Carrying Capacity

The concept of carrying capacity has a rich history in the natural resource professions. Applied to parks, carrying capacity addresses the amount and types of visitor use that can be accommodated without causing unacceptable impacts (Graefe et al. 1984; Shelby and Heberlein 1986; Manning 1999). Within the context of parks, carrying capacity has two components—resource and social. Resource carrying capacity refers to impacts that visitors can have on environmental and cultural resources, including soil compaction, destruction of vegetation, disturbance of wildlife, and damage to cultural artifacts. Social carrying capacity refers to impacts that visitors can have on the quality of the park experience, including crowding, conflicting uses, and aesthetic degradation.

Contemporary approaches to carrying capacity focus on indicators and standards of quality. Indicators of quality are measurable, manageable variables that define the quality of the resources and/or the visitor experience. Standards of quality define the minimum acceptable condition of indicator variables. Carrying capacity is managed by monitoring indicator variables and taking management action to maintain standards of quality. This management framework is central to contemporary carrying capacity processes, including Limits of Acceptable Change (Stankey et al. 1985), Visitor Impact Management (Graefe et al. 1990), and Visitor Experience and Resource Protection (NPS 1997; Manning 2001).

Visitor Experience and Resource Protection (VERP) has been developed as a visitor carrying capacity framework for the national park system (NPS 1997). An initial application of this framework was conducted at Arches National Park (Manning et al. 1993; Hof et al. 1994; Lime et al. 1994; Manning et al. 1996; Belnap 1998). This application resulted in a carrying capacity management plan that is being implemented at that park (NPS 1995). Subsequent applications of VERP have been conducted in selected units of the national park system, including Acadia National Park (Jacobi and Manning 1997) and Yosemite National Park (YOSE 2004). Additional applications of this carrying capacity framework are now proceeding at selected units of the national park system (Manning 2001).

Resources research within the VERP and other standards-based frameworks has focused on resource assessment, indicator identification and measurement, and standards formulation. Field surveys have been conducted to assess and monitor resource conditions on trails, campsites and other recreation sites (Marion 1994; Leung and Marion 1998; Marion and Leung 1997). Monitoring protocols and manuals have been developed to enhance the quality of field measurements (Cole 1989; Marion 1991). A large number of resource-based indicators have been proposed or adopted (Marion 1991; Watson and Cole 1992; Tarrant and Shafer 1997). As part of the Arches VERP project, Belnap (1998) has developed an empirical method to identify, evaluate and select resource indicators.

Visitors' acceptability to resource impacts has been investigated by means of site evaluations, simulated image evaluations, and visitor surveys (Roggenbuck et al. 1993; Manning et al. 1996; Dorwart et al. 2004). Visitors can often perceive negative resource impacts, some of which can adversely affect the quality of the recreation experience.

D. The Project

This project has three basic components. The first two components address the scientific research needed to support application of the VERP framework to Boston Harbor Islands. The research is focused primarily on developing data that will provide an empirical foundation for formulating indicators and standards of quality for both resource and social conditions. Programs of resource and social research were conducted in two phases during the first two years of the project. The research program was designed and conducted within the context of the third component of this project, an interdisciplinary VERP research/resource planning committee. The committee met periodically throughout the duration of the project, and met intensively during the final year of the project to incorporate study findings into a series of indicators and standards of quality for Boston Harbor Islands. This report presents results from the resource component research, part of which benefited from the social science component led by the University of Vermont group.

II. METHODS

Each of the three basic components of the project was supported by a set of study methods and/or processes. For the purposes of this report study methods for the resource component are described in the following sections.

The resource component of the project focused on identifying and developing resource-based indicators and related monitoring procedures as well as assisting in the formulation of standards on the selected indicators. Research activities were organized into three phases.

A. Phase I Research

The first phase of research was conducted between October 2000 and September 2001. In this phase the primary tasks were the analysis of park resources, identification of potential resource indicators, and selection of resource indicators. Major research activities included literature review, local experts survey, unofficial trail and campsite assessments, official trail and recreation site assessments with the involvement of Earthwatch volunteers.

Extensive searches and review of scientific literature were performed with special focuses on the types and sensitivity of park resources to visitor use, previous visitor impact research in the study area, and methodologies of recreation ecology research. Informal interviews were conducted to gather basic information about salient visitor impact concerns in the park.

Between March and April 2001, a mail-back 2-page *local expert survey* was developed and administered to 76 individuals on a mailing list provided by the NPS-Boston Harbor Islands Office. These individuals included members of the BOHA partnership, agency and park staff and other individuals who were affiliated or familiar with the park. The purpose was to solicit input from these knowledgeable individuals on visitor impact issues and possible problem areas. A copy of the survey is included in Appendix I.

Assessment and monitoring procedures were developed for recreation sites and trails. These procedures were largely modified from visitor impact assessment methods that were developed and applied to a variety of parks and forests, including Delaware Water Gap National Recreation Area, Shenandoah National Park, New River Gorge National River, Gauley National River, Great Smoky Mountains NP and Jefferson National Forest (Leung and Marion 1994, Leung and Marion 2000, Marion 1991, Marion and Leung 1997). Several new measurement items were developed for this study area. While locations of all official sites were known, unofficial sites were searched extensively on each possible island as suggested by park staff and revealed from the local expert survey.

For official and unofficial recreation sites a multiple-indicator assessment approach was adopted (Marion 1991, Leung and Marion 2000). The procedures began with a delineation of recreation site boundaries within which impact indicators were assessed. Inventory information, including GPS coordinates, site position, distance to water, distance to trail, and canopy cover, were evaluated. Two different GPS units (high-cost, professional-grade Trimble Geo Explorer III vs. low-cost, recreational-grade Garmin III) were used to document campsite locations. Results of a comparison of position accuracy between these GPS unites is provided in Appendix V.

Impact indicators assessed included a 5-point condition class rating (Table 2.1), area of disturbance as indicated by site size, vegetative groundcover on-site and at off-site controls (6-point cover scale), mineral soil exposure (6-point cover scale), tree damage (3 categories), root exposure (3 categories), stumps (count), trash (3 categories), human waste (3 categories), social trails radiating from site (count), and vandalism parameters (type, location, extent and loss of functionality). A simplified procedures were developed for rest/viewing areas, which were usually small with no or minimal facilities (i.e., benches). More details about the field procedures for site assessment are available in Appendix II.

Table 2.1. Condition class rating system for recreation sites.*

Condition Class	Descriptive Criteria
1	Site barely distinguishable; slight loss of vegetation cover and /or minimal disturbance of organic litter.
2	Site obvious; vegetation cover lost and/or organic litter pulverized in primary use areas. No bare soil other than fire scars.
3	Vegetation cover lost and/or organic litter pulverized on much of the site, some bare soil exposed in primary use areas.
4	Nearly complete or total loss of vegetation cover and organic litter, bare soil widespread.
5	Soil erosion obvious, as indicated by exposed tree roots and rocks and/or gullying.

* Include picnic sites, campsites, and rest/viewing sites; based on Marion (1991) and Marion and Leung (1997).

For official trail assessment an integrated approach was adopted by combining: (a) a *sampling-based* point assessment and (b) a *census-based* problem assessment (Marion and Leung 2001). Information gathered with the sampling-based point assessment can be used to characterize different trail segments in terms of length, width, tread composition and estimated extent of tread problems. On the other hand, information gathered with the census-based problem assessment can be used to document the types, extent and locations of pre-defined problem events occurring on or along the trails (Leung and Marion 2000, Marion and Leung 2001).

Assessment was conducted for the entire length of each trail segment under study. Two field staff persons were typically involved in implementing the procedures. One staff pushed a measuring wheel along the trail while stopping at each sampling point (every 200 feet in this study). This measuring staff also observed and took measurements for all occurrences of pre-defined problem events. Another staff served as the recording staff who recorded all data obtained by the measuring staff. All assessed trails were also mapped using GPS. More details about specific procedures can be referred to the trail assessment manual (Appendix III).

A rapid inventory and assessment approach (Hammitt and Cole, 1998) was adopted for unofficial or social trails. A social trail is defined as a discernible and continuous trail segment that was created by visitors (not constructed) and that is not part of the Park’s trail system as indicated on official maps and other media. For this type of trails a rapid assessment method was adopted. All social trails were mapped using GPS (Trimble GeoExplorer) with assistance provided by the Boston Support Office (Ms. Nigel Shaw). Each social trail segment was assigned to one of the following four condition classes (Table 2.2). To evaluate the efficacy of using social trail branch-off or offshoot points as a surrogate measure of social trail indicator the number of social trail points is correlated with other social trail measures such as number and sum of length.

Evaluation of soil quality and groundcover indicators were initially planned for the 2001 season but this task was postponed to summer/Fall 2002 due to the archeological evaluation process and the training requirements for Earthwatch volunteers.

Table 2.2. A condition class system for social trail assessment in BOHA.

Condition Class*	Descriptive Criteria
Class 1	Trails are disturbed but not well established. They retain at least 20 percent of vegetation cover on the treads. The boundaries between trail treads and off-trail areas are often unclear.
Class 2	Trails are disturbed and well established. They retain less than 20 percent of vegetation cover on the treads. These trails are less than 1 ft wide. The boundaries between trail treads and off-trail areas are often discernible.
Class 3	Trails are disturbed and well established. They retain less than 20 percent of vegetation cover on the treads and are between 1 and 2 ft wide. The boundaries between trail treads and off-trail areas are usually discernible.
Class 4	Trails are disturbed and well established. They retain less than 20 percent of vegetation cover on the treads and are more than 2 ft wide. The boundaries between trail treads and off-trail areas are usually discernible.

* Adapted from Cole et al. (1997).

B. Phase II Research

Phase II research (10/01-09/02) aimed at evaluating groundcover and soil quality indicators with respect to their sensitivity to visitor use. Changes in the amount and composition of ground cover are a common type of resource impact resulting from visitor use in parks and recreation areas (Liddle 1997; Hammitt and Cole 1998; Leung and Marion 2000). A change in ground cover on recreation sites typically shows a trend of decreasing vegetative ground cover and increasing bare soil exposure (Liddle 1997). Based on the recommendations of the State Archeologist, field procedures were modified to minimize ground disturbance.

A series of field measurements were conducted on Georges, Peddocks and Grape Islands between June and October 2002. These islands were selected for this additional study due to their accessibility, diversity of use level and diversity of environmental attributes. Appendix IV provides more details of the field procedures. Initial measurements were conducted in June 2002, with remeasurements performed in August and October 2002, respectively. Major indicators or variables assessed included: (1) vegetative and bare ground cover (measured by overall evaluation, quadrat-based measurement and continuous line transects), (2) soil compaction as measured by penetration resistance (Lowery and Morrison 2002), and (3) soil stability based on the slake test (Doran and Jones 1996; USDA 1999). Measurement of infiltration capacity was attempted but abandoned due to inefficiency of the procedures.

Quadrat-based and continuous line-transect measurements were applied within 12 circular sampling plots (6-m radius), six of which were located in high-use areas while the remaining six representing low-use areas. On each island 2 plots were randomly located within high-use zones (close to pier) while another 2 were randomly located in low-use zones. Within each plot 12 quadrats (25cm x 25cm) were randomly located along 6 radial transects that are 60^o apart.

Measurements were taken for the entire plot, along each line transect or within each quadrat, depending on the specific indicator measure.

(1) Ground cover (vegetation and bare soil) -- Data were collected at the beginning (June), middle (August), and end (October) of the visitor use season to evaluate see a seasonal trend in ground cover, Unfortunately, during the summer of 2002, Boston was experiencing drought conditions, which may have affected our August results. Ground cover composition was estimated using three different methods: point method assessment, quadrat assessment, and continuous line transect assessment. All ground cover for the overall and quadrat assessment techniques were estimated using a 7-point cover scale (0, 0-5, 6-25, 25-50, 51-75, 76-95, 96-100) adapted from the Daubenmire cover scale (Mueller-Dombois, & Ellenberg, 1974). This similar scale was used in Leung and Marion's (1999) camping impacts study in the Great Smoky Mountains. To help the observers be consistent in using the given scale, a laminated 8.5x11 inch reference sheet with visual representations of respective ground cover was available. For the point method, the entire site is estimated in one observation.

The continuous line transect estimations were performed by an observers who started at the center of each sample plot and walked the length of each 6-m transect. Measurements of ground cover were estimated as the principal type of ground cover along the transect changed, to the closest decimeter (10 cm). These was a 10-cm observation zone along each transect so that a principal ground cover type could be better determined. A beginning and end distance was recorded for each change in principal ground cover type. The amount of values to estimate ground cover depended on the amount of ground cover changes. There would be a minimum of six values for this site if all the transects reported one principal value of one ground cover type

Descriptive statistics and the independent samples t-tests with unequal variances were used to assess the statistical significance of the difference in cover estimates. T-tests were applied only between the quadrat and transect methods.

(2) Soil compaction by penetrometry -- Two types of penetrometers were evaluated and compared in term of their utility and consistency. This study adopted penetrometry as the soil compaction measure due to its minimal ground disturbance as required by park regulations and its efficiency in island settings. The pocket penetrometer (SOILTEST, Inc.) is a spring-loaded instrument with 15.2 cm in length and 1.9 cm in diameter. The instrument measures penetration resistance by pressing the 6.4 mm-diameter round tip 6.4 mm into the soil. When pushed into the ground a metal ring is pushed up the scale, marking the penetration resistance value in kg/cm^2. The Soil Compaction Tester (DICKEY-john Co.) is a portable cone penetrometer of 93 cm in total length with a dial on top to immediately read the soil compaction value (pounds per in^2). An angled cone attachment of 12.7 mm (½ in) or 19.1 mm (¾ in) is screwed onto the other end of the 70-cm rod that is pushed into the ground. The rod is marked every 7.6 cm (3 in) to enable measurement of soil compaction at 7.6 cm increments (up to 45.7 cm or18 in).

In each quadrat described above 4 penetration resistance (PR) readings were taken using pocket penetrometer (PP), and 4 pairs of PR measurements were taken using the Soil Compaction Tester (SCT) at the depth of 7.6 cm and 15.2 cm. Hence, the maximum numbers of PP and SCT readings for each plot were 48 and 96, respectively. Only the SCT readings at the 7.6-cm level are compared with PP readings. Due to rocks, roots, and compaction not all SCT measurements could be taken at their intended depths, resulting in reduced number of SCT readings in some cases. Eight background PR measurements were taken with two penetrometers, respectively, at adjacent environmentally similar control areas outside each plot. All measurements of a single plot were completed on the same day.

The same plots and quadrats were relocated and remeasured in August and October 2002 to evaluate temporal changes. The August data were collected during a severe drought, resulting in extremely high PR readings under unusual soil moisture regimes. For comparability purposes only data in June and October 2002 representing the beginning and end of a visitor use season are presented. PR readings from two plots representing the same use level were combined. Relative PR change of each plot was calculated by the difference between mean plot and control PR values divided by the control mean PR value. Relative changes are valid for comparison among sites with varied background PR levels. Data variability was evaluated by the coefficient of variation (CV) (standard deviation as the percentage of the mean). The percentage of successful SCT penetration to each depth level in each plot was reported as penetration depth. All SCT-PR readings were converted to kg/cm^2 for analysis and reporting.

(3) Soil Stability by Slake Test -- The slake test measures the stability of air-dried soil fragments or aggregates when exposed to rapid wetting (USDA 1999). A complete soil stability kit with a series of small sieve baskets was constructed. Half of the quadrats (6) within each sampling plot were randomly selected for this test. Within each selected quadrat soil fragments and aggregates were collected to fill the 16 sieve baskets, which were immersed into distilled water for 5 minutes before raising and lowering sieve baskets 5 times (i.e., 5 extraction-immersion cycles) to simulate rapid wetting conditions. Soil stability is rated using the 7-point rating scale (Table 2.3) according to the time required for the fragment to disintegrate during the five-minute immersion and the proportion of the soil fragment remaining on the sieve basket after the 5 extraction-immersion cycles.

Table 2.3. The Soil Stability Class based on slake test (USDA 1999).

Stability Class	Criteria for assignment to stability class (for "Standard Characterization")
0	Soil too unstable to sample (falls through sieve)
1	50 % of structural integrity lost within 5 seconds of insertion in water
2	50 % of structural integrity lost 5 - 30 seconds after insertion
3	50 % of structural integrity lost 30 - 300 seconds after insertion or < 10 % of soil remains on the sieve after 5 dipping cycles
4	10 - 25% of soil remaining on sieve after 5 dipping cycles
5	25 - 75% of soil remaining on sieve after 5 dipping cycles
6	75 - 100% of soil remaining on sieve after 5 dipping cycles

Phase II research also aimed at establishing monitoring protocols and procedures for selected indicators and were finalized as a monitoring procedural manual. As part of this effort a field workshop/demo was held on August 12, 2002, for BOHA Planning Committee members to discuss resource indicators and demonstrate monitoring procedures.

Indicators assessed in 2002 were added to the list of potential indicators from Phase 1 research. All indicators assessed in the two phases of research were evaluated based on criteria developed in previous VERP implementations (Table 2.4), the empirical data, and extensive discussion with the Planning Committee and project consultant (Dr. Jeffrey Marion, USGS/Virginia Tech). This process resulted in a final list of *four* selected indicators for VERP implementation.

Table 2.4. Evaluation criteria for potential VERP indicators.

CRITERIA *	DESCRIPTION
Low measurement impacts	The indicator can be measured with no or minimal level of ground disturbance
Reliable/Repeatable	The measurements of indicator by different field staff would show reasonable agreement
Correlation with use	The indicator is directly related to visitor use with good level of correlation
Ecologically relevant	The indicator must have conceptual relevance to concerns about ecological condition. It must reflect an important change of resource condition that would lead to significant ecological or social consequences
Respond to impacts	Change of resource condition can occur promptly after impacts are introduced
Respond to management	Resource conditions can be manipulated by management actions
Easy to measure	Field measurements are relatively straightforward to perform with minimal level of equipment needed
Low natural variability	Indicator has a limited level of spatial and temporal variability
Large sampling window	Field measurements can take place in most of the times in a year
Cost effective	Measurements of indicator are inexpensive. Little additional cost to management. Data gathered benefit management
Easy to train for monitoring	Field staff with no prior knowledge of field procedures can be easily trained to perform such procedures
Baseline data	There are existing data on the indicator, preferably with the use-impact link established
Response over different conditions	Impacts can be seen while still relatively slight

* The first four (shaded) are required criteria while the remaining nine are desirable criteria. These criteria were adapted from Belnap (1998), Consulting and Audit Canada (1995) and GYWVU (1999).

C. Phase III Research

The third and final phase of this project (10/02-12/03) was aimed at finalizing the indicator selection, assisting in the establishment of standards for the selected indicators, and assisting in the development of visitor carrying capacity guidelines for the park This phase also focused on integrating research findings between social science and resource component research and on reporting results in form of final reports as well as at conferences and peer-reviewed outlets.

III. STUDY FINDINGS

This section reports major results from the resource component study. It is organized by specific tasks as described in the cooperative agreement and the Methods section.

A. Task 1: Identification of Resource Indicators

1. Analysis of Park Resources

Printed documents were collected and GIS data acquired from the NPS Boston Support Office to develop an understanding of park resources and their relevance to recreational use. The rare, threatened and endangered (RTE) species layer was examined in particular in relation to locations of recreation sites and trails to develop spatial proximity indicators. Due to the complexity of these indicators they were not selected for VERP implementation. However, they should be examined occasionally when new assessment data, particularly social trails and unofficial sites, are available in order to detect temporal changes.

2. Review of Literature

A variety of sources were consulted to develop list of potential resource indicators. Previous VERP implementations were reviewed to provide input on potential indicators. Only a few previous implementations included a resource component. VERP was first applied in Arches National Park in Utah. Both resource and social components were included. Belnap (1998) described the process of developing resource indicators for the final VERP implementation plan. Similar procedures were developed for the Yellowstone Winter Use Plan in 1999 (GYWVU 1999).

3. Local Expert Survey

Twelve surveys were completed and returned. Despite the low response rate (16%), information provided by the respondents was helpful in identifying salient resource management concerns and potential problem areas on specific islands. For example, vandalism, unofficial sites and social trails were reported by respondents who also marked problem locations on the park map.

4. Results from Social Science Component

Another source of indicators was considered on the Phase I results of the social science component in which both resource and social indicators were included in the visitor survey. In that survey visitors were asked to indicate whether and the extent to which different social and resource elements add to or detract from the quality of recreation experience. Survey results suggested that trail and campsite impacts were elements that tend to detract from visitor experience (Manning and Budruk 2003)

B. Task 2: Evaluation of Potential Indicators

A substantial group of potential resource indicators were identified based on the above efforts (Table 3.1). These indicators included variables measured on recreation facilities such as recreation sites and trails, common ecological indicators related to visitor impacts (non facility bounded), and integrated indicators such as spatial proximity indices that combine trail/site measuments and locations of RTE species. Field assessment procedures of potential recreation site and trail impact indicators were developed and performed on 22 islands and peninsulas (referred all to as 'islands' hereafter) between June 26 and August 11, 2001 with assistance provided by 26 Earthwatch volunteers. All major islands that had public access were included. The field assessment also included all islands that have possible recreational use and impacts as indicated from the local experts survey or park staff.

1. Recreation Sites

A total of 144 recreation sites were assessed in 2001, including 82 official sites and 21 unofficial sites. Forty-one small viewing/rest areas were also assessed. Table 3.2 describes the distribution of sites on all islands. Georges and Outer Brewster Islands have most of the picnic sites. On the other hand, official campsites are located only on Bumpkin, Grape, Lovells, Peddocks and Thompson Islands. Visitor-created unofficial campsites were identified and assessed on 11 islands, especially on Rainsford (7) and Langlee Islands (3). Rest/viewing areas (sites with only a bench) are provided on 7 islands, particularly on World's End (17), Webb State Park (9) and Grape Islands (5).

As indicated by Figure 3.1 to Figure 3.6, the majority of recreation sites were in good resource conditions. Table 3.3 summarizes results on recreation site sizes. The aggregate size or disturbed area due to recreation site development was about 508,000 sq. ft or 11 acres. Sizes of recreation sites varied, with official sites contributing to more than 90% of the overall total site size for the entire park. The majority of disturbed areas were related to official picnic sites and, to a lesser extent, official campsites. Disturbed areas due to unofficial campsites were small, but they are distributed throughout BOHA islands. There were several very large official sites on Georges, Lovell, Peddocks and Bumpkin Island. Large unofficial sites also existed, but they were smaller than official sites. Large official sites may not be considered as a resource impact issue if they are actively maintained and the condition of those sites is stable. The existence and size of unofficial sites, however, should be a management concern requiring control measures.

Soil exposure seems to be higher on unofficial recreation sites, with about 30% of unofficial sites exhibiting 63% or more exposed soil on site. This indicates a potential resource impact concern. In contrast, about 30% of official sites had 38% or more exposed soil (Figure 3.3). Another way to evaluate soil exposure on recreation sites is based on the areal extent of soil exposure. This measure can be derived from percent soil exposure multiplied by site size. Table 3.9 shows that exposed mineral soil on recreation sites amounted to 53501 sq. ft or 1.23 acres or about 10.5% of all cumulative area of disturbance due to recreation development (Table 3.3). Most of the area of soil exposure occurred on official day-use (48%) and camping sites (39.2%), while unofficial sites contributed only a small portion of exposed soil problem from an areal perspective.

Table 3.1. List of potential indicators evaluated for BOHA carrying capacity study (resource component).

Types of Resources	Potential Indicators Evaluated	Suggested Indicators
General Land Resources	Vegetative groundcover change; Bare patches; Mineral soil exposure; Soil compaction (penetration resistance); Soil stability (slake test)	* Relative change in soil compaction
Unofficial Recreation Sites	Number of sites, Area of disturbance (site size), Condition class; Vegetative groundcover change; Mineral Soil exposure; Tree stumps or cut trees; Tree damage (trunk); Social trails radiating from site; Trash/litter; Human waste; Vandalism (occurrence, type, location, extent, loss of functionality); Spatial proximity indicator (total number of unofficial sites are close to known locations of RTE species)	**** Area Of Disturbance (Site Size) (in sq. ft)*** * Soil exposure * Tree damage
Unofficial/ Social Trails	Sum of length; Number of trail offshoot points; Density (Length/island area); Condition class rating; Length in poor condition classes (3-4); Spatial proximity indicator (Total length of social trails that are close to known locations of RTE species)	**** Density Of Social Trail (Sum of length per Island Area (in ft/acre)***
Official Recreation Sites	Number of sites; Area of disturbance (site size); Condition class; Vegetative groundcover change; Mineral Soil exposure; Tree stumps or cut trees; Tree damage (trunk); Social trails radiating from site; Trash; Human waste; Vandalism on and around site (occurrence, type, location, extent, loss of function); Spatial proximity indicator (Total number of sites that are close to known locations of RTE species)	**** Mineral Soil Exposure (in %)*** * Tree damage
Rest/Viewing Areas or Overlooks	Number of sites; Area of disturbance (site size); Condition class; Vegetative groundcover onsite; Mineral Soil exposure; Trash; Human waste; Vandalism on and around site (occurrence, type, location, extent, loss of function)	
Official Trails	Sum of length; Density (Length/island area); Bare patches (unpaved trails only); Soil erosion on tread (unpaved trails only); Tree root exposure (unpaved trails only); Muddy soil on tread (unpaved trails only); Running water on trail tread; Multiple parallel treads; Pavement condition rating (paved trails only); Vandalism along trail corridor (occurrence, type, location, extent, loss of function); Spatial proximity indicator: Total length of official trails falling within ecologically sensitive zones	**** Length of Eroded Tread on Unpaved Trails (sum of segments that have > 1ft of incision for mre than 10 ft in extent) (in ft)***

* Final recommendation for BOHA-VERP implementation.

Table 3.2. Number of recreation sites by type.

Island	Type of Recreation Sites				Island Sum
	Official Picnic Sites	*Official Campsites*	*Unofficial Sites*	*Rest/ Viewing Areas*	
Bumpkin	5	13	0	3	21
Button	0	0	1	0	1
Calf	0	0	1	0	1
Georges	8	0	0	3	11
Grape	3	14	0	5	22
Great Brewster	7	0	0	2	9
Green	0	0	0	0	0
Langlee	0	0	3	0	3
Little Brewster	2	0	0	2	4
Lovells	3	12	1	0	16
Middle Brewster	0	0	0	0	0
Outer Brewster	0	0	1	0	1
Peddocks	0	5	0	0	5
Raccoon	0	0	2	0	2
Ragged	0	0	1	0	1
Rainsford	0	0	7	0	7
Sarah	0	0	1	0	1
Sheep	0	0	0	0	0
Slate	0	0	2	0	2
Thompson	3	5	0	0	8
Webb State Park	2	0	0	9	11
World's End	0	0	1	17	18
TOTAL	**33**	**49**	**21**	**41**	**144**

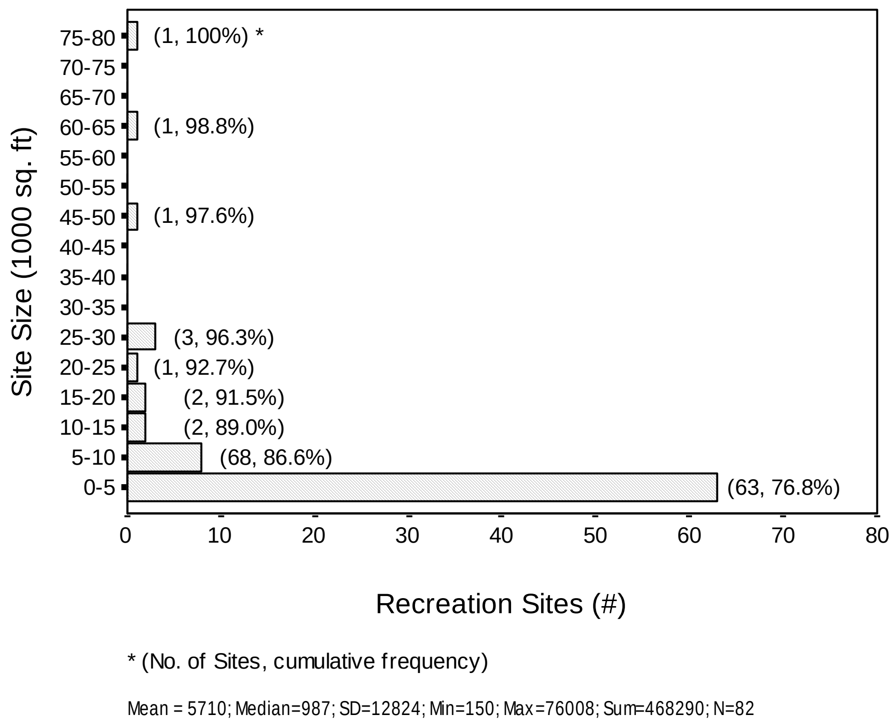


Figure 3.1. Frequency distribution and descriptive statistics for recreation site size (Official recreation sites).

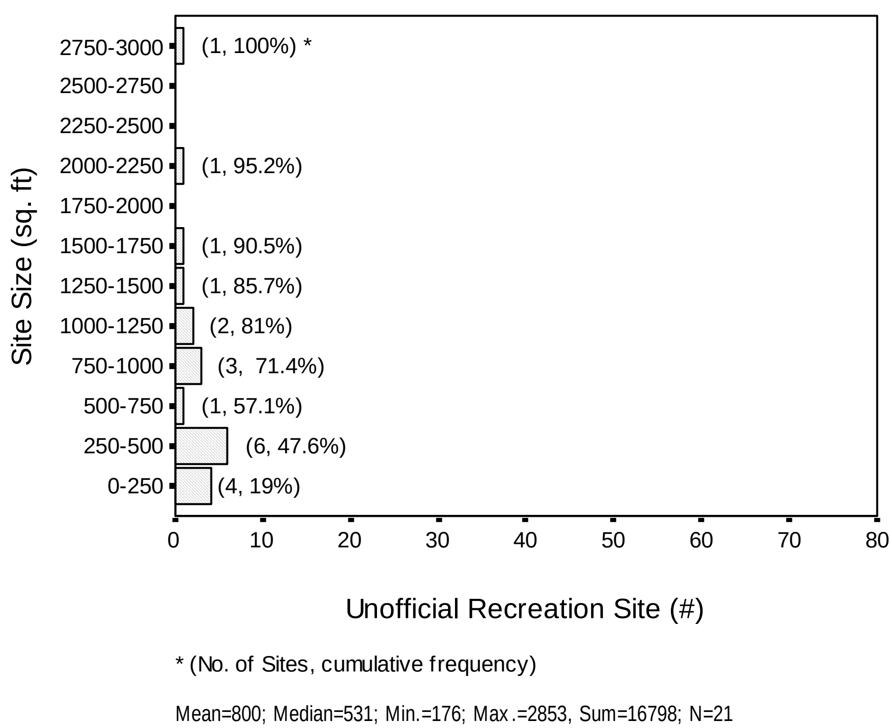


Figure 3.2. Frequency distribution and descriptive statistics for recreation site size (Unofficial recreation sites).

Table 3.3. Summary of areas of disturbance (recreation site sizes) (sq. ft) on BOHA islands.

Island	Type of Recreation Sites								Island Sum
	Official Picnic Sites		*Official Campsites*		*Unofficial Sites*		*Rest/Viewing Areas*		
	Median	**Sum**	**Median**	**Sum**	**Median**	**Sum**	**Median**	**Sum**	
Bumpkin	1871	16051	310	9543	--	--	50	150	25744
Button	--	--	--	--	250	250	--	--	250
Calf	--	--	--	--	1087	1087	--	--	1087
Georges	17158	213166	--	--	--	--	380	3814	216980
Grape	3900	15705	607	10839	--	--	180	1130	27674
Great Brewster	1800	17281	--	--	--	--	265	530	17811
Langlee	--	--	--	--	313	2190	--	--	2190
Little Brewster	669	1338	--	--	--	--	466	932	2270
Lovells	3584	13335	879	44098	840	840	--	--	58273
Outer Brewster	--	--	--	--	176	176	--	--	176
Peddocks	--	--	18670	110452	--	--	--	--	110452
Raccoon	--	--	--	--	366	732	--	--	732
Ragged	--	--	--	--	453	453	--	--	453
Rainsford	--	--	--	--	1157	9109	--	--	9109
Sarah	--	--	--	--	254	254	--	--	254
Slate	--	--	--	--	427	853	--	--	853
Thompson	358	1248	--	5281	--	--	--	--	6529
Webb SP	4975	9950	--	--	--	--	157	3558	13508
World's End		--	--	--	855	855	400	13344	14199
TOTAL	--	288076	--	180214	--	16798	--	23458	**508,546**

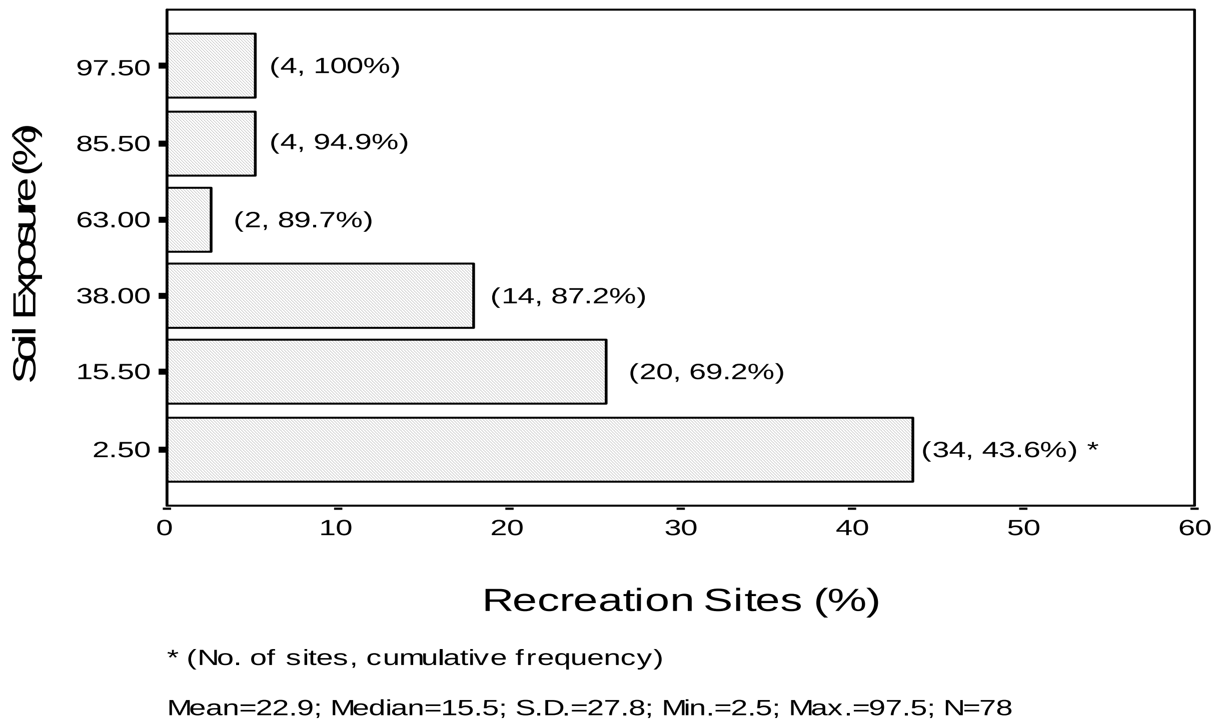


Figure 3.3. Frequency distribution and descriptive statistics for soil exposure (Official recreation sites).

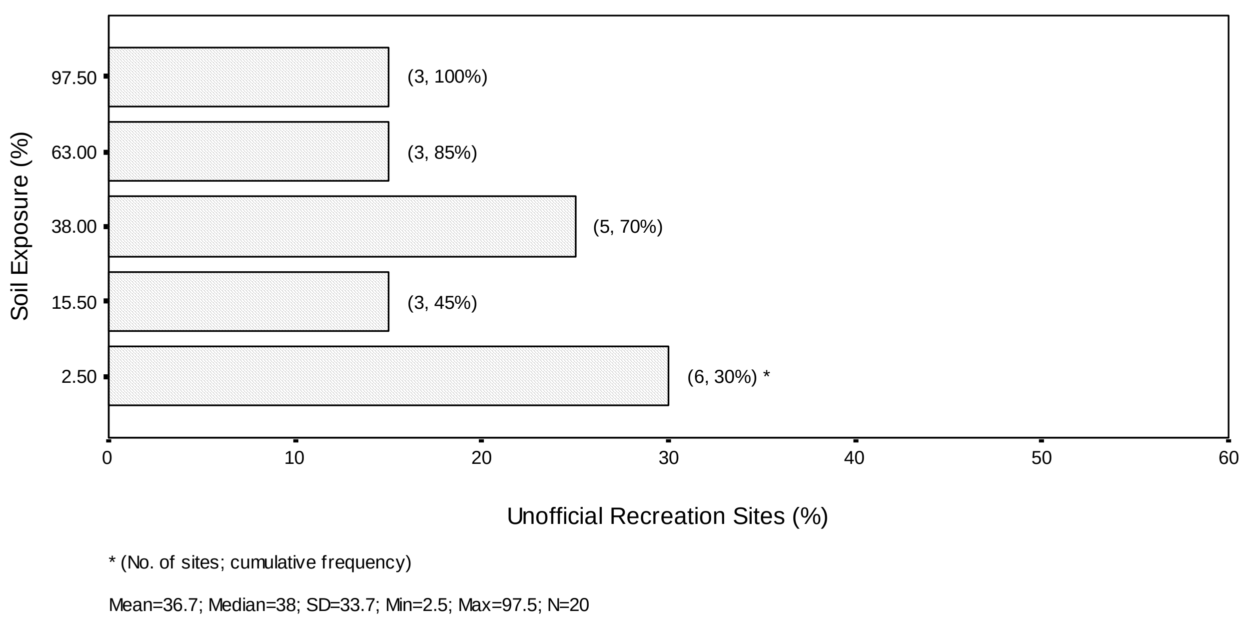


Figure 3.4. Frequency distribution and descriptive statistics for soil exposure (Unofficial recreation sites).

Table 3.4. Exposed mineral soil (percent) on recreation sites by site type.

Island	**Type of Recreation Sites**							
	Official Picnic Sites		*Official Campsites*		*Unofficial Sites*		*Rest/Viewing Areas*	
	Mean	Med.	Mean	Med.	Mean	Med.	Mean	Med.
Bumpkin	5.1	2.5	10.9	9.0	--	--	11.2	15.5
Button	--	--	--	--	63.0*	n/a	--	--
Calf	--	--	--	--	2.5*	n/a	--	--
Georges	13.4	15.5	--	--	--	--	2.5	2.5
Grape	2.5	2.5	26.6	15.5	--	--	5.1	2.5
Great Brewster	12.6	2.5	--	--	--	--	2.5*	n/a
Langlee	--	--	--	--	47.2	63.0	--	--
Little Brewster	20.3*	n/a	--	--	--	--	9.0*	n/a
Lovells	6.8	2.5	39.5	38.0	2.5*	n/a	--	--
Outer Brewster	--	--	--	--	15.5*	n/a	--	--
Peddocks	--	--	9.6	2.5	--	--	--	--
Raccoon	--	--	--	--	20.3*	n/a	--	--
Ragged	--	--	--	--	2.5*	n/a	--	--
Rainsford	--	--	--	--	44.9	38.0	--	--
Sarah	--	--	--	--	97.5*	n/a	--	--
Slate	--	--	--	--	38.0*	n/a	--	--
Thompson	50.3	38	59.9	63.0	--	--	--	--
Webb SP	50.5*	n/a	--	--	--	--	32.5	15.5
World's End	--	--	--	--	15.5*	n/a	16.9	15.5
Overall Mean/Median	**16.9**	**2.5**	**27.1**	**15.5**	**36.7**	**38.0**	**16.2**	**2.5**

* Less than 3 observations; no median values available.

Assessment results show that the problem of tree trunk damage was not serious currently. Official sites typically have 2 trees with some damage on tree trunk related to visitor use, while official sited typically have only 1 damaged tree. Exposed tree roots are not common on BOHA islands. Trees with moderately or seriously exposed roots existed on five islands (Bumpkin, Georges, Grape, Peddocks and Sararh), four of which are public use islands.

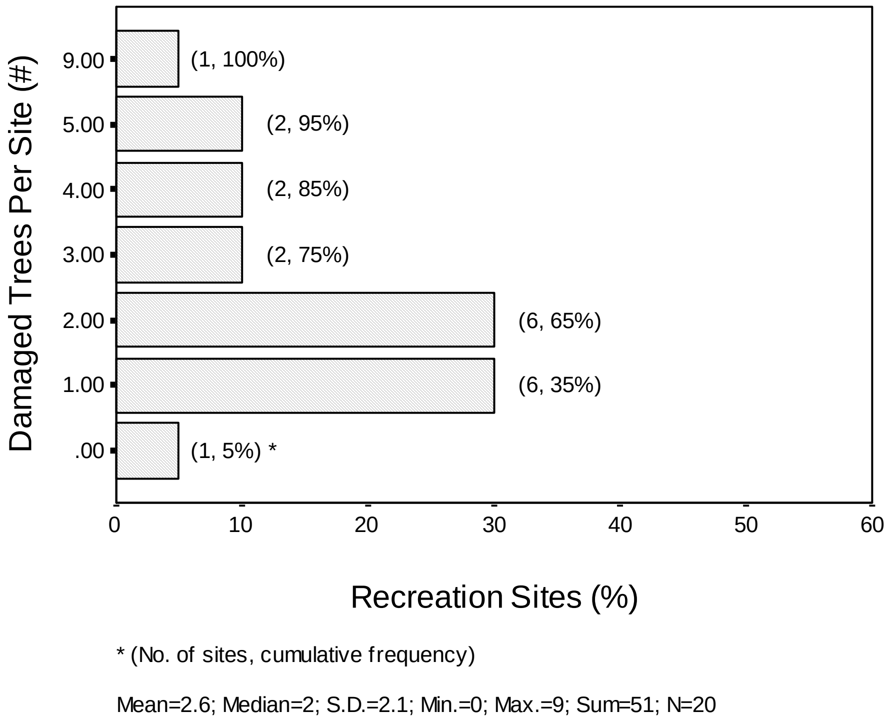


Figure 3.5. Frequency distribution and descriptive statistics for tree damage (Official recreation sites).

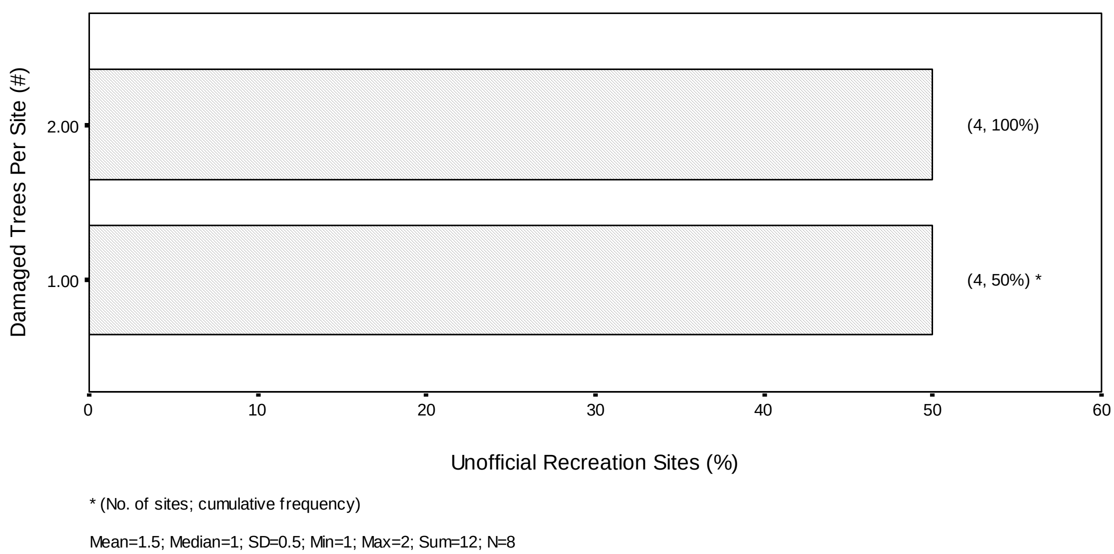


Figure 3.6. Frequency distribution and descriptive statistics for tree damage (Unofficial recreation sites).

Table 3.5. Number of damaged trees (on trunks) on recreation sites by site type.

Island	**Type of Recreation Sites**						**Island Sum**
	Official Picnic Sites		*Official Campsites*		*Unofficial Sites*		
	Median	Sum	Median	Sum	Median	Sum	
Bumpkin	2	3	1	7	--	--	10
Button	--	--	--	--	0*	0	0
Calf	--	--	--	--	0*	0	0
Georges	2	6	--	--	--	--	6
Grape	2	2	2	11	--	--	13
Great Brewster	0	0	--	--	--	--	0
Langlee	--	--	--	--	1	2	2
Little Brewster	0*	0	--	--	--	--	0
Lovell's	0	0	2	8	2*	2	10
Outer Brewster	--	--	--	--	0*	0	0
Peddock's	--	--	0	11	--	--	11
Raccoon	--	--	--	--	1.5*	3	3
Ragged	--	--	--	--	0*	0	0
Rainsford	--	--	--	--	2	2	2
Sarah	--	--	--	--	0*	0	0
Slate	--	--	--	--	1*	1	1
Thompson	0	0	0	0	--	--	0
Webb SP	3*	3	--	--	--	--	3
World's End	--	--	--	--	2*	2	2
TOTAL	**--**	**14**	**--**	**37**	**--**	**12**	**63**

* Less than 3 observations; no median values available.

Table 3.6. Condition class ratings of recreation sites on BOHA islands (by site type).

Condition Class	Type of Recreation Sites								All Sites (143)	
	Official Picnic Sites (33)*		*Official Campsites (49)*		*Unofficial Sites (21)*		*Rest/Viewing Areas (40**)*			
	Sites (#)	**%**	**Sites (#)**	**%**	**Sites (#)**	**%**	**Sites (#)**	**%**	**Sites (#)**	**%**
Class 1	1	3.0	6	12.2	4	19.0	5	12.5	16	11.2
Class 2	21	63.7	20	40.9	4	19.0	19	47.5	64	44.7
Class 3	7	21.2	15	30.6	7	33.4	10	25.0	39	27.3
Class 4	4	12.1	8	13.3	5	23.8	4	10.0	21	14.7
Class 5	0	0	0	0	1	4.8	2	5.0	3	2.1

* Total number of sites.
** Condition class rating is not applicable to one rest/viewing area and it was excluded from the analysis.

The majority of recreation sites were in good conditions, indicated by their low condition class ratings (Table 3.6). For example, seventy percent of official picnic sites had a condition class of 1 or 2. Higher percentage of unofficial sites (28.6%) was assigned as class 4 or 5 sites, indicating higher level of resource impacts on these illegal sites.

Table 3.7. On-site vegetative ground cover by type of recreation sites.

Site Type (# of Sites)	On-Site Vegetative Ground Cover (%)		
	Mean	*Median*	*Standard Deviation*
Official Picnic Sites (33)	72.5	85.5	30.1
Official Campsites (49)	64.0	85.5	32.8
Unofficial Sites (21)	44.3	38.0	34.4
Rest/Viewing Areas (40*)	76.9	85.5	27.4

** Condition class rating is not applicable to one rest/viewing area and it was excluded from the analysis.

All official recreation sites possessed good amount of vegetative ground cover. However, unofficial sites tend to have less on-site vegetation groundcover, with a median value of 38% as compared to 85% on official sites (Table 3.7). This finding agrees with the condition class results presented above.

Change in vegetative groundcover can be measured in absolute and relative terms. Absolute change is derived from the difference between off-site and on-site cover, while relative change is derived from the difference between off-site and on-site cover divided by the off-site cover. Relative change values can be used to compare among sites with varying background vegetative cover. As expected all recreation sites show decline in vegetative ground cover, though unofficial sites exhibit higher level of vegetation less on both absolute and relative terms (Table 3.8).

Table 3.8. Absolute and relative changes of vegetative ground cover on recreation sites.

Indicator	Type of Recreation Sites		
	Official Picnic Sites	*Official Campsites*	*Unofficial Sites*
Absolute groundcover change (%)*			
Mean	-22.1	-27.7	-43.0
Median	-12.0	-12.0	-35.5
S.D.	27.7	36.0	40.6
Relative groundcover change (%)**			
Mean	-24.4	-26.1	-43.6
Median	-12.3	-12.3	-55.6
S.D.	30.6	45.3	59.2

* Difference in ground vegetation cover between recreation site and its off-site control. Negative values indicate vegetation loss.
** Absolute change in coverage of ground vegetation as a percentage of 'initial' ground cover at off-site control.

Results of other impact indicators on recreation sites are presented in Table 3.9. Tree stumps existed on both official and unofficial sites, and extent of social trails radiating from these sites are comparable to each other. However, the amount of trash on unofficial sites was much greater than that on official sites, partly due to presence of trash disposal facilities on official sites. Human waste problem is almost non-existent in this study area.

Table 3.9. Assessment results of area of soil exposure, tree stumps, social trails (from sites), trash and human waste on and around recreation sites.

Indicator	Type of Recreation Sites								
	Official Picnic Sites (n=32)			*Official Campsites (n=46)*			*Unofficial Sites (n=20)*		
	Mean	**Median**	**Sum**	**Mean**	**Median**	**Sum**	**Mean**	**Median**	**Sum**
Area of soil exposure (sq. ft)*	804.7	139.8	25751	455.5	226.0	20952	339.9	136.4	6798.2
Tree stumps (#)	0.13	0	4	0.47	0	22	0.65	0	13
Social trails (#)	2.0	2.0	67	1.7	2	82	2.4	2	51
Trash (gallons)	0.76	0	25	0.77	0	37.5	2.76	2.5	52.5
Human waste (# of incidents)	0	0	0	0	0	0	0.05	0	1

* The product of percent soil exposure and site size (i.e., exposure% x size)

2. Vandalism Indicators

The 2001 assessment developed a number of physical measures on vandalism and this section reports results on this area. More vandalism events occurred on official sites, with carving and graffiti being the most common causes (Figure 3.7 and Table 3.6). The majority of events occurred on picnic tables and trees (Table 3.7). The extent of disturbance and actual effects on the functionality of facilities or resources due to vandalism events were relatively small (Figure 3.8 and 3.9).

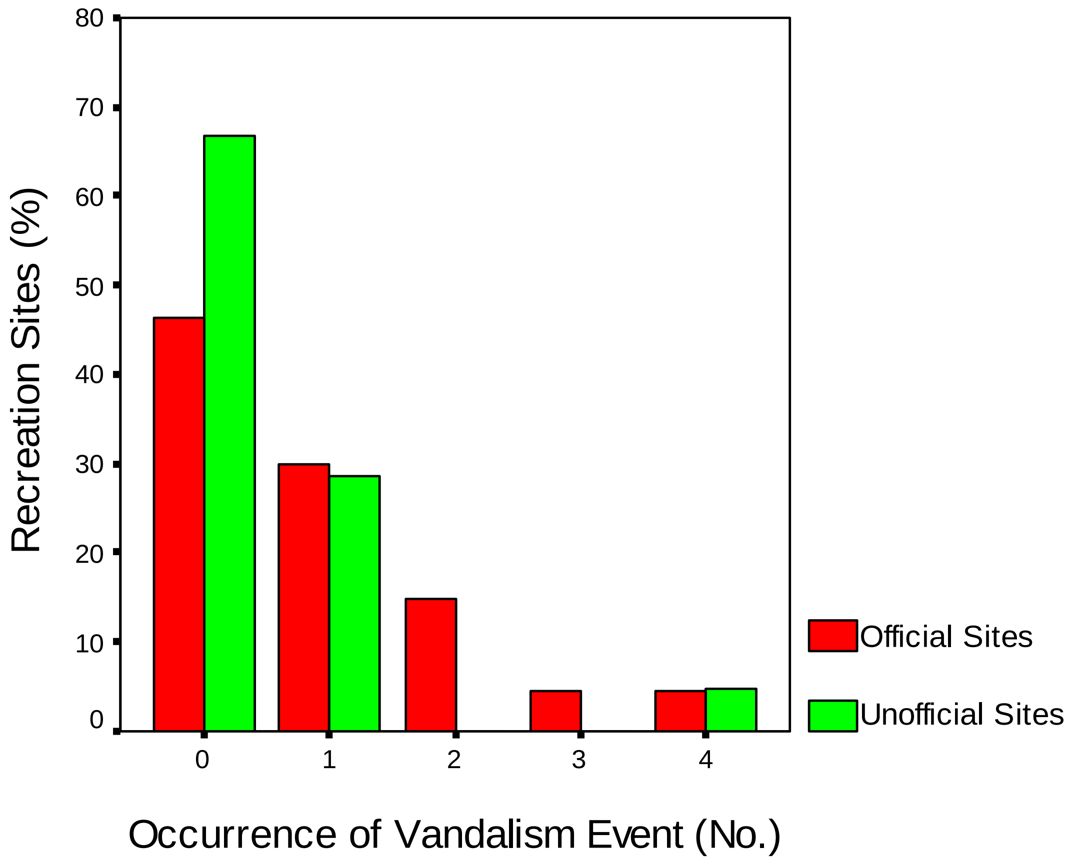


Figure 3.7. Occurrence of vandalism events.

Table 3.6. Type of Vandalism.

Type	Official Sites		Unofficial Sites		Total
	No.	%	No.	%	
Physical Alteration	4	6.0	5	23.8	9
Carving	24	35.8	0	0	24
Fire	4	6.0	1	4.8	5
Graffiti/painting	13	19.4	2	9.5	15
Attachment	1	1.5	0	0	1
Scratching	2	2.4	0	0	2

Table 3.7. Location of Vandalism.

Location	Official Sites		Unofficial Sites		Total
	No.	%	No.	%	
Tree	6	9.0	5	23.8	11
Rock	1	1.5	2	9.5	3
Bench	3	4.5	N/A	N/A	3
Picnic Table	26	37.3	N/A	N/A	15
Sign	1	1.5	N/A	N/A	1
Minor Structure	2	2.4	N/A	N/A	2
Toilet	3	4.5	N/A	N/A	3
Sun Shade	1	1.5	N/A	N/A	1
Building	2	2.4	N/A	N/A	2
Others	2	2.4	0	0	2

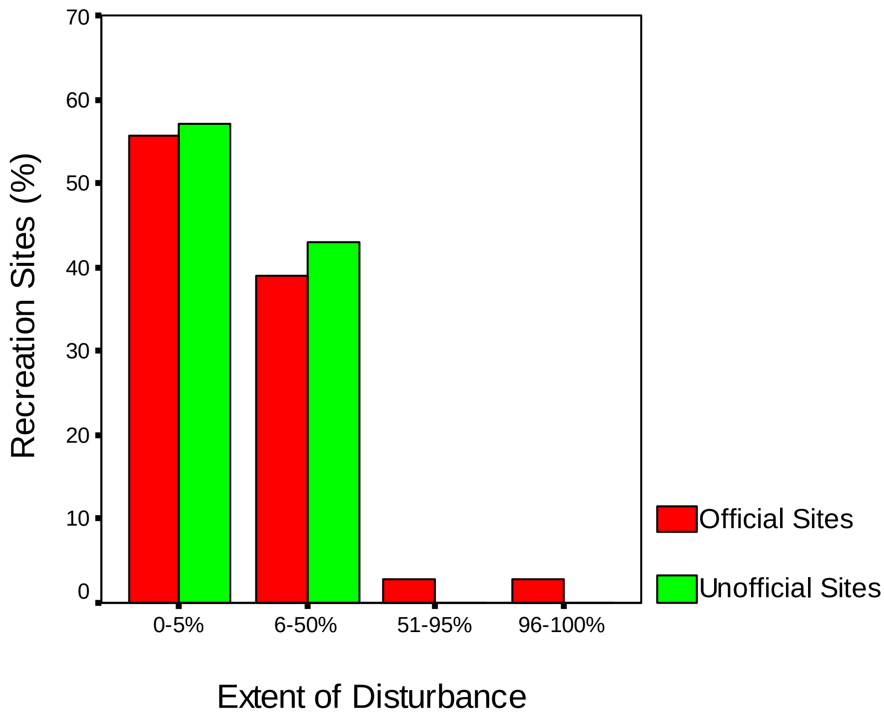


Figure 3.8. The extent of disturbance (proportion of reachable surface affected) due to vandalism events.

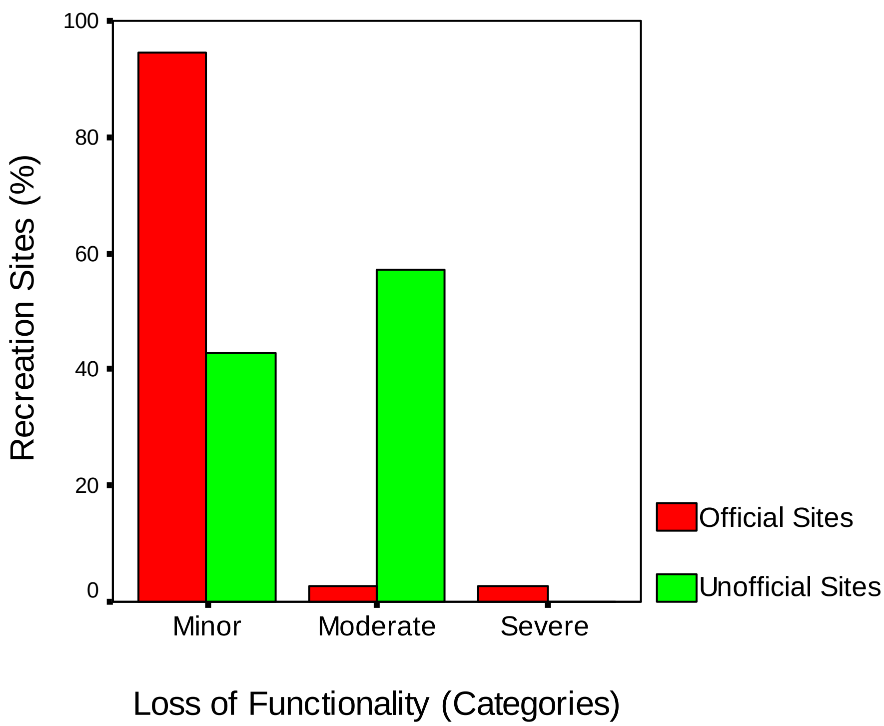


Figure 3.9. Loss of functionality of the facility or resource due to vandalism events.

3. Trails

Ninety-one official trails (19 miles) were assessed. Locations of all trail sampling points, trail problem events were mapped using GPS. Tables 3.8 and 3.9 present the overall and island-by-island results of problem assessment on official trails. There were 15 occurrences of soil erosion as defined by the procedures (1 ft incised for at least 10 ft long), affecting 1,228 ft of park trails. Such an extent of tread erosion is not serious as compared to other studies (Hammitt and Cole 1998; Leung and Marion 2000; Marion and Leung 2001). Thompson Island and Webb State Park seem to have more presence of soil erosion and muddy soil on trail treads (Table 3.9).

Table 3.8. Overall results of official trail assessment on BOHA islands.

Trail Tread Problem	No. of Occurrences	Length of Problem Segments (ft)				
		Mean	*Minimum*	*Maximum*	*Std. Dev.*	*Sum*
Bare Batches	5	39.2	8	72	27.4	196
Soil Erosion	15	81.9	5.0	271	90.2	1228
Root Exposure	10	35.6	18	70	20.0	356
Wet Muddy Tread	12	15.0	5	24	6.3	180

Table 3.9. Results of official trail assessment by island.

Island	Length of Unpaved Trails Assessed (ft)	Bare Patches		Soil Erosion		Root Exposure		Wet Muddy Tread	
		Sum (ft)	*ft/mile*	*Sum (ft)*	*ft/mile*	*Sum (ft)*	*ft/mile*	*Sum (ft)*	*ft/mile*
Grape	7618	0	0	0	0	0	0	0	0
Great Brewster	2699	196	398	15	30.4	0	0	24	47.0
Peddocks	12,179	0	0	10	4.3	0	0	0	0
Thompson	9849	0	0	581	311.5	0	0	96	51
Webb SP	5556	0	0	204	194	0	0	53	50
World's End	25804	0	0	418	85.5	356	72.8	7	2

More than 123,000 linear feet of social trails (23 miles) on 14 different islands were assessed and mapped using GPS. Results show that World's End, Georges Island, Thompson Island and Rainsford Island have substantial presence of social trails. The density of social trails is a more appropriate measure to compare among islands of different size. World's End, Georges Island and Racoon Island had the highest social trail density, which is indicative of the proliferation of visitor impacts and potential effect on natural resources due to such proliferation (Table 3.10). It should be noted that the actual length of social trail on Racoon Island is small, but the island's small size resulted in high density value.

Table 3.10. The extent and density of social trails by island.

Island	Area (acre)	Social Trails	
		Total Length (ft)	***Density (ft/acre)***
Bumpkin	32.7	551	16.9
Calf	22.4	3121	139.3
Georges	41.3	9329	225.9
Grape	53.7	1416	26.4
Langlee	5.2	878	168.8
Lovells	51.9	20	115.0
Outer Brewster	20.1	1673	83.2
Peddocks	210.4	7049	33.5
Racoon	3.6	736	204.4
Rainsford	21.6	5389	27.6
Slate	12.7	1610	126.8
Thompson	169.9	3732	22.0
Webb SP	25.3	2185	86.3
World's End	274.3	75959	276.9
		Sum = 123153 ft	

The relationship between social trail (ST) branch-off or offshoot points and total length of social trail was examined for 9 islands with sufficient social trails. Statistical analysis show a strong positive correlation (r=0.726) between social trail points and social trail lengths. The regression model (r square = 0.81) is listed as follows:

ST Length = -4366 + 269 (ST Points)

This finding suggests that for interim or rapid monitoring counting social trail points branching off official trails may be an effective way to estimate the extent of social trails without walking the entire length of social trails, which requires substantial amount of field time. The applicability of such findings beyond this park is yet to be determined.

4. Spatial Proximity Indicators

Attempts were made to develop integrated indicators that combine spatial distribution of visitor impacts and sensitive park resources. GIS layers of sensitive resources were used to overlay with social trails and recreation sites layers. The main advantage of this type of indicators is their utility in providing a more direct measurement of potential threat of visitor use to ecological integrity due to the juxtaposition of visitor impacts and sensitive resources. However, the main disadvantage of this type of indicators is that they are more complex to derive and GIS expertise is required in the process. The selection of buffer size depends on the nature of the rare, threatened and endangered (RTE) species affected and management objectives. The following provides two examples of such indicators.

Table 3.11 shows total length of social trails that exist within 50 or 100 m of known location of RTE plant or animal species. Results show that there are 141 m of social trails within 50 m of RTE species locations. This problem is more severe on Lovells Island where least tern might be affected by social trail use. The length of social trails increased substantially to 690 m if the buffer was extended to 100 m. Proximity of social trails to least tern is evident on Lovells and Rainsford Islands.

Table 3.11. Total length of social trails that is spatially proximate to RTE species*.

Island	**50-meter Buffer**	**100-meter Buffer**	**Species Affected**
Bumpkin	13.2* *	13.2	Seabeach dock
Georges	26.2	135.7	Barn owl
Lovells	101.4	259.0	Least tern
Rainsford	0	260.4	Least tern
Thompson	0	21.9	Seabeach dock
Total	140.8	690.2	---

* Partly based on BOHA Draft Rare Species GIS Database (Ver. Nov. 29, 2001)
** Figures in meters

A similar analysis was performed for unofficial or illegal recreation sites. Table 3.12 displays results of the proximity analysis. Three unofficial sites (2 on Bumpkin and 1 on Lovells) were located with 50 meters of seabeach dock and least tern. When the buffer was extended to 100 meters 14 more unofficial sites were included. The problem seems to be more evident on Bumpkin and Lovells Islands.

Table 3.12. Number of unofficial recreation sites that is spatially proximate to known locations of RTE species.

Island	50-Meter Buffer	100-Meter Buffer	Species Affected
Bumpkin	2	9	Seabeach dock
Georges	0	1	Barn owl
Langlee	0	1	American Sea-blite
Lovells	1	5	Least tern
Rainsford	0	1	Least tern
Total	3	17	

* Partly based on BOHA Draft Rare Species GIS Database (Ver. Nov. 29, 2001)

5. Soil Quality and Ground Cover Indicators

i. Soil Compaction

The Beginning of Use Season

High use plots started with higher PR values on both islands in June. On Georges Island (Ud soil), the mean PP-PR was 3.0 kg/cm^2 for high use plots and 2.1 kg/cm^2 for low use plots. The relative PR change based on PP was 54.3% for high use plots and 53.0% for low use plots. On the other hand, the mean SCT-PR was 31.6 kg/cm^2 for high use plots and 18.8 kg/cm^2 for low use plots. The relative PR change based on SCT readings was 66.4% for the high use area and –0.05% for low use area, indicating essentially the same PR level between use and control sites in the latter case.

PR values as measured by both penetrometers were lower on Grape Island (NpC/PtB soil). For example, the mean PP-PR was 2.0 kg/cm^2 for high use plots and 1.5 kg/cm^2 for low use plots. According to the relative PR difference, use sites on Grape Island actually had more substantial compaction change as compared to their off-site controls. For example, relative PR changes for PP were 85.9% and 143.5% for high and low use plots respectively, while those for SCT were 111.7% and 53.5%.

With respect to variability of PR measurements, results were comparable between the two soil types, with CV values ranging from 23.1% to 37.1% on Georges Island (Ud) and 31.2% to 42.1% on Grape Island (NpC/PtB). The measurements on high-use Ud plots (Georges) showed less variability while the NpC/PtB plots (Grape) exhibited a reverse pattern. Pocket penetrometer readings appeared to have a higher variability than SCT readings in most cases, particularly on Grape Island.

The End of Use Season

All Georges Island plots were reassessed in October 2002. Due to inclement weather conditions, only one high use plot and one low use plot were remeasured on Grape Island, resulting in less number of readings. Consistent with June data, high PR values were recorded on high use sites based on both penetrometers. On Georges Island, The PP mean was 2.3 kg/cm^2 for high use plots and 1.6 kg/cm^2 for low use plots, both of which were lower than the beginning of season. The relative PR changes based on PP were 35.4% and 60.9% for high and low use plots. The SCT-PR mean for the high use plot was 23.7 kg/cm^2 and 24.5 kg/cm^2 for the low use plot. The relative PR changes were 21.3% and 25.9% for high and low use plots.

On Grape Island, the PP-PR mean was 2.4 kg/cm^2 for the high use plot and 1.8 kg/cm^2 for the low use plot. These values were higher than the June values. The relative PR changes based on PP were 34.8% and 42.7% for the high and low use plots, which were lower than the June values. The SCT results showed similar patterns on this island.

Both soil types exhibited a higher variability of PR measurements at the end of use season, with CV values ranging from 26% to 51.7% for George Island and 17.5% to 35.9% for Grape Island. In the Ud soil type (Georges) there was the same pattern where high use sites exhibited less variability, while in the NpC/PtB soil type (Grape) there was less variability on low use sites. Quite consistently, PP showed a higher degree of variability than SCT in both soil types.

Penetration Depths

These measurements were applicable to only SCT. The results suggest that soil was generally less penetrable on high use sites and on Georges Island (Ud), on which most of the SCT measurements were not able to reach the depth of 15.6 cm. At the 7.6 cm level there was a decreasing trend in penetration depth from the beginning of use season (83.3-95.8%) to the end of season (68.8-79.2%). Soil was more penetrable on Grape Island (NpC/PtB soil). Twenty-four percent to 46% of SCT measurements reached the penetration depth of 15.6 cm. The soil was less penetrable at the 7.6cm level in October, with the percent penetrated decreased from 100% to 85% on the high use site.

There are several other observations from this study. Firstly, the relative PR changes in this study were much lower than those reported in previous studies (e.g., Marion and Cole 1996). This may be related to generally higher PR levels on both use and control areas in BOHA as compared to campsites in Delaware Water Gap (Marion and Cole 1996). Secondly, the PR level of Georges Island was generally higher than that of Grape Island. A number of factors, such as soil type, amount of use (higher visitation on Georges Island), may have contributed to this variation. Thirdly, the high use plots on Georges Island showed less data variability for both penetrometers, whereas less data variability were found on the low use areas on Grape Island. A possible explanation is that soil strength could become more uniform in compacted soil. Finally, the relative PR changes were found to decrease in most cases from June to October, indicating the closing gap of PR between use and control areas. Both decreasing on-site PR values and/or increasing control PR values may have caused this effect.

There are a number of limitations in this study. Only 2 islands and 2 penetrometer types were involved. Bulk density and soil moisture were unavailable to provide more comprehensive comparison. The control areas are not entirely free of human influence and may be subject to limited foot traffic.

While soil compaction has been excluded from the final list of resource indicators for BOHA VERP implementation, this study has provided the park with baseline PR data on three different islands (data on Peddocks Island were not presented here). It seems useful to conduct similar measurements on selected sites that show signs of growing degradation. The PR data can inform management of the need for visitor and/or site management actions to reduce soil compaction and increase soil quality of recreation sites.

ii. Ground Cover

Georges Island

Due to the small sample size the overall observation results cannot be directly compared to the transect and quadrat results through significance tests. As expected, the low use sites have a higher amount of vegetation cover (95%) than the high use sites (77%). The high use sites have a greater percent (15.1%) of bare soil than low use sites (less than 1%). Measuring vegetative ground cover has a variability range of 0.07 to 0.25, which is lower than that of bare ground cover range of 0.93 to 2.60.

For the overall observation method, the high use sites show an indication of recovery with a vegetation increase of 86% to 91% and a soil decrease of 10% to 8% between June and October. Low use sites had more cover in the ‘other’ category because vegetative ground cover decreased from 100% in June to 96%, but soil remained at 0%. There is 0% bare ground in October for both use levels.

Table 3.13 highlights results of the quadrat and transect estimation methods for Georges Island. With all three months combined, the quadrat and transect methods of evaluating vegetation on the low use sites were found to be significantly different by 11%.

Table 3.13. Ground cover estimates on Georges Island using quadrat and transect methods (all months combined).

Groundcover Type/Use Level		Ground Cover Estimates*		Difference between Quadrat Vs. Transect Methods *(T-test significance)*
		Quadrat Method *Mean (S.E.)*	**Line Transect Method** *Mean (S.E.)*	
Vegetative Ground Cover				
	High Use	71.6 (3.4) n = 72	77.0 (4.5) n=36	0.347
	Low Use	81.7 (2.5) n = 72	92.5 (2.5) n=36	**0.003*** **
	Combined Use	76.7 (2.1) n = 144	84.8 (2.7) n=72	0.021**
Bare Ground (Exposed Soil)				
	High Use	3.8 (1.5) n = 72	6.3 (1.3) n=36	0.212
	Low Use	0.9 (0.3) n = 72	0.3 (0.1) n=36	0.082
	Combined Use	2.3 (0.8) n = 144	3.3 (0.7) n=72	0.375

* All values are in percents (%). ** Significant: $p < 0.05$. *** **Significant**: $p < 0.01$

Both the quadrat and transect methods can be used to evaluate bare soil ground cover (Table 3.13). There were no months or use levels that were found to be significantly different. For all months combined, there was a range of significance values of 0.08 to 0.37. When the quadrat and the transect methods are compared, all but one transect mean were higher than that of the quadrat method. In the case of low use levels on bare ground, the transect estimates were slightly lower than that of the quadrat method.

Grape Island

The low use sites have a higher percentage (99%) than the high use sites (92%). The high use sites have a greater amount of vegetation cover (6.5%) than of bare soil than low use sites, less than 1%. Measuring vegetative ground cover has a variability range of 0.02 to .83, which is lower than that of bare ground cover, 1.48 to 2.33. The trends on the high use sites over the three months indicate recovery with vegetation percentage increasing from 93% to 100%. Likewise, soil percentages are decreasing from 5.5% to no visible bare soil. For the low use sites vegetation is at 100% with no bare soil for June and October.

Table 3.14 highlights the significance of the quadrat and transect methods in estimating ground cover on Grape Island. With all three months combined, the quadrat and transect methods of estimating vegetative ground cover were found to be significantly different by 12.2% and 12.5% for high use sites and low use sites, respectively.

Both the quadrat and transect methods can be used to evaluate bare soil ground cover (Table 3.14). There were no months or use levels that were found to be significantly different. For all months combined, there was a range of significance values of 0.16 to 0.66.

There was no pattern found when comparing the quadrat method to the transect method, though two transect means were higher than the quadrat means.

Table 3.14. Ground cover estimates on Grape Island using quadrat and transect Methods (all months combined)

Groundcover Type/Use Level		Ground Cover Estimates*		Difference between Quadrat Vs. Transect Methods *(T-test significance)*
		Quadrat Method *Mean (S.E.)*	**Line Transect Method** *Mean (S.E.)*	
Vegetative Ground Cover				
	High Use	76.0 (3.2) n = 60	88.2 (2.3) n=30	**0.003*****
	Low Use	93.9 (1.3) n = 60	81.4 (3.9) n=29	**0.005*****
	Combined Use	84.9 (1.9) n = 120	84.8 (2.3) n=59	0.969
Bare Ground (Exposed Soil)				
	High Use	6.7 (1.9) n = 60	4.9 (1.3) n=30	0.443
	Low Use	0.1 (0.1) n = 60	0.7 (0.4) n=29	0.160
	Combined Use	3.4 (1.0) n = 120	2.9 (0.7) n=59	0.655

* All values are in percents (%). ** Significant: $p < 0.05$. *** **Significant**: $p < 0.01$

iii. Soil Stability

Soil stability was evaluated as a potential indicator through the slake test (Doran and Jones 1996; USDA 1999). Results show that this measure did not vary much among the sampling sites, ranging from 4.1 to 6.0 (Table 3.15). Soil stability appears to be higher on high use sites in most cases. While soil stability decreased from June to October on Georges Island, Grape Island exhibits the opposite pattern where soil stability actually increased between June and October. Due to its narrow range of values this indicator was determined to be less desirable.

Table 3.15. Results of soil stability assessment by the slake test.

Island/Use Level		**Soil Stability Rating* (S.D.) [n]**	
		June 2002	**October 2002**
Georges	High Use	5.43 (.43) [6]	4.48 (.37) [6]
	Low Use	5.29 (.23) [6]	4.13 (.82) [6]
Peddocks	High Use	5.60 (.47) [6]	N/A
	Low Use	5.25 (.61) [6]	N/A
Grape	High Use	5.57 (.28) [6]	5.85 (.25) [3]
	Low Use	5.40 (.30) [6]	6.00 (.00) [3]

* Based on a 7-point stability rating scale (USDA 1999).

C. Task 3: Final Selection of Indicators and Standards

Based on evaluation of tested indicators using the established criteria (Table 3.16) as well as extensive discussion with the BOHA Planning Committee in association with project consultant Dr. Jeffrey Marion, four indicators were finally selected for adoption in BOHA VERP plan. They are:

1) **The density of social trails,**
2) **The area of disturbance of unofficial recreation sites,**
3) **The extent of eroded treads on official trails**
4) **The extent of exposed mineral soil on official recreation sites.**

Table 3.17 shows the applicability of the selected indicators to individual islands. The decision was based on environmental characteristics and sensitivity of resources on island, public accessibility of island, amount of visitor use, and the current level of visitor resource impacts. Standards associated with each indicator were recommended (Table 3.18) by the BOHA planning committee based on a series of workshops and dialogue in which the investigators were involved. Table 3.19 provides a format useful for inclusion in the carrying capacity guidelines being developed by BOHA. It shows current condition and proposed standard for individual islands on each selected indicator. A comparison between current condition and proposed standard suggests that management actions may be needed for several islands where current conditions exceed the corresponding standard by far. Alternatively, discussion is needed on the alternative and appropriate measures to bring all islands within standards. For example, some of the social trails might be designated as official trails if they are determined to be distributed in resistant locations and these trails are important routes for visitors to access recreation sites.

Table 3.16. Evaluation matrix of potential resource-based indicators.

Table 1. Evaluation Matrix of Potential Resource-based Indicators.

SELECTION CRITERIA*	POTENTIAL RESOURCE INDICATORS											
	Social trails		*Trail conditions*	*Unofficial Rec. sites*	*Rec. site conditions*	*Proximity to sensitive resources*	*Groundcover composition*		*Soil Quality*		*Human litter (trash)*	*Vandalism*
	Extent/density	*Distribution*					*Vegetative*	*Bare soil*	*Compaction*	*Aggregate stability*		
Low measurement impacts	+	+	+	+	+	+	+	+	+	+	+	+
Reliable/Repeatable	+	+	+	+	+	+	+	+	+	+	0	0
Correlation with use	+	+	+	+	+	0	+	+	+	-	+	+
Ecologically or socially relevant	+	+	+	+	+	+	+	+	+	+	0	0
Respond to impacts	+	+	+	+	+	+	+	+	+	+	+	?
Respond to management	0	0	+	+	+	+	+	+	+	+	+	+
Easy to measure	+	0	+	+	+	0	+	+	+	+	0	-
Low natural variability	+	+	+	+	+	+	-	0	0	0	?	n.a.
Large sampling window	+	+	+	+	+	+	+	+	+	+	+	+
Cost effective	0	0	0	0	0	0	+	+	+	+	+	+
Easy to train for monitoring	0	0	+	+	+	0	+	+	+	+	0	0
Baseline data	0	0	+	0	+	+	-	-	-	-	-	-
Response over different conditions	+	+	0	+	0	?	+	+	+	+	-	-
Recommended for BOHA-VERP implementation**	✓✓	?	✓	✓✓	✓✓	?	✗	✓	✓	✗	✗	✗

* The first 4 criteria are required while the other 9 are desirable criteria. These criteria were adapted from previous VERP studies (Belnap, 1998; Greater Yellowstone Winter Visitor Use Management Working Group, 1999).

\+ = criterion satisfied 0 = criterion partially satisfied (or varies by zone/area) - = criterion not satisfied ? = questionable/undecided

n.a. = not applicable

✗ = not recommended ✓ = recommended ✓✓ = highly recommended ? = questionable/undecided

Table 3.17. Applicability of selected four resource indicators to individual islands.

Island	Recommended Resource Indicators			
	Density of Social Trails (ft/acre)	Area Disturbed by *Unofficial* Recreation Sites (sq ft)	Bare Soil Exposure on Recreation Sites (%)	Eroded Tread Surface on Unpaved *Official* Trails (ft/mile)**
*Bumpkin**	X	X	X	
Button	X	X		
Calf	X	X		
*Georges**	X	X	X	
Grape	X	X	X	X
*Great Brewster**	X	X	X	X
Green	X	X		
Langlee	X	X		
*Little Brewster**	X	X	X	
Little Calf	X	X		
*Lovells**	X	X	X	
Middle Brewster	X	X		
Outer Brewster	X	X		
*Peddocks**	X	X	X	X
Raccoon	X	X		
Ragged	X	X		
Rainsford	X	X	X	
Sarah	X	X		
Sheep	X	X		
Slate	X	X		
*Thompson**	X	X		X
*Webb State Park**	X	X	X	X
*World's End**	X	X		X

A symbol 'X' denotes that the indicator is applicable to the island.
* Island (and peninsula) with current public access.
** Indicators in shade were selected in the first round and were excluded from the final consideration.

Table 3.18. Final Selection of Resource Indicators* -- Justification and Monitoring Strategy

This table provides justification and detailed information on four selected resource indicators in a format useful to be incorporated into the park's carrying capacity guidelines. While *tree damage on recreation sites and relative soil compaction on recreation site* are not included in the final recommendation, they should be considered at a less-frequent monitoring cycle (every 3-5 years) if funding and human resources permit.

Indicator	Measure and Unit	Justification of Indicator	Applicability to Mgt. zones	Monitoring Strategy		Justification of Standards
				Method	***Frequency***	
Density of Social Trails	Cumulative length of social trail segments divided by island area (feet/acre)	1) Ecological Significance • Vegetative groundcover damage and soil exposure • Potential for soil erosion on exposed trail treads, particularly on dunes and steep slopes • Penetration into sensitive resources such as habitats of RTE species without planning and management control 2) Social/Managerial Significance • Detract from visitor experience (visual impacts, safety concern) • Often at poor locations • Evidence of lack of management • Increased management cost 3) Logistics/Feasibility • Low cost • Limited training required • Low measurement impacts	Applied to all zones. However, it is especially important for *natural feature emphasis* and *managed landscape emphasis* zones.	Field mapping & assessment of social trails with a GPS unit. Resource condition of each social trail segment is assessed using a 4-point condition class rating scale (adapted from Cole et al., 1997).	1-2 years (Interim assessment can be performed by tallying number of social trail offshoot points)	1) Natural Feature Emphasis/Historic Preservation Zones: Social trails are fundamentally unacceptable (max. std.=0), but minimal extent is tolerable on less-sensitive islands (min. std.=0-10) 2) Managed Landscape Emphasis: Minimal extent of social trails is acceptable (max. std.=10), but they should not exceed 0.1% of an island's area (min. std.=50) 3) Multiple Use Emphasis: Some extent of social trails is expected (min. std.=50) due to heavy visitor use. However, the extent should not exceed 1% of an island's area (max.=500)

Area of Disturbance on Unofficial Recreation Sites	Cumulative size of unofficial day and overnight recreation sites (square feet)	1) Ecological Significance • Direct loss of habitats • Vegetative groundcover damage • Potential for soil erosion • Penetration into sensitive resources such as habitats of RTE species without planning and management control 2) Social/Managerial Significance • Detract from visitor experience (visual impacts, trash, possible human waste) • Invite further use • Often at poor locations • Evidence of lack of management • Increased management cost 3) Logistics/Feasibility • Low cost • Limited training required • Low measurement impacts	Applied to all zones. However, it is especially important for *natural feature emphasis* and *managed landscape emphasis* zones	Apply established recreation site assessment procedures (adapted from Marion 1991 and Leung and Marion, 1998). Site size is estimated using the geometric figure method.	1-2 years (Interim assessment can be performed by tallying number of unofficial sites or assessing a selected sample of sites)	1) Natural Feature Emphasis/Historic Preservation Zones: Unofficial recreation sites are fundamentally unacceptable (min. std.=0, max. std.=0). However, for islands where unofficial sites already exist, the amount of impacts should not be allowed to expand beyond the current condition (Button, Outer Brewster, Ragged, Sarah), or in some cases should be reduced because of degrading site conditions (Calf, Langlee, Raccoon, Rainsford, Slate, World's End). 2) Managed Landscape Emphasis/Multiple Use Emphasis: Unofficial recreation sites are unacceptable since official recreation sites are provided (max. std.=0; min. std.=0). It is feasible, however, to increase number of official sites that are appropriately located to accommodate increased visitor use.

Bare Soil Exposure on Official Recreation Sites	Extent of exposed mineral soil within the boundary of an official recreation site (percent)	1) Ecological Significance • Soil compaction and reduced infiltration • Accelerated soil erosion, particularly on sloped sites, sites with thin soil layer, and sites with erodible soil types • Potential for tree root exposure 2) Social/Managerial Significance • Detract from visitor experience (visual impacts, trash, possible human waste) • Increased management cost 3) Logistics/Feasibility • Low cost • Limited training required • Low measurement impacts • Large monitoring window	Applied to all islands with official recreation sites.	Apply established recreation site assessment procedures (adapted from Marion 1991 and Leung and Marion, 1998). The extent of bare soil exposure is assessed by a 6-point visual rating scale or by applying line transects and quadrats	1-2 years (Interim assessment can be performed by assessing a selected sample of sites or the problem sites)	1) Natural Feature Emphasis Zone: Not applicable. See the above indicator. 2) Managed Landscape Emphasis: Minimal extent of bare soil exposure is acceptable on recreation sites (max. std.<10), but they should not exceed 30% beyond which soil erosion was found to become substantial. 3) Multiple Use Emphasis: Some extent of bare soil exposure (max. std.=10) is expected on heavily used recreation sites, such as those on Georges and Thompson Islands. However, the extent of bare soil should not exceed 50% at which erosion becomes a significant concern. ***Probabilistic standards*** may be considered for this indicator. In other words it is acceptable to have a few 'problem' sites so long as the majority (e.g., 90% of the sites) are in good condition. Management effort would concentrate on those few problem sites.

Eroded Treads on Official Trails	Extent of trail treads showing evidence of soil erosion (> 1ft of incision for more than 10 ft in length). (ft)	1) Ecological Significance • Accelerated soil erosion, particularly on sloped segments, areas with thin soil layer, and sites with erodible soil types • Potential for tree root exposure 2) Social/Managerial Significance • Detract from visitor experience (visual impacts) • Safety concerns (ankle injuries) • Increased management cost 3) Logistics/Feasibility • Low cost • Limited training required • Low measurement impacts • Large monitoring window	Applied to all islands with official trails.	Apply established trail problem assessment procedures (Leung and Marion 1999). A measuring wheel is used to document the start and end point of each erosion event. Potential of GPS use should be explored	1-2 years (Interim assessment can be performed by assessing a selected sample of trails)	1) Natural Feature Emphasis Zone: Not applicable. See the above indicator. 2) Managed Landscape Emphasis: Minimal extent of eroded treads is acceptable. 3) Multiple Use Emphasis: More eroded treads are expected on heavily-used islands. However, these islands usually have paved trail system to contain visitor use. Therefore soil erosion does indicate of unacceptable condition due to overuse or inappropriate behavior.

Table 3.19. Current conditions and proposed standards for the selected resource indicators.

A. Density of Social Trails

Unit of Measure: Amount of Social Trails Per Unit Island Area (ft/acre)

Condition/ Standard	**Island**								
	Bumpkin	Button	Calf	Georges	Grape	Great Brewster	Green	Langlee	Little Brewster
Current Condition	34.9	0	139.3	230.4	40.0	0	0	168.8	0
Proposed Standard	10	0	0	50	10	10	0	0	10

Condition/ Standard	**Island**							
	Little Calf	Lovells	Middle Brewster	Outer Brewster	Peddocks	Raccoon	Ragged	Rainsford
Current Condition	0	31.2	0	83.2	34.1	204.4	0	27.6
Proposed Standard	0	10	0	0	10-50	0	0	10

Conditions/ Standard	**Island**					
	Sarah	Sheep	Slate	Thompson	Webb State Park	World's End
Current Condition	0	0	126.8	25.0	55.5	15.5
Proposed Standard	0	0	0	10	10	10

B. Area Disturbed by *Unofficial* Recreation Sites

Unit of Measure: Sum of recreation site sizes (Square feet)

Condition/ Standard	**Island**								
	Bumpkin	Button	Calf	Georges	Grape	Great Brewster	Green	Langlee	Little Brewster
Current Condition	0	250	1087	0	0	0	0	2190	0
Proposed. Standard	0	0	0	0	0	0	0	0	0

Condition/ Standard	**Island**							
	Little Calf	Lovells	Middle Brewster	Outer Brewster	Peddocks	Raccoon	Ragged	Rainsford
Current Condition	0	840	0	176	0	732	452	9109
Proposed Standard	0	0	0	0	0	0	0	0

Condition/ Standard	**Island**					
	Sarah	Sheep	Slate	Thompson	Webb State Park	World’s End
Current Condition	254	0	853	0	0	855
Proposed Standard	0	0	0	0	0	0

C. Bare Soil Exposure on Recreation Sites

Unit of Measure: Mean percent exposed mineral soil on recreation site.

Condition/ Standard	Bumpkin	Button	Calf	Georges	Grape	Great Brewster	Green	Langlee	Little Brewster
Current Condition	9.2 (2.5)*	63**	2.5**	13.4 (15.5)	23.6 (15.5)	12.6 (2.5)	--	47.2 (63.0)	20.3**
Proposed Standard	20	N/A	N/A	20	20	20	N/A	N/A	20

Condition/ Standard	Little Calf	Lovells	Middle Brewster	Outer Brewster	Peddocks	Raccoon	Ragged	Rainsford
Current Condition	--	29.9 (15.5)	--	15.5**	9.6 (2.5)	20.3**	2.5**	44.9 (38.0)
Proposed Standard	N/A	20	N/A	N/A	20	N/A	N/A	N/A

Condition/ Standard	Sarah	Sheep	Slate	Thompson	Webb State Park	World's End
Current Condition	97.5**	--	38**	56.3 (56.5)	50.5**	15.5**
Proposed Standard	N/A	N/A	N/A	20	20	20

* Median in parenthesis; ** Less than 3 observations, no mean or median value available.

D. Eroded Tread Surface on Unpaved *Official* Trails

Unit of Measure: Length of eroded trail segments per trail mile (lineal ft)

Condition/ Standard	Bumpkin	Button	Calf	Georges	Grape	Great Brewster	Green	Langlee	Little Brewster
Current Condition	0*	0	0	0*	0	10	0	0	0*
Proposed Standard	50	N/A	N/A	25	50	50	N/A	N/A	N/A

Condition/ Standards	Little Calf	Lovells	Middle Brewster	Outer Brewster	Peddocks	Raccoon	Ragged	Rainsford
Current Condition	0	0*	0	0	6 **	0	0	0
Proposed Standard	N/A	N/A	N/A	N/A	25-50	N/A	N/A	N/A

Condition/ Standard	Sarah	Sheep	Slate	Thompson	Webb State Park	World's End
Current Condition	0	0	0	93 ***	194 ***	89 ***
Proposed Standard	N/A	N/A	N/A	50	50	50

***** All trails on this island are paved.
** Portions of the trail system on the island are paved.
*** Portions of the trail system is graveled (may support management-related vehicular traffic)

IV. SUMMARY AND CONCLUSIONS

A. Accomplishments and Implications

The resource component of this project has identified and evaluated a host of resource indicators from different sources. The final selection of four indicators by the BOHA planning committee reflects not only these indicators' social and ecological significance, but also the feasibility and efficiency of monitoring them in the long run.

The process of selecting resource indicators and standards was performed in concert with the social science component. The integration between resource and social science components is manifest in several different elements of this program. First, indicators of resource quality were included in the social science survey (Manning and Budruk 2003). Second, the findings of Phase 1 social survey were reviewed as one source of indicators of resource quality. Third, the researchers in the two study components communicated in order to link campsite condition class ratings (resource component) to specific simulated photographs (social component). Data integration was also performed for visual displays (e.g., Leung et al. 2002 in Section VI) and more in-depth relational analysis.

This project has also provided baseline information on which future evaluation can be based. This information include resource conditions on official recreation sites and trails, the extent of illegal or unofficial sites and trails, soil compaction and ground cover on selected islands, and vandalism.

Study findings have implications for management. Recreation resource conditions were found to be acceptable in general. The majority of recreation sites were in good condition with respect to soil exposure, tree damage and vandalism, even though the size of some recreation sites is substantial. Evaluation may be needed to evaluate the appropriate size of these large recreation sites and determine if such sheer size is necessary.

The major concern seems to be related to the proliferation and degradation of unofficial recreation sites and trails. These use areas and trails are often not located in resistant locations, nor are they planned for withstanding use pressure. No maintenance is performed on these sites. In addition, several social trails were found to be in close proximity to locations of RTE species, such as on Lovells and Bumpkin Islands. Although this problem is not widespread among all islands, it should be addressed proactively before more social trails are created by visitors that may threaten sensitive zones.

Specific islands of concern include degrading unofficial recreation sites on Rainsford Island and unofficial (social) trails on World's End. Guidelines for strategies and actions to management visitor impacts exist and are widely available (Anderson et al. 1998; Cole et al.1987; Manning 1999). Such resources should be reviewed to shortlist the most appropriate options for second-round review by park staff and the public. The finally selected strategies and actions should then be implemented and evaluated on-site.

B. Study Limitations

There are several important limitations of this study, including indicator selection, field logistics, soil study limitations and weather. The selection of indicators was based on not only their ecological and social significance, but also practical considerations such as efficiency, low-cost and low-impact of their measurements. These criteria have effectively limited the choice of potential resource indicators to a subset of feasible indicators. Despite this, the selected indicators should be indicative of the direct effects of visitor use on the islands for monitoring purposes. In order to understand and evaluate the full ecological consequences of visitor resource impacts research studies would be required. Monitoring of the selected indicators would provide warning signs of visitor impact problems, but it is insufficient to understand causal relationships, relative importance of influential factors and impact processes.

There weere several logistical limitations to this study. It was very challenging to commute to non-public use islands even with support from UMASS and NPS-BOHA office. The reliance on public transportation with limited schedule to public use islands was not efficient to conduct field data collection.

A number of field staff plus Earthwatch volunteers were involved in the field data collection. The interrater variability of measurements may have resulted. This problem was minimized by detailed training and field practice.

Soil sampling was considered for evaluating soil quality as potential resource indicators. The study plan was scaled down based on advice by State's Archeological Office. The current set of soil quality measurements provides a preliminary picture of soil resource conditions. More detailed studies on soil properties and degradation due to visitor use and other threats are needed but they are beyond the VERP process.

The inclement weather in October 2002 prevented us from performing a complete set of field measurements on ground cover and soil quality indicators. The droughts in summer 2002 also compromised the quality of this data set.

C. Concluding Remarks

This study has provided scientific input to the process of indicator development and standards establishment as part of the VERP implementation. With the continued growth of visitation the VERP implementation is a proactive approach to managing for appropriate visitor use without compromising the resource protection goal. It is critical now that monitoring programs be established for these selected resource and social indicators.

V. REFERENCES CITED

Anderson, D., Lime, D., and Wang, T. (1998). Maintaining the Quality of Park Resources and Visitor Experiences: A Handbook for Managers. St. Paul, MN: University of Minnesota Cooperative Park Studies Unit.

Belnap, J. (1998). Choosing indicators of natural resource condition: A case study in Arches National Park, Utah, USA. Environmental Management 22(4): 635-642.

BOHA (USDI National Park Service, Boston Harbor Islands National Park Area) (2002). Boston Harbor Islands National Park Area – General Management Plan. Boston, MA: BOHA.

Cole, D., Peterson, M., and Lucas, R. (1987). Managing Wilderness Recreation Use. USDA Forest Service General Technical Report INT-230.

Cole, D. N. (1989). Wilderness Campsite Monitoring Methods: A Sourcebook. General Technical Report INT-259. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Cole, D. N., Watson, A. E., Hall, T. E., and Spildie, D. (1997). High-Use Destinations in Wilderness: Social and Biophysical Impacts, Visitor Responses, and Management Options. Research Paper INT-RP-496. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Consulting and Audit Canada (1995). What Tourism Managers Need to Know: A Practical Guide to the Development and Use of Indicators of Sustainable Tourism. Madrid: World Tourism Organization.

Doran, J. W. and Jones, A. J. (1996). Methods for Assessing Soil Quality. Madison, WI: Soil Science Society of America.

Dorwart, C. E., Leung, Y.-F., and Moore, R. (2004). Managing visitors' perceptions. Parks and Recreation 39(5): 24-31.

Graefe, A., Vaske, J., and Kuss, F. (1984). Resolved issues and remaining questions about social carrying capacity. Leisure Sciences 6:497-507.

Graefe, A., Kuss, F., and Vaske, J. (1990). Visitor Impact Management: The Planning Framework. Washington, D.C.: National Parks and Conservation Association.

GYWVU (Greater Yellowstone Winter Visitor Use Management Working Group) (1999). Winter Visitor Use Management: A Multi-Agency Assessment. Final Report of Information for Coordinating Winter Recreation in the Greater Yellowstone Area. Jackson, WY: USDI National Park Service.

Hammitt, W. E. and Cole, D. N. (1998). Wildland Recreation: Ecology and Management (2nd Ed.). New York: John Wiley.

Hof, M., Hammitt, J., Rees, M., Belnap, J., Poe, N., Lime, D., and Manning, R. (1994). Getting a handle on visitor carrying capacity—A pilot project at Arches National Park. Park Science 14:11-13.

Jacobi, C. and Manning, R. (1997). Applying the Visitor Experience and Resource Protection Process to Acadia National Park Carriage Roads: A Summary of Research and Decision-Making. National Park Service Technical Report NPS/NESO-RNR/NRTR/98-5.

Leung, Y.-F. and Marion, J. L. (1995). A Survey of Campsite Conditions in Eleven Wilderness Areas of the Jefferson National Forest. Blacksburg, VA: USDI National Biological Service, Virginia Tech Cooperative Park Studies Unit.

Leung, Y.-F. and Marion, J. L. (1998). A Survey of Whitewater Recreation Sites on Fiver West Virginia Rivers. Blacksburg, VA: USGS Biological Resources Division, Cooperative Park Studies Unit.

Leung, Y.-F. and Marion, J. (1999). Characterizing backcountry camping impacts in Great Smoky Mountains National Park, USA. Journal of Environmental Management 57(3): 193-203.

Leung, Y.-F. and Marion, J. L. (2000). Recreation impacts and management in wilderness: A state-of-knowledge review. In: Cole, D. N.; McCool, S. F.; B.orrie, W. T., and O'Loughlin, J., comps. Wilderness Science in a Time of Change Conference - Volume 5: Wilderness Ecosystems, Threats, and Management; Missoula, MT. Proceedings RMRS-P-15-VOL-5. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station, pp. 23-48.

Liddle, M. (1997). Recreation Ecology. London: Chapman and Hall.

Lime, D. W. and Stankey, G. H. (1971). Carrying capacity: Maintaining outdoor recreation quality. In: Larson, E. H., ed. Recreation Symposium Proceedings; Syracuse, NY. Upper Darby, PA: USDA Forest Service, Northeastern Forest Experiment Station, pp. 174-184.

Lime, D., Manning, R., Lewis, M., and Freimund, W. (1994). Indicators and Standards of Quality for the Visitor Experience at Arches National Park: Phase II Research. University of Minnesota Cooperative Park Studies Unit.

Lowery, B. and Morrison, J. E. (2002). Soil penetrometers and penetrability. In: Dane, J. and Topp, C., eds. Methods of Soil Analysis, Part 4 - Physical Methods. Madison, WI: Soil Science Society of America, pp. 363-388.

Manning, R. (1979). Strategies for managing recreational use of national parks. Parks 4:13-15.

Manning, R., Lime, D., McMonagle, R., and Nordin, P. (1993). Indicators and Standards of Quality for the Visitor Experience at Arches National Park: Phase I Research. University of Minnesota Cooperative Park Studies Unit.

Manning, R., Lime, D., and Hof, M. (1996). Social carrying capacity of natural areas: theory and application in the U.S. National Parks. Natural Areas Journal 16:118-27.

Manning, R. (1999). Studies in Outdoor Recreation (2^{nd} Ed.). Corvallis, OR: Oregon State

University Press.

Manning, R. E. (2001). Visitor Experience and Resource Protection: A framework for managing the carrying capacity of national parks. Journal of Park and Recreation Administration 19(1): 93-108.

Manning, R. E. and Budruk, M. (2003). Results of carrying capacity research at Boston Harbor Islands, a national park area (social component). Unpublished report.

Marion, J. L. (1991). Developing a Natural Resource Inventory and Monitoring Program for Visitor Impacts on Recreation Sites: A Procedural Manual (Natural Resources Report NPS/NRVT/NRR-91/06). Denver, CO: USDI National Park Service, Natural Resources Publication Office.

Marion, J. L. (1994). An Assessment of Trail Conditions in Great Smoky Mountains National Park. Research/Resources Management Report. Atlanta, GA: USDI National Park Service, Southeast Region.

Marion, J. L. and Cole, D. N. (1996). Spatial and temporal variation in soil and vegetation impacts on campsites. Ecological Applications 6(2): 520-530.

Marion, J. L. and Leung, Y.-F. (1997). An Assessment of Campsite Conditions in Great Smoky Mountains National Park. Research/Resources Management Report. Atlanta, GA: USDI National Park Service, Southeast Regional Office.

Marion, J. L. and Leung, Y.-F. (2001). Trail resource impacts and an examination of alternative assessment techniques. Journal of Park and Recreation Administration 19(3): 17-37.

Mueller-Dombois, D. and Ellenberg, H. (1974). Aims and Methods of Vegetation Ecology. New York: John Wiley.

NPS (USDI National Park Service) (1995). VERP: Implementation Plan, Arches National Park. Denver, CO: Denver Service Center.

NPS (1997). The Visitor Experience and Resource Protection (VERP) Framework—A Handbook for Planners and Managers. Publication NPS D-1215. Denver, CO: NPS Denver Service Center.

NPS (2000). Management Policies 2001. Publication NPS D-1416. Washington, DC: NPS Office of Policy.

Roggenbuck, J.W., Williams, D.R., and Watson, A.E. (1993). Defining acceptable conditions in wilderness. Environmental Management 17(2):187-97.

Shelby, B. and Heberlein, T. (1986). Carrying Capacity in Recreation Settings. Corvallis, OR: Oregon State University Press.

Stankey, G., Cole, D., Lucas, R., Peterson, M., Frissell, S., and Washburne, R. (1985). The Limits of Acceptable Change (LAC) System for Wilderness Planning. General Technical Report INT-176. USDA Forest Service, Intermountain Research Station.

Tarrant, M. A. and Shafer, C. S. (1997). Condition indicators for distinct wilderness: Is there uniformity? International Journal of Wilderness 3(4):29-33.

USDA (U.S. Dept. of Agriculture) (1999). Soil Quality Test Kit Guide. Ames, IA: USDA Natural Resources Conservation Service, Soil Quality Institute.

Watson, A. and Cole, D. (1992). LAC indicators: An evaluation of progress and list of proposed indicators. In Merigliano, L.L. (ed.), Ideas for Limits of Acceptable Change Process (Book 2), (pp. 65-84). Washington, DC: USDA Forest Service, Recreation Staff.

YOSE (Yosemite National Park) (2004). User Capacity Management Program for the Merced Wild and Scenic River Corridor. Yosemite, CA: USDI National Park Service, Yosemite National Park.

VI. OTHER RESEARCH PRODUCTS

In addition to this final report a variety of research products were produced throughout the resource component study. Some of these products were generated in collaboration with the social science component research group (UVM).

A. Publications

Manning, R. E., Y.-F. Leung, and M. Budruk. Forthcoming. Research to support management of visitor carrying capacity on Boston Harbor Islands. *Northeastern Naturalist.* (BOHA Special Issue)

Leung, Y.-F. and K. Meyer. 2004. Soil compaction as indicated by penetration resistance: A comparison of two types of penetrometers. In: Harmon, D., B. M. Kilgore, and G. E. Vietzke (eds.) *Protecting Our Diverse Heritage: The Role of Parks, Protected Areas, and Cultural Sites -- Proceedings of the George Wright Society/National Park Service Joint Conference; April 14-18, 2003; San Diego, CA.* Hancock, MI: The George Wright Society, pp. 370-375.

Leung, Y.-F., N. Shaw, K. Johnson, and R. Duhaime. 2002. More than a database: Integrating GIS data with the Boston Harbor Islands visitor carrying capacity study. *The George Wright Forum* 19(1): 69-78.

B. Posters Delivered at Professional/Academic Conferences

Meyer, K. and Y.-F. Leung. 2003. Evaluating soil compaction and ground cover indicator measures for visitor use planning on Boston Harbor Islands. Poster presented at the *Boston Harbor Islands Science Symposium; Oct. 7, 2003; Boston, MA.*

Budruk, M., P. Newman, W. Valliere, J. Bacon, D. Laven, R. Manning, and Y.-F. Leung. 2003. Incorporating Earthwatch volunteers into park and protected area research. Poster presented at the ***12th George Wright Society Conference on Resource Management in Parks and on Public Lands; April 14-18, 2003. San Diego, California***.

Newman, P., M. Budruk, R. E. Manning, and Y.-F. Leung. 2002. Volunteerism and research in the national parks: A tale of two studies. Paper presented at the ***9th International Symposium on Society and Resource Management; June 2-5, 2002; Bloomington, Indiana***.

Johnson, K. and Y.-F. Leung. 2002. Developing visitor impact indicators and monitoring procedures for recreation sites on Boston Harbor Islands. Poster presented at the ***Boston Harbor Islands Biodiversity Seminar; May 30, 2002; Cambridge, Massachusetts.***

C. Oral Presentations Delivered at Academic/Professional Conferences

Meyer, K. and Y.-F. Leung. 2004. Estimating vegetative and bare ground cover as visitor impact indicators: A comparison of three methods. Paper presented at the 26th *Southeastern Recreation Research Conference*; February 8-10, 2004; Charleston, South Carolina.

Leung, Y.-F., M. Budruk, and R. Manning. 2003. Assessing and monitoring physical and social impacts of vandalism: Results from the Boston Harbor Islands National Recreation Area. Paper presented at the ***12th George Wright Society Conference on Resource Management in Parks and on Public Lands; April 14-18, 2003. San Diego, California***.

Leung, Y.-F., K. Johnson, and K. Meyer. 2003. Developing visitor impact monitoring indicators and procedures for Boston Harbor Islands National Park Area. Paper presented at the ***12th George Wright Society Conference on Resource Management in Parks and on Public Lands; April 14-18, 2003. San Diego, California***.

Manning, R. E., Y.-F. Leung, and M. Budruk. 2003. Research to support management of visitor carrying capacity on Boston Harbor Islands. Paper presented at the *Boston Harbor Islands Science Symposium; Oct. 7, 2003; Boston, MA.*

Smith, C., M. Smith, and Y.-F. Leung. 2003. Recreational GPS for work and play. Workshop presented at the ***2003 Annual Meeting of North Carolina Parks and Recreation Society; Nov. 3, 2003; Durham, NC.***

Leung, Y.-F., R. E. Manning, M. Budruk, and K. Johnson. 2002. Integrating resource and social analysis in the evaluation of visitor carrying capacity of campsites on Boston Harbor Islands. Paper presented at the ***9th International Symposium on Society and Resource Management; June 2-5, 2002; Bloomington, Indiana***.

Shaw, N., K. Johnson, Y.-F. Leung, and R. Duhaime. 2001. More than a database: Boston Harbor Islands resource and visitor analysis. Paper presented at the Spatial Odyssey 2001 - The National Park Service GIS Conference; Dec. 3-7, 2001; Primm Valley Resort, Nevada.

D. Presentations Delivered to General Public

Manning, R. E., Y.-F. Leung, P. Newman, and M. Budruk. 2001. Informing carrying capacity decision making in national parks. Poster presented at the ***21st Annual Earthwatch Institute Conference. November 17, 2001. Waltham, Massachusetts.***

Valliere, W. and Y.-F. Leung. 2000. Carrying capacity research in national parks. Poster presented at the ***20th Annual Earthwatch Institute Conference. November 18, 2000. Cambridge, Massachusetts.***

VII. APPENDICES

The following pages contain detailed field procedures and forms:

Appendix I	--	*Local Expert Survey Questionnaire*
Appendix II	--	*Field Procedures for Assessing and Monitoring Recreation Sites*
Appendix III	--	*Field Procedures for Assessing and Monitoring Official Trails*
Appendix IV	--	*Field Procedures for Assessing Ground Cover and Soil Quality Indicators*
Appendix V	--	*A Comparison of Positional Accuracy between Trimble Geo Explorer III GPS and Garmin III GPS (Part of a Presentation Made at 2003 North CarolinaRecreation and Park Society Annual Conference; Durham, NC)*

APPENDIX I

Boston Harbor Islands, A National Park Area
VISITOR CARRYING CAPACITY STUDY - RESOURCE COMPONENT

Local Experts Survey

Your responses to this survey will facilitate our field data collection effort, and also help us build a complete database and identify important resource indicators. Your additional comments, suggestions and information will be appreciated. Thank you very much for your time and valuable input!

A. Some Information About You:

1. Your Name: ____
2. Your Agency/Organization: ____
3. Your Job Title: ____
4. Your Contact Information: (Mailing Address)____

[Please attach business card] ____

(Phone)______________________ (Fax) ____________________

(E-mail)____

(Website)____

B. Your Knowledge About Boston Harbor Islands (BOHA)

1. How long have you been associated with BOHA? _____________ Years

2. Please rate the severity of visitor-caused impacts on the Boston Harbor Islands using the *Problem Severity Scale* as described below. You are welcome to discuss your ratings with your staff/colleagues. Please circle the appropriate response and provide additional comments.

Problem Severity Scale:	**0 = not a problem** **1 = A problem in a few areas** **2 = A problem in many areas** **3 = A problem in most areas**

Visitor Impacts	Problem Severity Scale **(Circle one)**	Comments: **(What types? Where?)**
a. Resource damage on *official* trails	0 1 2 3	____________________________
b. Increasing number of *unofficial* (social) trails	0 1 2 3	____________________________
c. Resource damage on *unofficial* trails	0 1 2 3	____________________________
d. Resource damage on *official* campsites	0 1 2 3	____________________________
e. Increasing number of *unofficial* (illegal) campsites . . .	0 1 2 3	____________________________
f. Resource damage on *unofficial* campsites	0 1 2 3	____________________________
g. Resource damage on day-use (e.g., picnic) sites	0 1 2 3	____________________________
h. Resource damage at *official* piers/boat landings	0 1 2 3	____________________________
i. Resource damage at *unofficial* private boat landings . .	0 1 2 3	____________________________
j. Litter caused by visitors	0 1 2 3	____________________________
k. Graffiti/Vandalism caused by visitors	0 1 2 3	____________________________
l. Excessive noise caused by visitors	0 1 2 3	____________________________
m. Other (please specify):________________	0 1 2 3	____________________________

3. This study is most concerned with those resource elements that are impacted or threatened by visitor use. Resource elements can be physical (e.g., soil, landform features), biological (e.g., vegetation, wildlife, birds) or man-made (e.g., facilities, historical structures). In your opinion, which resource elements are most sensitive to *visitor-caused* impacts on the Boston Harbor Islands? Please provide island-specific information if you have any.

4. **IMPORTANT:** Based on your knowledge of the Islands, use a pencil or pen to **mark** all locations of *visitor-impacted* or *sensitive* areas on the map provided. Be sure to **label** the type of impact or sensitive area for each location you have marked. Examples of these locations may include, but not limited to:

– Unofficial (illegal) campsites,
– Actively eroding trail segments
– Popular unofficial landing areas for private boats
– Areas with proliferating network of social trails
– Areas with evidence of graffiti and vandalism
– Areas with sensitive resource elements (examples given in Question 3)
– Heavily used day-use areas
– Areas with extensive exposed soil (bare patches)

C. Other Comments or Suggestions: (Use the back if necessary)

[* If you know of anyone who may provide valuable input to this survey, please let me know his/her name and contact information. Thank you!]

THANK YOU FOR YOUR INPUT!

Please use the enclosed self-addressed stamped envelope to return your completed survey, or you can send or fax your completed survey to:

Dr. Yu-Fai Leung
Parks, Recreation and Tourism Management
North Carolina State University
Box 8004, Biltmore Hall
Raleigh, NC 27695-8004
Phone: (919)513-3489; Fax: (919)515-3687; Email: *leung@unity.ncsu.edu*

LAND COVER


Legend
Drumlin Contours
Open Land (Meadow, Scrub and Sumac)
Wetland
Forest
Tidal Flat
North Shore
Salem
Marblehead
Lynn
Nahant
Revere
REVERE
Revere Beach
EVERETT
CHELSEA
Broad Sound
Mystic River
Charlestown
East Boston
Airport
Maverick
North Station
Government
Aquarium
Long Wharf
Park Street
Downtown Crossing
Chinatown
South Station
Charles River
WINTHROP
WINTHROP BEACH
Logan International Airport
SNAKE I.
THE GRAVES
MASSACHUSETTS BAY
Inner Harbor
BOSTON HARBOR
DEER ISLAND
GREEN ISLAND
LITTLE CALF I.
CALF ISLAND
OUTER BREWSTER ISLAND
MIDDLE BREWSTER ISLAND
GREAT BREWSTER ISLAND
SHAG ROCKS
LITTLE BREWSTER ISLAND
BOSTON
Broadway
CASTLE ISLAND
South Boston
CARSON BEACH
L - ST. BEACH
Old Harbor
NIX'S MATE
LOVELL'S ISLAND
GALLOP'S ISLAND
SPECTACLE ISLAND
LONG ISLAND
GEORGE'S ISLAND
JFK / U. Mass.
THOMPSON ISLAND
RAINSFORD ISLAND
Savin Hill
MALIBU BEACH
SAVIN HILL BEACH
Dorchester Bay
MOON ISLAND
Dorchester
TENEAN BEACH
Squantum
PEDDOCK'S ISLAND
SPINNAKER ISLAND
HANGMAN ISLAND
NANTASKET BEACH
North Quincy
WOLLASTON BEACH
Quincy Bay
HULL
BUMPKIN ISLAND
SHEEP ISLAND
NUT ISLAND
Hingham Bay
Wollaston
Houghs Neck
GRAPE ISLAND
SLATE ISLAND
WORLD'S END
RACCOON ISLAND
WEBB STATE PARK
LANGLEE I.
RAGGED I.
SARAH I.
QUINCY
Hingham Harbor
Back River
Hewitt's Cove
MILTON
Quincy Center
Fore River
WEYMOUTH
HINGHAM
BUTTON I.
COHASSET
KILOMETERS
MILES

APPENDIX II

Boston Harbor Islands National Park Area

Recreation Site Impact Assessment & Monitoring Manual (Rev. 12/02)

Dr. Yu-Fai Leung
Parks, Recreation and Tourism Management, North Carolina State University

This manual describes impact assessment procedures for recreation sites on Boston Harbor Islands National Park Area. The intent is to provide park managers with standardized, quantitative and reliable information on resource conditions on recreation sites. Parts of this manual were adapted from previous studies (Marion, 1991; Marion and Leung, 1997; Leung and Marion, 1998). For the purposes of this study, any identifiable area that has day or overnight recreational use is considered a recreation site. Both *official* and *unofficial* sites are to be surveyed. These sites include overnight camping sites and day use sites.

This study integrates a simple condition class rating and a multiple-indicator approach to recreation site assessment and monitoring. Three types of recreation site information are collected:

1) Inventory parameters - Information of site location environmental attributes
2) Impact parameters - Information about extent and intensity of resource impacts on site
3) Vandalism parameters - Information about evidence of vandalism due to depreciative visitor behavior

These procedures are designed to be reasonably 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. Precision refers to our ability to get the same results if we had different crews apply the same measurements to the same recreation site.

Recreation site assessment data are useful for evaluating current resource conditions, detecting spatial and temporal trends, and evaluating management effectiveness. Park managers may also use this information valuable in park management decision-making frameworks such as the National Park Service's Visitor Experience and Resource Protection (VERP) framework. Recreation site data can also be used for analytical and monitoring purposes. For example, site impact data can be examined in association with relevant environmental and use-related factors. Site impact data can also be compared to data from future assessments (using the same procedures) for monitoring purposes: identifying trends in site condition and evaluating the effectiveness of implemented management actions.

Assessment is conducted on each recreation site. Two field staff are typically needed for implementing the procedures in between 15-25 minutes. One staff usually perform most measurements while the other records the data. For more details about different recreation site assessment and monitoring methodologies please refer to Cole (1989), Marion (1991) and Leung and Marion (2000).

Materials:
- Compass, peephole type
- GPS Unit (Garmin and/or Trimble)
- Island Maps (Park maps, USGS topographic maps or digital raster graphics; 1:24,000 or finer)
- Tape measure (100 foot, marked in tenths) or electronic distance measurer
- Flagged wire pins (optional)
- Digital camera (fully charged with sufficient memory)
- Clipboard, monitoring manual, field forms (some on waterproof paper), pencils
- Clinometer

Procedures

General Site Information

1) Island: Record the full name of the island.

2) Site Type: Record the type of the site: **C=Campsite; D=Day Use Site**

3) Site Number: Each site is to be numbered consecutively. The following coding format is adopted:

Island Code + S (Feature Type) + Serial Number

Island Code:

Bumpkin - BU	Button - BT	Calf - CF	Georges - GE	Grape - GR	G. Brewster - GB
Green - GN	Langlee - LA	L. Brewster - LB	Lowells - LO	M. Brewster - MB	O. Brewster - OB
Peddocks - PE	Raccoon - RC	Ragged - RG	Rainsford - RA	Sarah - SA	Sheep - SH
Slate - SL	Thompson - TH	Webb SP - WB	World's End - WE		

Feature Type: Use 'S' for all recreation sites
Serial Number starts at 01.
Examples: (a) The third site assessed on Grape Island = GRS03
(b) The eleventh site assessed on Bumpkin Island = BUS11

When sites are reassessed, examine the GPS-mapped locations and field forms to determine if each site was present during the previous survey. Relocate site reference points with photos and GPS unit(s). Number new sites with any unique number larger than those used in previous surveys.

4) Legality: If the recreation site under consideration is listed on official park brochures, it is considered an official (O) site. If not it should be recorded as an unofficial (U) site.

5-6) Date and Time: Record date (month, day, and year) and starting time when the site was evaluated (eg. June 12, 2001 = 06/12/01).

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

Describe Location: Describe the site 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. Verify your pace periodically. Accurate site location descriptions are essential to site relocation. Mark the approximate recreation site on an island map and draw sketch a local area map as necessary.

7-12) Site Reference Point: A reference point must be chosen for each site. This point must be visible from all site boundaries. See 'Impact Parameters' for details of point selection. The location of reference point is documented by multiple ways, including GPS, a reference photo and reference point location measurements.

GPS (Garmin): If a professional grade GPS unit is not available, use a Garmin or similar recreational-grade GPS unit to record the coordinates of the reference point on each site.

GPS (Trimble): If available, use the Trimble GPS GeoExplorer Unit to record the coordinates of the reference point on each site. Mark 'Y' on form. Save the information as a file in the GPS unit for downloading upon return to the office.

Reference Photo: 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 site and assist in reference point location. Select a vantage point which provides the best view of the site and reference point location. Try to select a photopoint location which clearly shows the reference point location in relation to nearby trees or boulders. It may be necessary to take a separate reference point photograph in some instances. Place the tape measure against the reference point stake so that it is clearly visible in the camera viewfinder. Take a picture, pointing the camera down to include as much of the site groundcover as possible. Use site number as the file name for each phot. Also record the compass bearing and distance from the reference point to the photopoint. At the end of each day photo files should be downloaded to the notebook computer.

Reference Point Measurements: Document the location of the site reference point based on its spatial relationship with three permanent features on or near the site. See 'Impact Parameters' for details

Inventory Parameters

13) Intersite Visibility: Record the number of other sites in the area, which, if occupied, would be visible from the site. This is a social variable to assess site inter-visibility, 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.

14) 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.

15) Site Slope: Use the clinometer to identify the "average" slope of the site. Pick a transect across the site which runs perpendicular to the slope and is "typical" of the site'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.

16) Site Position: Examine the map, relative to the ridge or mountain upon whose slope the site is located, record an "F" for "Foot" in the site is at the base of the slope along a permanent or intermittent stream, record a "U" for "Upper Slope" if the site 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.

17) Distance to Formal Trail: Using the following categories, indicate the distance from the closest boundary of the site to to the nearest formal park trail:

1=<25 ft 2=26-100 ft 3=101-200 ft 4=>201 ft

18) Distance to Water: Using the above categories, indicate the distance from the closest boundary of the site to the closest water source.

19) Water Body Type: Using the following codes, indicate the type of water source:

S=Spring C=Creek/River M=Marine P=Pond N=None within a 5 minute walk

20) Dominant Tree Species: Identify the site's dominant tree species (not individual tree) based on the extent of coverage (shading) of the ground within site boundaries. If you are unable to determine the specific species list the general group of trees ie. pine, oak, or walnut.

21) Tree Canopy Cover: Estimate the percentage of tree canopy cover directly over the site. Imagine that the sun was directly overhead. What portion of the ground within site 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%

22) Site Expansion: Evaluate the adjacent off-site areas for their potential to restrict site 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=Low expansion potential: off-site areas are completely unsuitable for any expansion due to the factors listed above.

Impact Parameters

Assessment of site impacts begins with establishing the sites' boundaries and measuring its size. The following four-step procedures describe the use of the **Geometric Figure Method** for determining the sizes of recreation sites.

Step 1. Identify Site Boundaries. Walk the site perimeter and identify site boundaries by pronounced changes in vegetation cover, vegetation height/disturbance, vegetation composition, surface organic litter, and topography. In case of dense forest overstories recreation sites may have very little vegetation, necessitating the determination of boundaries by changes in organic litter (i.e. areas where leaves are untrampled and intact vs. areas where leaves are pulverized or absent). When defining the site 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. Identify Island and Satellite Areas. Identify any undisturbed "islands" of vegetation inside site boundaries (often due to clumps of trees or shrubs) and disturbed "satellite" use areas outside site boundaries (often due to tent sites, cooking sites, or horse use areas). Use site boundary definitions for determining the boundaries of these areas. Record the compass bearing and distance from the center of each island or satellite site to the site reference point (see Step 3).

Step 3. Select and Record Site Reference Point. Select a site reference point that is preferably: a) visible from all the site 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 reference point nail and site tag. Embed a temporary stake through the eyelet on the tape measure at the reference point location. Reference the reference point 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 reference point location. For each feature, take a compass bearing (nearest degree) and measure the distance (nearest 1/10 foot) from the reference point 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 careful in taking these bearings and measurements as they are critical to relocating the reference point in the future.

Examples:
1) Sycamore tree, 3.2 ft dbh, 23.2 ft at 195^o (the only sycamore tree on site)
2) Boulder, 17.9 ft at 312^o, (distance and bearing to highest point)
3) Permanently-anchored fire grill, 29.5 ft at 78^o

Options: Some sites may lack the necessary permanent reference features for locating the reference point accurately. 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 reference point. This option will introduce more error in comparisons with future measurements, particularly if the site boundaries are not pronounced. Note your actions regarding use of these options.

Step 4. Measuring Size of Site Area, Island Area(s) and Satellite Area(s). Use the geometric figure method to determine the areas of recreation sites, disturbed "satellite" sites, and interior undisturbed "island" sites. This method 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 (see the last page of the instructions for illustrations) 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.

23) Condition Class: Record the Condition Class of each site using the following rating scale:

Condition Class Rating System	
Class 1:	Site barely distinguishable; slight loss of vegetation cover and /or minimal disturbance of organic litter.
Class 2:	Site obvious; vegetation cover lost and/or organic litter pulverized in primary use areas. No bare soil other than fire scars.
Class 3:	Vegetation cover lost and/or organic litter pulverized on much of the site, some bare soil exposed in primary use areas.
Class 4:	Nearly complete or total loss of vegetation cover and organic litter, bare soil widespread.
Class 5:	Soil erosion obvious, as indicated by exposed tree roots and rocks and/or gullying.

24) 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 site 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 focusing 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%

25) Graminoid Cover Onsite: Follow the procedures for parameter 24 but assess only the coverage of grasses and sedges combined within site boundaries.

26) 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 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 which would closely resemble the site area had the 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.

27) Graminoid Cover Offsite: Follow the procedures for parameter 26 but assess only the coverage of grasses and sedges combined.

28) Bare Soil Exposure: Estimate the percentage of mineral soil exposure (bare soil with no plant or litter cover) within the site and satellite use area boundaries using the vegetative cover categories.

29-31) Tree Damage: Tally each live tree (>1 in. diameter at 4.5 ft.) within or on 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 with site 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).

32-34) Root Exposure: Tally each live tree (>1 in. diameter at 4.5 ft.) within or on 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 site 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.

35) 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 site 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.

36-42) Site Facilities: Count all facilities that exist within site boundaries, including satellite areas, including picnic tables, benches, fire sites (indicate grates or pits), toilet (indicate type), sun shade, shelter, and any other facilities (specify type).

43) Number of Trails: A count of all trails leading away from the outer site 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 site boundaries.

44) 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.

45) Litter/Trash: Evaluate the amount of litter/trash within or easily visible from site 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.

Vandalism Parameters

46) Number of Occurrences Onsite: Record the total number of vandalism incidents within site boundaries. A graffiti of several words or symbols is counted as one occurrence.

47) Type of Vandalism: Record the specific type(s) of vandalism. Examples include physical alteration, carving, fire, graffiti/painting, attachment, removal/stealing, scratching and others (specify).

48) Location of Disturbance: Record the location where vandalism occurs. Examples include building, bench, minor structure (such as fire hydrants or drinking water fountains) signs, tables and others (specify).

49) Extent of Disturbance: Estimate the amount of *contiguous reachable* surface that is directly affected by vandalism (in one of the four extent categories): **1=0-5% 2=6-50% 3=51-95% 4=96-100%**

50) Loss of Functionality: Evaluate the degree of vandalism and determine if the functionality of the non-living features (such as picnic tables) and overall health of living features (such as trees) are compromised by vandalism. Record the degree of functionality loss in one of the three categories:

1 = Minor (the feature/facility is still fully functional)
2 = Moderate (the feature/facility has lost some of its productivity)
3 = Severe (the function of feature/facility total compromised)

51) Total Site Area: Using a calculator and the worksheet on the back of the form, compute and sum the area of each island, satellite, and exposed soil areas (also see 'Impact Parameters' for detailed procedures). Record these values in the spaces provided on the back of the form and calculate the Total Site Area.

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 site, 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.

References

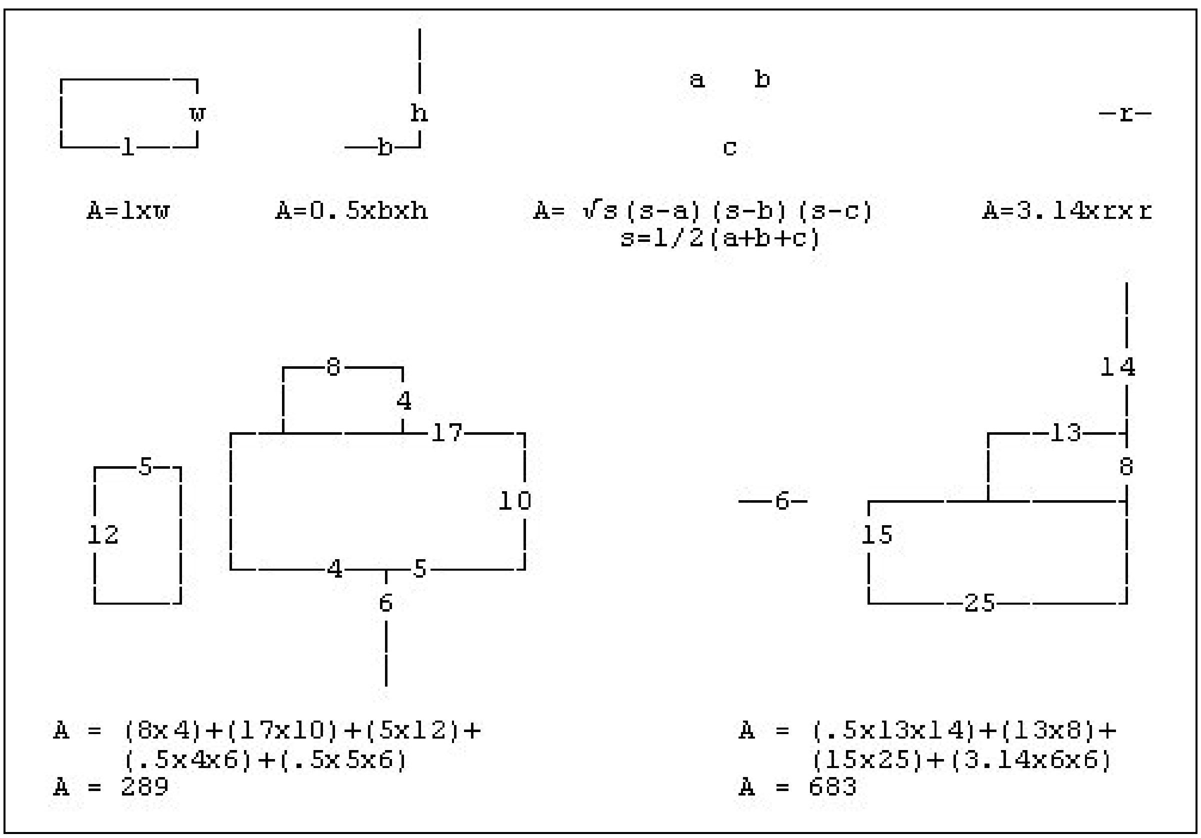
Cole, David N. 1989. Wilderness Campsite Monitoring Methods: A Sourcebook. General Technical Report INT-259. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Leung, Yu-Fai; Marion, Jeffrey L. 1998. A Survey of Whitewater Recreation Sites on Fiver West Virginia Rivers. Blacksburg, VA: USGS Biological Resources Division, Cooperative Park Studies Unit

Leung, Yu-Fai; Marion, Jeffrey L. 2000. Recreation impacts and management in wilderness: A state-of-knowledge review. In: Cole, David N.; McCool, Stephen F.; Borrie, William T.; O'Loughlin, Jennifer, comps. Wilderness Science in a Time of Change Conference - Volume 5: Wilderness Ecosystems, Threats, and Management; Missoula, MT. Proceedings RMRS-P-15-VOL-5. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 23-48.

Marion, Jeffrey L. 1991. Developing a Natural Resource Inventory and Monitoring Program for Visitor Impacts on Recreation Sites: A Procedural Manual. Natural Resources Report NPS/NRVT/NRR-91/06. Denver, COUSDI National Park Service, Natural Resources Publication Office. (**Note:** Readers can be referred to this document for photographs illustrating site boundaries, vegetative ground cover classes, soil exposure, tree damage, and root exposure)

Marion, Jeffrey L.; Leung, Yu-Fai 1997. An Assessment of Campsite Conditions in Great Smoky Mountains National Park. Research/Resources Management Report. Atlanta, GA: USDI National Park Service, Southeast Regional Office.



Geometric Figure Method: Calculation Examples.

Boston Harbor Islands National Park Area

Recreation Site Assessment & Monitoring Form

General Site Information

1) Island ___________________ 2) Site Type (C/D) ________ 3) Site No. _________________

4) Legality ____ (O/U) 5) Date (m/d/y) _ _ / _ _ / _ _ 6) Time ___:___am/pm

Inventoried by _______________ Describe Location ____

7-12) Site Reference Point:

GPS: (Garmin) ____________[Lat.]____________[Long.] (Trimble) (Y / N) _____

Reference Photo: Bearing ____° Distance _____ft Description _______________________________________

Reference Point Measurements: (1) Feature __________________ Bearing ____° Distance _____ft

(2) Feature __________________ Bearing ____° Distance _____ft

(3) Feature__________________ Bearing ____° Distance _____ft

Inventory Parameters

13) Intersite Visibility _____

14) Aspect _____°

15) Site Slope _____ %

16) Site Position (F=Foot M=Midslope U=Upper Slope) _____

17) Distance to Formal Trail (1=<25 ft 2=26-100 ft 3=101-200 ft 4=>201 ft) _____

18) Distance to Water (Use categories in Parameter #17 above) _____

19) Water Body (S=Spring C=Creek/River M=Marine P=Pond N=None= > 5 min. walk) _____

20) Dominant Tree Species: Common Names: ____________________________________

21) Tree Canopy Cover (1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%) _____

22) Site Expansion (1=High 2=Moderate 3=Low) _____

Impact Parameters

-- Apply Geometric Figure Method --

23) Condition Class (1 to 5) _____

24) Vegetative Ground Cover Onsite

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

25) Graminoid Cover Onsite (Use categories in Parameter #24 above) _____

26) Vegetative Ground Cover Offsite (Use categories in Parameter #24 above) ____

27) Graminoid Cover Offsite (Use categories in Parameter #24 above) ____

28) Bare Soil Exposure (Use categories in Parameter #24 above) _____

29-31) Tree Damage None/Slight ______________ Moderate ___________ Severe ________

32-34) Root Exposure None/Slight ______________ Moderate ___________ Severe ________

35) Number of Tree Stumps _____

36-42) Number of Site Facilities:

Picnic Tables ______ Benches ______ Fire sites ______(grates/pits) Toilet _____(type:)

Sun Shade ______ Shelter ______ Others (specify: _________) _______

43) Number of Trails _____

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

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

Vandalism Parameters

46) Number of Occurrences Onsite ____

47) Type (A=Phys. Alteration C=Carving F=Fire G=Graffiti/Painting
H=Attachment O=Other R=Removal/Stealing S=Scratching) ____

48) Location of Disturbance
(B=Building C=Bench H=Minor Structure O=Other S=Sign T=Table) ____

49) Extent of Disturbance (% Contiguous Reachable Surface Affected)
(1=0-5% 2=6-50% 3=51-95% 4=96-100%) _____

50) Loss of Functionality (1=Minor 2=Moderate 3=Severe) _____

Total Site Area

51) Site Area (calculations from below) _____ ft^2

Geometric Figure Method

Shapes and Dimensions

1)

2)

3)

4)

5)

6)

Satellite Area Dimension(s)	Bearing	Distance (ft)	Island Area Dimension(s)	Bearing	Distance (ft)

Total Site Area = Main Site Area: _____ + Satellite Area(s):_____ ! Island Area(s):_____
= ______ ft^2

Comments:____

Boston Harbor Islands National Park Area --Rest/Viewing Site Assessment & Monitoring Form

1) Island ________________ 2) Site No. ______________ 3) Inventoried by ___________

4) Date (m/d/y) _ _ / _ _ / _ _ 5) Time ___:___am/pm 6) GPS (Trimble) (Y / N) _____

7) Site Facilities (*Number of each type*):

Benches ___ Chairs __ Fire sites ___(grate/pit) Toilet ___(type:) Sun Shade ___ Shelter ___ Other___ (specify: ________)

8) Site Size (*Apply geometric figure method with pacing*): ____ ft^2

___ Rectangle: W = _______ft (W) X H=______ ft

___ Circle: R = _______ft

___ Triangle S1= _____ft S2=_____ft S3=______ft

9) Condition Class (1 to 5) ____

10) Vegetative Ground Cover Onsite (1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%) ____

11) Soil Exposure (1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%) ____

12) Litter/Trash (N=None S=Some M=Much) ____

13) Occurrences of Vandalism (*Number*) ____

14) Vandalism Type (A=Phys. Alteration C=Carving F=Fire G=Graffiti/Painting O=Other R=Removal/Stealing S=Scratching) ____

15) Location of Vandalism (B=Building C=Bench H=Minor Structure O=Other S=Sign T=Table) ____

16) Loss of Functionality due to Vandalism (1=Minor 2=Moderate 3=Severe) ____

Boston Harbor Islands National Park Area – Rest/Viewing Site Assessment & Monitoring Form

1) Island ________________ 2) Site No. ______________ 3) Inventoried by ___________

4) Date (m/d/y) _ _ / _ _ / _ _ 5) Time ___:___am/pm 6) GPS (Trimble) (Y / N) _____

7) Site Facilities (*Number of each type*):

Benches ___ Chairs __ Fire sites ___(grate/pit) Toilet ___(type:) Sun Shade ___ Shelter ___ Other___ (specify: ________)

8) Site Size (*Apply geometric figure method with pacing*): ____ ft^2

___ Rectangle: W = _______ft (W) X H=______ ft

___ Circle: R = _______ft

___ Triangle S1= _____ft S2=_____ft S3=______ft

9) Condition Class (1 to 5) ____

10) Vegetative Ground Cover Onsite (1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%) ____

11) Soil Exposure (1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%) ____

12) Litter/Trash (N=None S=Some M=Much) ____

13) Occurrences of Vandalism (*Number*) ____

14) Vandalism Type (A=Phys. Alteration C=Carving F=Fire G=Graffiti/Painting O=Other R=Removal/Stealing S=Scratching) ____

15) Location of Vandalism (B=Building C=Bench H=Minor Structure O=Other S=Sign T=Table) ____

16) Loss of Functionality due to Vandalism (1=Minor 2=Moderate 3=Severe) ____

Boston Harbor Islands National Park Area – Rest/Viewing Site Assessment & Monitoring Form

1) Island ________________ 2) Site No. ______________ 3) Inventoried by ___________

4) Date (m/d/y) _ _ / _ _ / _ _ 5) Time ___:___am/pm 6) GPS (Trimble) (Y / N) _____

7) Site Facilities (*Number of each type*):

Benches ___ Chairs __ Fire sites ___(grate/pit) Toilet ___(type:) Sun Shade ___ Shelter ___ Other___ (specify: ________)

8) Site Size (*Apply geometric figure method with pacing*): ____ ft^2

___ Rectangle: W = _______ft (W) X H=______ ft

___ Circle: R = _______ft

___ Triangle S1= _____ft S2=_____ft S3=______ft

9) Condition Class (1 to 5) ____

10) Vegetative Ground Cover Onsite (1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%) ____

11) Soil Exposure (1=0-5% 2=6-25% 3=26-50% 4=51-75% 5=76-95% 6=96-100%) ____

12) Litter/Trash (N=None S=Some M=Much) ____

13) Occurrences of Vandalism (*Number*) ____

14) Vandalism Type (A=Phys. Alteration C=Carving F=Fire G=Graffiti/Painting O=Other R=Removal/Stealing S=Scratching) ____

15) Location of Vandalism (B=Building C=Bench H=Minor Structure O=Other S=Sign T=Table) ____

16) Loss of Functionality due to Vandalism (1=Minor 2=Moderate 3=Severe) ____

APPENDIX III

Boston Harbor Islands National Park Area (BOHA)
Trail Impact Assessment and Monitoring Manual (Ver. 12/02)
Dr. Yu-Fai Leung
Parks, Recreation and Tourism Management, North Carolina State University

This manual describes trail assessment and monitoring procedures that are developed to provide BOHA managers with standardized, quantitative and reliable information on trail segments and their condition, existing trail maintenance features, and vandalism along trail corridors. Parts of these procedures were adapted from previous studies (Marion 1994; Leung and Marion 1999; Marion and Leung, 2001).

Four types of trail information are collected:

1) *Inventory Information* -- general information about trail segments, such as tread width, tread surface type, tread surface composition;
2) *Resource Condition Information* -- standardized quantitative information about the type and extent of resource impacts on trails, such as soil erosion, wet soil and multiple treads;
3) *Design and Maintenance Information* -- the number and effectiveness of two major trail maintenance features, namely drainage dips and water bars; and
4) *Vandalism Information* – the number, types and extent of vandalism occurring along the trail corridor.

These procedures are 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 different crews apply the same measurements to the same trail segment.

This study adopts an *integrated* approach to trail assessment and monitoring, combining: (a) a *sampling-based* point assessment **(PART A)** and (b) a *census-based* problem assessment **(PART B)**. Information gathered with the sampling-based point assessment can be used to characterize different trail segments in terms of length, width, tread composition and estimated extent of tread problems. On the other hand, information gathered with the census-based problem assessment can be used to document the types, extent and locations of pre-defined problem events occurring on or along the trails. These two types of assessment yield two different types of information for park managers. For a comparison between the two approaches please consult Leung and Marion (2000) and Marion and Leung (2001).

Trail condition data are useful for justifying and prioritizing trail management and maintenance activities. Park managers may also use this information valuable in park management decision-making frameworks such as the National Park Service's Visitor Experience and Resource Protection (VERP) framework. Trail data can also be used for analytical and monitoring purposes. For example, trail impact data can be examined in association with relevant environmental and use-related factors. Trail data can also 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.

Assessment is conducted along the entire length of the each trail segment under study. Two field staff are typically needed for implementing the procedures. One staff pushes a measuring wheel along the trail while stopping at each sampling point (every 200 feet in this study). This measuring staff also observes and takes measurements for all occurrences of pre-defined problem events. Another staff serves as the recording staff who writes down all data obtained by the measuring staff.

A Trail Assessment & Monitoring Form consists of two parts: *Part A* is designed for the sampling-based assessment, with columns for recording distance of sampling point from trail head, tread width, tread incision, pavement condition, tread composition and problem extent. *Part B* of the form is designed for the census-based problem assessment, with 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: GPS Unit (e.g., Trimble GeoExplorer)
Clinometer
Tape measure (25') or electronic distance measurer
This Monitoring manual
Clipboard
Measuring wheel*
Digital camera (fully charged & with sufficient memory)
Field forms
Pencils

** Verify the measurement unit of the measuring wheel. They are usually in feet or meters. Do unit conversion if necessary.*

GENERAL PROCEDURES AND INVENTORY PARAMETERS

The procedures described in this manual apply only to *official* trails that are marked on park maps or otherwise identified by park staff. Before going out to the field, the field staff should familiarize themselves with the trail(s) to be assessed by reviewing maps, park brochures and digital spatial data (digital orthophoto quads, digital raster graphics, etc.). Bring to the field a copy of island map or orthophoto printout on which notes can be made.

Always begin new trail segments with a new form. The following parameters apply to the entire trail segment and <u>must be filled out at the top of each form</u>: *Island, Date, Time (beginning), Inventoried by (name of field staff), Trail Code (see below), Trail Name (if it has an official name), Trail Head (short description), GPS Ready (yes or no), Weather, and Comments (any comments on this trail segment).*

Trail Code: Each trail is to be numbered consecutively. The following numbering format is adopted:

Trail Code = Island Code + 'T' (Feature Type) + Serial Number

Island Code:

Bumpkin - BU	Button - BT	Calf - CF	Georges - GE	Grape - GR	G. Brewster - GB
Green - GN	Langlee - LA	L. Brewster - LB	Lowells - LO	M. Brewster - MB	O. Brewster - OB
Peddocks - PE	Raccoon - RC	Ragged - RG	Rainsford - RA	Sarah - SA	Sheep - SH
Slate - SL	Thompson - TH	Webb SP - WB	World's End - WE		

Feature Type: Use 'T' for all trails
Serial Number starts at 01.
Examples: (a) The third trail surveyed on Grape Island = GRT03
(b) The eleventh trail surveyed on World's End = WET11

PROCEDURES – FORM A

A common approach to characterizing overall trail condition is through sampling-based point assessment. In this study systematic sampling is adopted with the interval set at ***200 feet***. In other words, trail tread width, incision depth, pavement condition, tread composition and problem events are measured or otherwise evaluated at sampling points that are 200 feet apart, starting at the trail head.

Following is detailed description of each parameter:

<u>Distance from Trail Tread</u> – distance reading at each sampling point. In this study the readings should be

200ft, 400ft, 600ft, etc. Since at least *three* sampling points are needed for characterizing a trail, *special procedures* will be required for any trail that is shorter than 600 ft:

-- For trails with lengths between 250 to 600 ft, two additional sampling points should be set at 20 feet from the trail head and 20 feet before the trail end (Four points in total).

– For trails with lengths shorter than 250 ft, three sampling points are set at 20 feet from the trail head, at the center point of the trail length, and 20 ft before the trail end (Three points in total).

<u>Tread Width</u> – defined as the width of the trail on which traffic actually occur. It is measured by stretching a tape measure from one edge of the trail tread to another edge at each sampling point.

<u>Tread Incision</u> – defined as the depth underneath the post-construction trail surface. It is evaluated at each sampling point using a 4-point rating scale. This parameter should be measured in association with tread width measurement.

<u>Pavement Condition</u> – this parameter is applicable to *paved trails only*. It is evaluated at each sampling point using a 4-point rating scale. The pavement is classified into one of the four conditions: *Excellent* condition with very smooth surface and no cracks, *good* condition with smooth surface and minor existence of cracks, *fair* condition with somewhat irregular surface due to minor existence of disintegrated pavement, or *poor* condition with very irregular surface due to extensive occurrence of disintegrated pavement. Walking on trails with poor condition rating is unsafe.

<u>Tread Composition</u> – This parameter indicates trail condition and its sensitivity to visitor impacts. Composition of different tread elements should be estimated as <u>10% increments</u> and the total of all elements should add up to100%.

<u>Problem</u> – This parameter is measured only at each sampling point. The proportion of the tread width affected by each type of problem is estimated..

PROCEDURES – PART B

Another useful approach to documenting trail impacts is through census-based problem assessment. This approach is adopted *in addition to* the systematic point assessment. Twelve pre-defined problem event types have been identified. Each problem event is measured using Part B of the assessment form as field staff are walking on each trail. For ***point*** events only Dist1 (beginning distance) is recorded, while for ***linear*** events both Dist1 (beginning distance) and Dist2 (ending distance) must be recorded. The *minimum detection size* of linear problem events is 10 ft. In other words, small incidents are excluded and only problem events that have 10 ft in linear extent should be recorded to ensure efficiency in the field. Codes for all linear events start with a letter 'B'. To make sure the measurement of a linear event is completed a dash (-) sign can be written in the narrow space under the 'Code' column (left side) when each linear measurement begin (i.e., Dist1 is recorded). When the ending distance (Dist2) of the same event is measured, the dash sign can be converted into a plus '+' sign to indicate that this event is closed. Following is detailed description of each pre-defined event type:

<u>**REF -** Reference Point</u>: Record the code and distance for this parameter periodically when you come across a permanent feature which can be used by park staff to compare and/or recalibrate their wheel readings to those you record in the future. As wheels tend to be inaccurate over long distances, try to include a reference point approximately every 1/2 mile (1 mile = 5280 feet, 1/2 mile = 2640 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.

BE1 -> BE? - Soil Erosion or Eroded Tread (begin/end): The intent of this indicator is to identify trail sections that are experiencing substantial soil erosion *following trail construction*. Only eroded treads with more than 1 foot in depth (incision) should be recorded. Careful attention to the general natural contour of the land in adjacent off-trail areas and to tell clues about the original tread location and subsequent erosion is important. 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. The two soil erosion/eroded tread parameters are defined as:

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 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

BBP - Bare Soil Patches (begin/end): – This parameter is applicable to *grassy trail segments (trail tread that is intended to be covered by groundcover vegetation) only*. For this type of trails bare patches indicate the first signs of soil erosion. In addition to the beginning and ending distance of this event, record the percentage of trail tread that is affected by this problem in the Comments column.

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. In addition to the beginning and ending distance of this event, record the percentage of trail tread that is affected by this problem in the Comments column.

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 site boundaries, are indicated by pronounced changes in ground vegetation cover, composition, and height, or organic litter. Two expansion widths (actual expansion width, excluding the typical trail width) are defined:

BW3: 3 - 6 feet wider than the typical trail width
BW6: > 6 feet wider than the typical trail width

BWS - Wet Soil (begin/end): Record for trail sections which exhibit temporary, seasonally, or permanently wet or boggy soils. 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. In addition to the beginning and ending distance of this event, record the percentage of trail tread that is affected by this problem in the Comments column.

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. In addition to the beginning and ending distance of this event, record the percentage of trail tread that is affected by this problem in the Comments column.

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 in the Comments column.*

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 BE? Parameter above) in the Comments column.*

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

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

VD? - Vandalism: All events of resource damage due to visitor's depreciative behavior along the trail corridor should be recorded. Use the following codes for type of resource being vandalized:

F: Park facilities (specify in comments column) **T**: Trees **O**: Others (specify)

Also record the type of vandalism in the comments column. Examples include graffiti, physical removal, physical alteration, carving, etc.)

Comments: Record additional comments that are related to the problem event.

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. <u>For each photo, record the trail name and a description for labeling purposes in a photo log or on the trail forms.</u>

REFERENCES CITED

Leung, Y.-F. and Marion, J. L. 1999. Assessing trail conditions in protected areas: An application of a problem-assessment method in Great Smoky Mountains National Park, USA. *Environmental Conservation* 26(4): 270-279.

Leung, Y.-F. and Marion, J. L. 2000. Recreation impacts and management in wilderness: A state-of-knowledge review. In: Cole, D. N., McCool, S. F., Borrie, W. T., and O'Loughlin, J., comps. Wilderness Science in a Time of Change Conference - Volume 5. Proceedings RMRS-P-15-VOL-5. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station, pp. 23-48.

Marion, J. L. 1994. *An Assessment of Trail Conditions in Great Smoky Mountains National Park*. Research/Resources Management Report. Atlanta, GA: USDI National Park Service, Southeast Region. 155p.

Marion, J. L. and Leung, Y.-F. 2001. Trail resource impacts and an examination of alternative assessment techniques. *Journal of Park and Recreation Administration* 19(3): 17-37.

Boston Harbor Islands National Park Area

Trail Assessment & Monitoring Form

Island ____________ Date ____/____/____ Time_________am/pm Inventoried by___________________
Trail Code __________ Trail Name (if any)_____________________ Trail Head ________________________
GPS Ready (Trimble) ______(Y/N) Weather___________ Comments____________________________________

PART A – GENERAL ASSESSMENT

Distance from trail head (ft)	Tread Width (ft)	Tread Incision (Class 1-4) [a]	Pavement Condition (Class 1-4) [b]	Composition (total = 100%) [c]								Problem (%) [d]			
				G	L	M	P	R	S	T	V	E	U	W	X

[a] **Tread Incision Classes: 1 = <6 inches 2 = 6 in-1 ft 3 = 1-2 ft 4 = >2ft**
[b] **Pavement Condition Classes (Paved/graveled trails only): 1 = Excellent 2 = Good 3 = Fair 4 = Poor**
[c] **Tread Composition: G = Gravel L= Plant litter M = Mulch P=Pavement R=Parent rock S = Soil T=Natural stones V=Vegetation**
[d] **Tread Problem (at the sampling point): E=Erosion U=Multiple Treads W=Wet Soil X=Root Exposure O=Other**

PART B – PROBLEM EVENTS

(Refer to next page for codes)

Code	Dist1	Dist2	Class [e]	Comments	Code	Dist1	Dist2	Class [e]	Comments

e Width classes: 1 = 0-2.9 ft 2 = 3-5.9 ft 3 = 6-8.9 ft 4 = 9-11.9 ft 5 = $ 12 ft

Trail Problem Event Codes (Part B)

CODE	DESCRIPTION	REMARKS ON MEASUREMENT
REF	Reference Point	Permanent features only; aid in relocation
BE?	Soil Erosion/Tread Incision	Erosional Depth Rating: (?): 1 = 1-1.9 ft 2 = 2-2.9 ft 3 = 3-3.9 ft and so on ... Record Soil Texture: TC,TS,TI,TL,TO,TG,TR
BBP	Bare Soil Patches	*For grassy trails only*; Record % tread width with this problem (e.g., 50% = batch patches on half of the tread on average)
BRE	Root Exposure	Record % tread width with this problem (e.g., 50% = exposed tree roots on half of the tread on average)
BW?	Excessive Width	Rating: (?): 3 - 3-6 ft than the typical width 6 - > 6 ft than the typical width and so on ...
BWS	Wet Soil	Include standing water; Record % tread width with this problem (e.g., 50% = wet soil on half of the tread on average)
BWT	Running Water on Tread	Record % tread width with this problem (e.g., 50% = running water on half of the tread on average)
BMT	Multiple Treads	Record number of treads
BEG	Excessive Grade	Only record sections where trail grades exceed 20%. Record soil texture: TC,TS,TI,TL,TO,TG,TR
DD?	Drainage Dip	(?) – Effectiveness Ratings: V - Very effective P - Partially effective I - Ineffective
WB?	Water Bar	(?) – Effectiveness Ratings: V - Very effective P - Partially effective I - Ineffective Record water bar type (log, rock, rubber, etc.)
VD?	Vandalism	(?) – Resource Type: F - Park Facilities (specify type) T - Trees O - Others (specify) Record the type of vandalism (graffiti, physical alteration, carving, etc.)

APPENDIX IV

BOHA Carrying Capacity Project
Resource Component

FIELD MANUAL 2002

Dr. Yu-Fai Leung
Parks, Recreation and Tourism Management
North Carolina State University
Version June 22, 2002

OBJECTIVES

1) To assess and evaluate the utility of potential biophysical (soil and vegetation) indicators.
2) To evaluate temporal changes of resource conditions on selected trails and campsites by remeasurements

FIELD METHODS

I. Approach

- Field sampling is primarily based on major soil series (NpC, Ua, BbC)
- Field data collection is focused on four major public-use islands: *Georges, Lovells, Grape and Peddocks*. Other islands may be added as necessary
- The hierarchy of sampling involves FOUR levels: (1) sampling plots, (2) line transects, (3) sampling quadrats, and (4) measurement points.
- Measurements are performed along each line transect and within each sampling quadrat
- Background penetration resistance is measured on adjacent and environmentally-similar control areas
- Some soil quality measurements (slake tests and soil texture) are performed on selected quadrats only

II. Sampling (FORM A)

<u>Equipment</u>

Clip board and pencil
Field forms
Measuring tape
Tent pole (center point)
10 flags
Nut (buried underneath the center point)
Digital camera (center point and other relevant photos)
GPS units: Garmin and Trimble GeoExplorer

<u>Procedures</u>

- Within each selected soil type, 2 high use (HUS) areas and 2 low use (LUS) areas will be selected. They should be as close to each other as possible for better comparisons
- TWO 6-m radius circular sampling plots are randomly placed in each HUS area and LUS area
- The center of plot is determined randomly by tossing a coin
- Within each sampling plot SIX linear sub-transects are randomly placed. Each sub-transect is essentially a radius connecting the circle center and perimeter. The orientation (compass bearing) of the first sub-transect is determined randomly, while each of the subsequent sub-transects is 60 degrees *clockwise* from the previous sub-transect. The two opposite sub-transects (i.e., 1^{st} and 4^{th} sub-transects) form a full transect (e.g., T1 = T1A + T1B)
- TWO 25cmX25cm quadrats are randomly located along each line transect (determined by random numbers)
- Spatial reference of the center point is documented using photo, GPS (Garmin and Trimble) and coordinate geometry (distance and compass bearing)
- Overall evaluation of the sampling plot is performed using the 0-6 cover scale and 0-5 erosion codes (see reference card)

III. Quadrat Measurements (FORM A)

Equipment

Same as Part II
Quadrats
Pocket penetrometer
Cone penetrometer

Procedures

- Along each line sub-transect TWO 25cm X 25cm quadrats are located. Quadrats should be placed on the right side of the sub-transect (looking from the center point). If two quadrats are too close to each other (within 10 cm) select the second quadrat again using random number.

- Within EACH quadrat the following indicators are measured:
  - cover estimates of tree seedlings, forbs/herbs, grasses, weeds (name type if possible), lichens or mosses, and exposed soil (each in 7 categories, should add up to 100%)
  - observe groundcover within each quadrat vertically and record the appropriate cover class in each of the following cover types (also see reference card):

Class 0	Not present
Class 1	Minimal amount - 5%
Class 2	6-25%
Class 3	26-50%
Class 4	51-75%
Class 5	76-95%
Class 6	96-100%

  - penetration resistance-pocket (4 points at the centers of each quadrat side); push vertically
  - penetration resistance-cone (4 points next to pocket PR measurements); measure readings vertically at two levels: 0-3 inches and 3-6 inches; use the small cone (½ in) as standard, but if the soil is too soft, change to the large (3/4 in) cone and take the reading from the outer scale.

Penetration Resistance at Controls (FORM A1)

* Penetration resistance is also measured at eight randomly selected points in the adjacent and environmentally-similar areas served as controls. Eight pocket-PR readings and eight pairs of cone-PR readings are taken

IV. Line Transect Continuous Measurements (FORM B)

Equipment

Same as Parts I and II

Procedures

- Different types of groundcover along each line transect are continuously assessed using FORM B. These groundcover types include:
  - Vegetation-grasses

- Vegetation-weed (name types if possible)
- Vegetation-tree seedlings
- Vegetation-herbaceous plants
- Bare soil patches
- Bare soil with surface crust
- Bare soil with evidence of rill or gully erosion
- Other types as appropriate

- For each groundcover type record the starting and ending point of each occurrence that <u>intersects</u> with or are contained within 5cm from the line transect

V. Soil Tests (FORM B)

<u>Equipment</u>

3 slake test kits
Small shrovel or scoop

<u>Procedures</u>

-On each transect randomly select one quadrat and perform the following analysis:

* Slake test (see reference card)
* Soil texture by the feel method (see reference card)
* refer to the *USDA Soil Quality Test Kit Guide* for detailed procedures

- Soil aggregate fragments for the slake test should be taken as soon as the sampling plot is laid out to allow time for air drying

FORM A - SAMPLING PLOT AND QUADRAT-BASED MEASUREMENTS

Date: _________________Start Time: ______(am/pm)End Time: ________ (am/pm) Island: _________

Start Weather: __________End Weather: __________Staff:_______ **SAMPLING PLOT No: ______________**

Center Point Location: Description:____ Garmin GPS (UTM): ___________________ Photo___ Nut___

Reference Point: Object Description:____ Distance from center point (m):________ Bearing: ________

General Plot Data: Slope____ Aspect____ Canopy (0-6)__ Grass (0-6)__ Weed (0-6)__ Trash (0-6)__ Erosion (0-5):___ Write comments on back -->

Transect No. ___________________ Sub-Transect A Bearing: _____________ Sub-Transect B Bearing: _____________

Quad No.	Distance from center point (m)	Surface Composition (class 0-6) [0=None;1=min.-5%;2=6-25%;3=26-50%;4=51-75%;5=76-95%;6=96-100%]								Penetration Resistance (Pocket)				Penetration Resistance (Cone)								Soil Tests Selected (check 1)
		grass	weed (+type)	tree seedl.	moss/ lichen	plant litter	bare soil	trash	Other (____)	#1	#2	#3	#4	#1		#2		#3		#4		
														3in	6in	3in	6in	3in	6in	3in	6in	

Transect No. ___________________ Sub-Transect A Bearing: _____________ Sub-Transect B Bearing: _____________

Quad No.	Distance from center point (m)	Surface Composition (class 0-6) [0=None;1=min.-5%;2=6-25%;3=26-50%;4=51-75%;5=76-95%;6=96-100%]								Penetration Resistance (Pocket)				Penetration Resistance (Cone)								Soil Tests Selected (check 1)
		grass	weed (+type)	tree seedl.	moss/ lichen	plant litter	bare soil	trash	Other (____)	#1	#2	#3	#4	#1		#2		#3		#4		
														3in	6in	3in	6in	3in	6in	3in	6in	

Transect No. ___________________ Sub-Transect A Bearing: _____________ Sub-Transect B Bearing: _____________

Quad No.	Distance from center point (m)	Surface Composition (class 0-6) [0=None;1=min.-5%;2=6-25%;3=26-50%;4=51-75%;5=76-95%;6=96-100%]								Penetration Resistance (Pocket)				Penetration Resistance (Cone)								Soil Tests Selected (check 1)
		grass	weed (+type)	tree seedl.	moss/ lichen	plant litter	bare soil	trash	Other (____)	#1	#2	#3	#4	#1		#2		#3		#4		
														3in	6in	3in	6in	3in	6in	3in	6in	

FORM A1 – Penetration Resistance at Controls

SAMPLING PLOT NO.____________ Date_________ Time_______(am/pm) Staff ____________

Penetration Resistance (Pocket)		Penetration Resistance (Cone)		
Point	Reading (kg/cm^2)	Point	Reading (pounds/in^2)	
			0-3 inches	3-6 inches
#1		#1		
#2		#2		
#3		#3		
#4		#4		
#5		#5		
#6		#6		
#7		#7		
#8		#8		

FORM B – LINE TRANSECT CONTINUOUS ASSESSMENT AND SOILTESTS

Date: _________ Start Time: ______(am/pm) End Time: ________ (am/pm) Island: _________
Start Weather: __________ End Weather: __________ Staff:________________________

SAMPLING PLOT No: ________________

I. LINE TRANSECT CONTINUOUS ASSESSMENT

Transect No.	Begin distance (m)	End distance (m)	Surface type	Transect No.	Begin distance (m)	End distance (m)	Surface type

Continue on back (y/n)?___

II. SOIL TESTS

Transect No.	Quad-rat	Soil Texture	Slake Test								
			Individual Slake Ratings								*Average Rating*

Transect No.	Begin distance (m)	End distance (m)	Surface type	Transect No.	Begin distance (m)	End distance (m)	Surface type

Comments:

9. Slake Test

The slake test measures the stability of soil when exposed to rapid wetting. This test is qualitative and should be measured on air-dried soil fragments or aggregates.

Materials needed to measure slaking:

- **complete soil stability kit**
- **sampling scoop**
- **distilled water (1 L)**

Did You Know?
Soil stability serves as a qualitative indicator of soil biological activity, energy flow, and nutrient cycling. Binding of soil particles must constantly be renewed by biological processes.

Considerations: The soil should be **air-dry** when performing this test. If the soil is not dry, collect surface fragments as described in Step 1 and allow them to dry. Be careful not to destroy the soil fragments while sampling.

1 Collect Surface Fragments

- Carefully remove soil fragments or aggregates from the soil surface. If there is a surface crust, carefully sample pieces of it. Use the **flat end** (handle) of the scoop to lift out surface and subsurface fragments. If the soil has been tilled, collect some aggregates (about 1 cm in size). Be careful not to shatter the soil fragments or aggregates while sampling.

- Collect 16 separate soil fragments. If there is a surface crust, collect eight fragments of the crust and eight fragments from below the crust.

Figure 9.1

2 Fill Box with Water

- Remove all sieve baskets from the stability kit.

- Fill the compartments in the box with water. The water should be 2 cm deep and at approximately the same temperature as the soil.

Figure 9.2

3 Test Soil Fragments

- Place soil fragments in the sieve baskets **(Figure 9.1).**

- Lower one of the sieves into a box compartment filled with water **(Figure 9.2)**.

4 Observe Fragments

- Observe the soil fragment for **five minutes**. Refer to the stability class table below to determine classes 1 and 2.

- After five minutes, raise the basket out of the water, then lower it to the bottom. It should take one second for the basket to clear the surface and one second to return to the bottom.

- Repeat immersion four times (total of five immersions). Refer to the stability class table below to determine classes 3 through 6.

5 Record Ratings

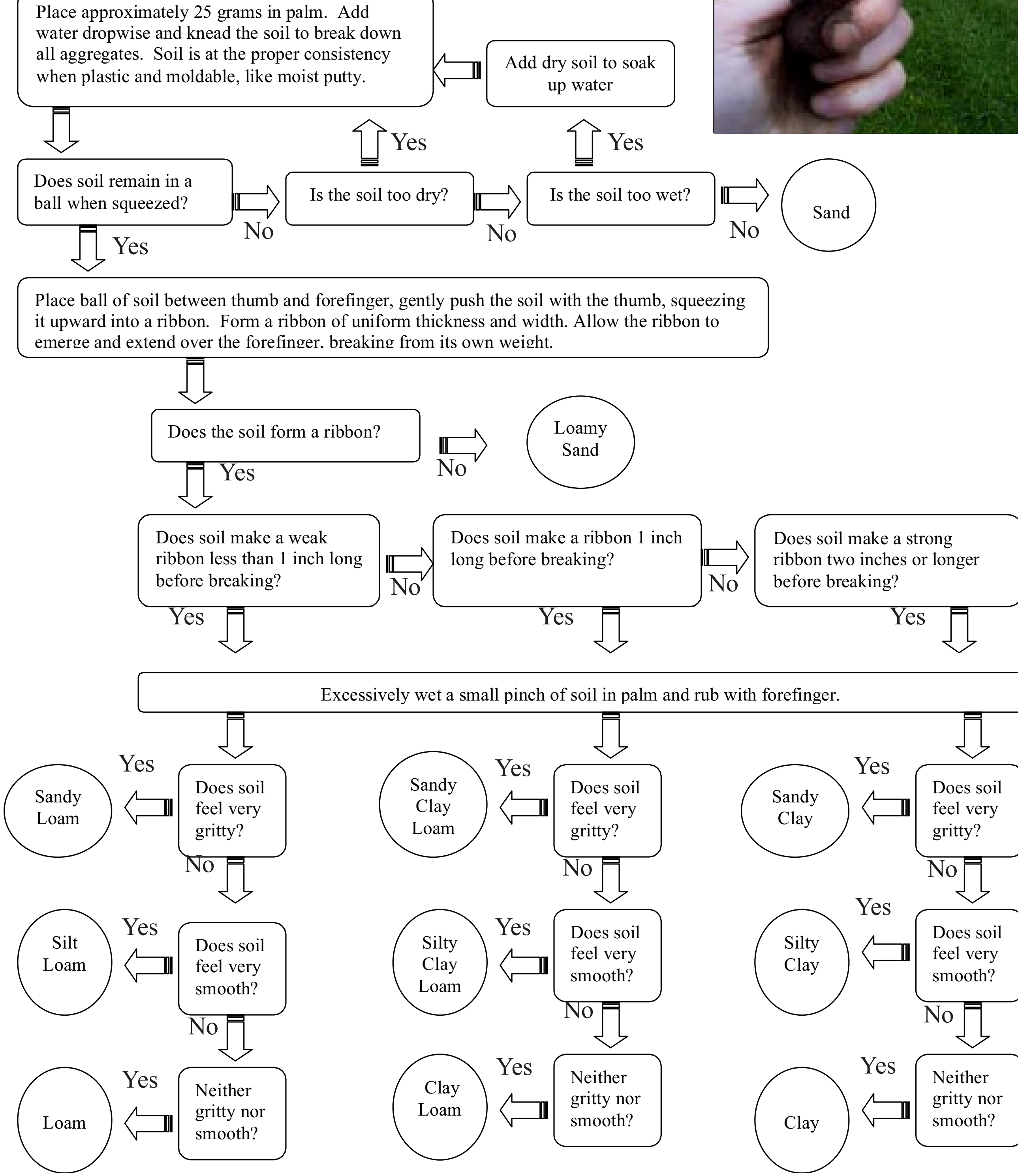
- Soil stability is rated according to the time required for the fragment to disintegrate during the five-minute immersion and the proportion of the soil fragment remaining on the mesh after the five extraction-immersion cycles. **[See table below.]**

- Record the stability ratings for all 16 soil fragments or aggregates on the Soil Data worksheet.

Stability class	Criteria for assignment to stability class (for "Standard Characterization")
0	Soil too unstable to sample (falls through sieve).
1	**50 %** of structural integrity lost within **5 seconds** of insertion in water.
2	**50 %** of structural integrity lost **5 - 30 seconds** after insertion.
3	**50 %** of structural integrity lost **30 - 300 seconds** after insertion or **< 10 %** of soil remains on the sieve after 5 dipping cycles.
4	**10 - 25%** of soil remaining on sieve after 5 dipping cycles.
5	**25 - 75%** of soil remaining on sieve after 5 dipping cycles.
6	**75 - 100%** of soil remaining on sieve after 5 dipping cycles.

TEXTURE BY FEEL PROCEDURE

Making a Ribbon



GROUND VEGETATION COVER CLASSES (0-6)
Photo Examples

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

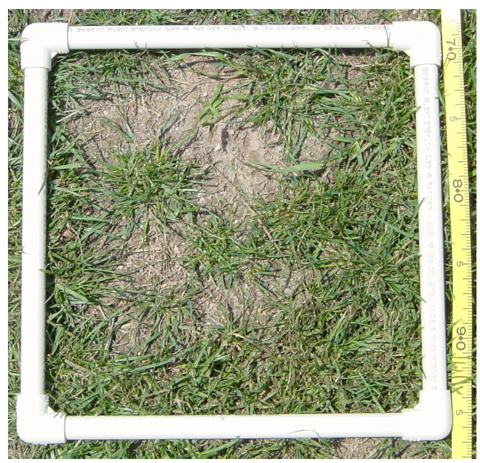
Class 0 = Not Present

Class 1: minimal amount-5%

Class 2: 6-25%

Class 3: 26-50%

Class 4: 51-75%



Class 5: 76-95%

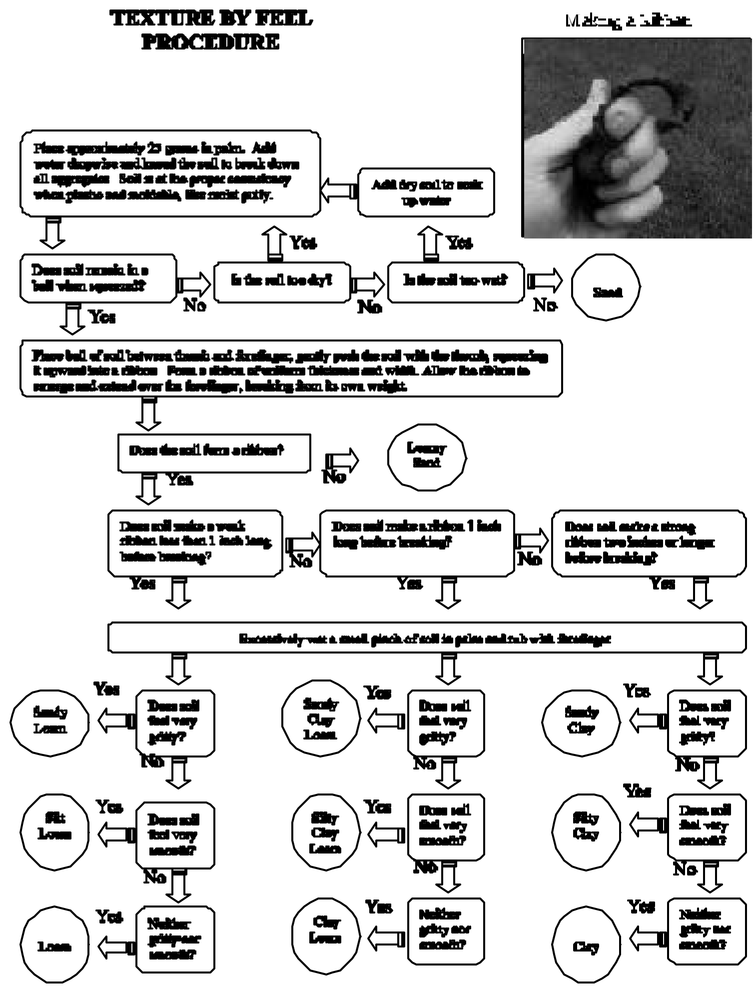
Class 6: 96-100%

EROSION CODES (Form A)

Code	Indicators
0	No exposure of tree roots; no surface crusting; no splash pedestals; over 70% plant cover (ground and canopy)
½	Slight exposure of tree roots; slight crusting of the surface; no splash pedestals; soil level slightly higher on upslope or windward sides of plants and boulders; 30-70% plant cover
1	Exposure of tree roots; formation of splash pedestals; soil mounds protected by vegetation; all to depths of 1-10mm; slight surface crusting; 30-70% vegetation cover
2	Tree root exposure; splash pedestals and soil mounds to depths of 1-5cm; crusting of the surface; 30-70% plant cover
3	Tree root exposure; splash pedestals and soil mounds to depths of 5-10cm; 2-5mm thickness of surface crust; grass muddied by wash and turned downslope; splays of coarse material due to wash and wind; less than 30% plant cover
4	Tree root exposure; splash pedestals and soil mounds to depths of 5-10cm; splays of coarse material; rills up to 8cm deep; bare soil
5	Gullies; rills over 8cm deep; blow-outs and dunes; bare soil

SLAKE TEST – SOIL STABILITY CLASS (Form B)

Stability Class	Criteria for assignment to stability class (for "standardized characterization")
0	Soil too unstable to sample (falls through sieve)
1	**50 %** of structural integrity lost within **5 seconds** of insertion in water
2	**50 %** of structural integrity lost **5 - 30 seconds** after insertion in water
3	**50 %** of structural integrity lost **30 - 300 seconds** after insertion <u>or</u> **< 10 %** of soil remains on sieve basket after 5 dipping cycles
4	**10 - 25 %** of soil remaining on sieve basket after 5 dipping cycles
5	**25 - 75 %** of soil remaining on sieve basket after 5 dipping cycles
6	**75 - 100 %** of soil remaining on sieve basket after 5 dipping cycles



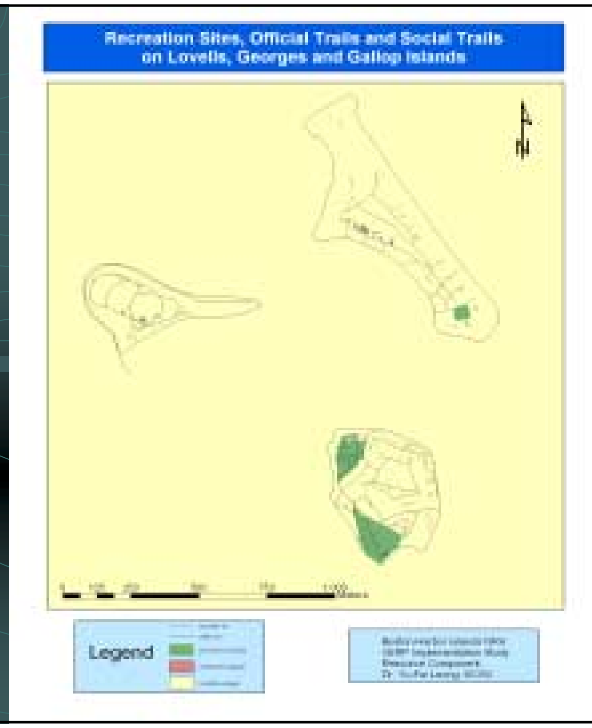
APPENDIX V

Comparing Recreational Grade and Survey Grade GPS

-- *Boston Harbor Islands Example*

Study Area


JUN 28 2001



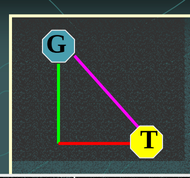
Recreation Site Assessment Study

- Conducted in 2001
- Part of a larger visitor use planning project
- Inventory and condition assessment of all recreation sites and trails on 22 islands and peninsulas
- Recreation sites were mapped using two types of GPS units to evaluate comparability

Methods

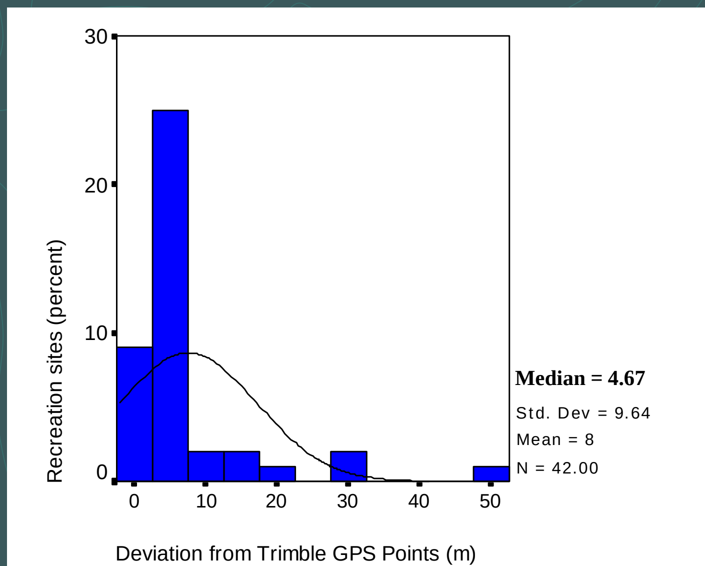
- Survey grade GPS – ***Trimble Geo Explorer III***; data were differentially corrected through post processing
- Recreational grade GPS – ***Garmin III***, waypoint for each site, no differential correction
- 42 sites from 5 islands were selected for comparison
- Garmin data were collected in Lat./Long. and were converted to UTM for comparison
- Comparison:
  - Difference in latitude (northing)
  - Difference in longitude (easting)
  - Distance or deviation of Garmin waypoints from Trimble points

Results



Parameter/ Statistic	Difference in latitude (m)	Difference in longitude (m)	Horizontal Distance (m)
Mean	5.08	4.63	7.50
Median	3.45	2.13	4.67
Std. Dev.	5.92	8.19	9.64
Range	0 - 24.19	0.03 - 44.73	0.65 - 50.85
Statistical significance (t test)	Yes (p<.000)	Yes (p<.001)	Yes (p<.000)

Distribution of Data (Horizontal Distance)



Boston Harbor Islands Summary

- Garmin GPS is good enough for mapping sites ($\geq 25m^2$ or 300 ft^2) but <u>not</u> mapping points
- Most deviations are small
- Differential correction is important for Trimble GPS data
- Understanding and handling of outliers (extreme differences)