National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Forest Vegetation Monitoring Protocol version 2.0

Great Lakes Inventory and Monitoring Network

Natural Resource Report NPS/GLKN/NRR—2014/799

ON THE COVER
Isle Royale National Park, viewed northward from Ojibway Tower.
Photograph by: Jessica Grochowski

Forest Vegetation Monitoring Protocol version 2.0

Great Lakes Inventory and Monitoring Network

Natural Resource Report NPS/GLKN/NRR—2014/799

Suzanne Sanders and Jessica Grochowski

National Park Service
2800 Lake Shore Dr. East
Ashland, WI 54806

April 2014

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate high-priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received formal peer review by subject-matter experts whose background and expertise put them on par technically and scientifically with the authors of the information.

This report is available in digital format from http://science.nature.nps.gov/im/units/glkn/index.cfm and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Sanders, S. M. and J. Grochowski. 2014. Forest vegetation monitoring protocol version 2.0: Great Lakes Inventory and Monitoring Network. Natural Resource Report NPS/GLKN/NRR—2014/799. National Park Service, Fort Collins, Colorado.

NPS 920/124450, April 2014

Contents

Page

Contents (continued)

Figures

Page

Tables

Page

Standard Operating Procedures

Abstract

Forest vegetation provides an integrated measure of terrestrial ecosystem health by expressing information about climate, soils, and disturbance, as well as browse, and exotic species invasion. We developed a comprehensive protocol that incorporates the Network's monitoring plans for terrestrial vegetation as well as those of related Vital Signs, including terrestrial pests and pathogens, problem species, and succession. Monitoring will be conducted on a nine-year rotation, with each of the Great Lakes Inventory and Monitoring Network's parks visited in one season out of every nine years. Monitoring plot locations were selected to ensure that the sites are randomly located, but spatially balanced throughout the park. The Hybrid plot is used during on-the-ground sampling, with extensive data collected on trees, tree seedlings, and the groundlayer, in addition to browse and coarse woody material. Data are housed in a Microsoft Access database, and appropriate metadata are generated annually. Quality control measures include both on site assessments of accuracy, as well as extensive data checking. Finally, all work from each season is reported annually, with detailed reports generated after the completion of each nine-year rotation.

Acknowledgments

This protocol could not have been completed without the input of numerous individuals both within and outside of the Park Service. We are grateful to Chip Scott and Andrew Lister of the U.S. Forest Service's Northern Monitoring Program. They have assisted with multiple aspects of plot selection. We are also grateful to Tony Olsen of the U.S. Environmental Protection Agency for assistance with algorithms for site selection. We wish to thank Mark Hart for his contributions on data handling and to Sarah Pratt and Rebecca Key for their assistance with database development and GPS preparation. We thank several individuals associated with the University of Wisconsin-Madison, including Erika Mudrak, Dave Rogers, Rachel Collins, and Dan Olson, for contributing in various ways to this protocol. We are also grateful to Don Waller and Sarah Johnson for their contributions to the first version. Finally, we would like to thank all who have spent time reviewing the various sections of this protocol. These people include Erik Beever, Mark Fulton, Joe O'Brien, Scott Weyenberg, Wendy Cass, Lee Frelich, and Christopher Woodall. The comments raised by these reviewers have, undoubtedly, raised the quality of the protocol.

Background and Objectives

Rationale for Monitoring Vegetation Communities

Terrestrial vegetation was ranked third among all 46 Vital Signs evaluated by the National Park Service (NPS) Great Lakes Network for incorporation into a long-term monitoring strategy. Terrestrial vegetation serves as an integrated measure of terrestrial ecosystem health by expressing information about climate, soils, and disturbance (Randerson et al. 2002), as well as browse (Côte et al. 2004), and exotic species invasion (Ojima et al. 1991). Further, terrestrial vegetation serves as a trophic base for other ecosystem components (Fortin et al. 2005). Because of this interwoven relationship between terrestrial vegetation and both biotic and abiotic components, we have developed a comprehensive protocol that incorporates the Network's monitoring plans for terrestrial vegetation as well as those of related Vital Signs, including terrestrial pests and pathogens, problem species, and succession. Because forests predominate the landscape in the Great Lakes Network national parks (Route and Elias 2007), this protocol will focus exclusively on forested vegetation.

Network Parks and Ecosystems

The nine park units of the Great Lakes Inventory and Monitoring Network (GLKN) extend from the boreal forests of northern Minnesota to the sand dunes of southern Lake Michigan (Figure 1) and represent the major freshwater ecosystems of the Upper Midwest.

Figure 1. Nine National Park units of the Great Lakes Inventory and Monitoring Network.

Apostle Islands National Lakeshore (APIS) is located near Bayfield in extreme northwestern Wisconsin. It consists of 21 islands, ranging in size from 1 to 4,000 hectares, and a 19-kilometer segment along the mainland shore of Lake Superior. The lakeshore is at the northwestern limits of the hemlock-white pine and northern hardwood forest and also contains elements of the southern boreal forest. The lakeshore has a wide variety of sandscapes such as barrier spits, cuspate forelands, beaches, and dunes that provide unique habitats for plants and wildlife. In addition, 13,560 hectares of the park have been designated as wilderness.

Grand Portage National Monument (GRPO) is located 56 kilometers northeast of Grand Marais, Minnesota in the extreme northeastern 'arrowhead' region of the state near the Canadian border. The monument protects 287 hectares of land including the historic trading post of the North West Company on Lake Superior, the site of Fort Charlotte on the Pigeon River, and a 13.7 kilometer historic canoe portage trail that connects the two sites. The portage trail crosses several riparian areas and over the Grand Portage Highlands with a 240-meter rise in elevation. The area is covered by a near-boreal forest, with birch-aspen-spruce-fir communities dominating most sites. The Grand Portage trail corridor bisects the Grand Portage Band of Minnesota Chippewa Reservation. Surrounding land use greatly influences resource management at GRPO. Forestry practices on Reservation lands are carefully integrated with wildlife management objectives, and large areas are set aside to preserve the near wilderness character of the region.

Indiana Dunes National Lakeshore (INDU) spans approximately 40 kilometers along southern Lake Michigan and includes 6,070 hectares. Biological diversity is one of the most significant features of the lakeshore and a primary reason for its establishment. This diversity is greater than most areas of similar size because Indiana Dunes lies at the convergence of several ecological zones, and includes components of northern conifer forests, temperate hardwood forests, and tallgrass prairies. Diverse habitat types include beaches, bogs, prairies, black oak savannas, forests, wetlands, and marshes. The Lakeshore is composed of unconsolidated soils on which landforms range from open beach and active dunes to stabilized and extensively vegetated older dunes and moraines. Some dunes, like Mount Baldy, rise to heights of over 30 meters above the shoreline.

Isle Royale National Park (ISRO) is a remote island archipelago in northwestern Lake Superior. It consists of one large island that is 72 kilometers long and 14 kilometers wide, surrounded by about 400 small islands. The park protects 231,395 hectares, with 53,426 hectares (23%) designated as wilderness. The island is densely forested with northern boreal spruce-fir forest near the cool, moist shoreline of Lake Superior, and northern hardwoods in the warmer, drier interior. Inland lakes, ponds, and streams are numerous throughout Isle Royale.

Mississippi National River and Recreation Area (MISS) extends 116 kilometers along the Mississippi River and six kilometers along the Minnesota River and encompasses about 21,800 hectares of public and private land and water. Less than 40 hectares of land, all on islands within the river, are actually owned and under regulatory authority of the NPS. This section of river, some of which flows through metropolitan St. Paul and Minneapolis, is a major transportation corridor and yet a place for recreation and quiet in the midst of an urban environment. The numerous private, state, county, and other federal landowners make management of access, resource use, and development complex. The rivers themselves, and the riparian zones along the shorelines and islands, are the primary biotic communities of interest.

Pictured Rocks National Lakeshore (PIRO) protects 28,893 hectares of land including 67 kilometers of Lake Superior shoreline and 4,751 hectares within the Beaver Basin Wilderness. The park is located along the south-central shore of Lake Superior within a transition zone between the boreal and eastern deciduous forest biomes. Hardwood forests are prevalent, although conifers dominate some sites, and wetlands are common throughout the park. The cold, moist climate along the lakeshore greatly influences the biotic communities. The park is divided into two distinct ownership and management zones; the federally owned shoreline zone, known as the “core”, and a non-federal “inland buffer zone”. Sustained yield timber harvesting and other consumptive uses are allowed in the buffer zone; however, these uses were intended by Congress to be subordinate to public recreation and the protection of “the usefulness and attractiveness of the lakeshore.”

The St. Croix National Scenic Riverway (SACN) protects 37,529 hectares including 405 kilometers of the St. Croix and Namekagon Rivers in eastern Minnesota and northwest Wisconsin. The park spans three major biomes: boreal forest, eastern deciduous forest, and oak and pine savanna, while wetlands are also common throughout the park. The rivers themselves, and the riparian zones along them, greatly influence the biotic communities. The park is divided into two distinct management zones: the upper St. Croix and Namekagon Rivers, and the lower St. Croix River. Numerous private, state, county, and other federal landowners along the corridor make management of access and resource use complex.

Sleeping Bear Dunes National Lakeshore (SLBE) protects 28,813 hectares of land and water along the northeastern shore of Lake Michigan. The lakeshore includes two large islands in Lake Michigan: North and South Manitou. There are 169 kilometers of Lake Michigan shoreline, 26 inland lakes, and four streams. The interior forested areas were dominated by both sugar maple and American beech, although the latter species has experienced significant declines due to the impact of beech bark disease in the previous five years.

Voyageurs National Park (VOYA) is located approximately 480 km north of Minneapolis, Minnesota in the forested lake region along the Minnesota-Ontario border. Voyageurs is composed of 88,243 hectares, of which approximately 33,908 hectares (38%) are covered by lakes and ponds. Two large reservoirs, with hundreds of islands, form much of the lake area, but there are 26 smaller lakes and hundreds of beaver ponds and drainage systems. The interior of the park is typical southern boreal spruce/fir forest, but deciduous trees dominate some areas.

Current Threats to Vegetation in NPS Units

The forests of the Great Lakes Network parks are threatened by a number of direct and indirect stressors. Direct stressors include several insect pests that are now present at the eastern Network parks and are spreading westward. These include beech scale (*Cryptococcus fagisuga*, together with the native fungi *Neonectria faginata* and *N. ditissima*, a causal agent of beech bark disease) which was first discovered in Nova Scotia in 1911 (Houston 1994) and is now present on beech trees in PIRO and SLBE. While there is some literature suggesting how the beech resource will respond to this threat, little is known about vegetation response following its decline, especially in network parks located at the northwestern edge of the beech range (For exceptions, see Papaik et al. 2005, Morin et al. 2007). Another insect pest, emerald ash borer (*Agrilus planipennis*), was first reported near the Detroit, Michigan area in 2002 (Muirhead et al. 2006) and, as of 2013, has been confirmed at INDU and SLBE and in the counties where MISS is located. This insect is lethal to all species of ash; it is not known how the surrounding vegetation will respond following this decline.

Earthworms are another group of exotic pests adversely impacting the forests of the upper Midwest. Earthworms are believed to have been absent from areas directly affected by the Pleistocene glaciations, an expanse that includes all Network parks (Hendrix and Bohlen 2002). Although natural earthworm dispersion is relatively slow, on the order of 5 – 10 meters per year (Marinissen and van den Bosch 1992, Dymond et al. 1997, Hale et al. 2005), the introduction of earthworms from recreational fishing greatly augments their spread into previously worm-free areas (Bohlen et al. 2004). Exotic European earthworms, which have been reported in multiple Great Lakes Network parks, rapidly change soil properties resulting in an increased thickness of the A soil horizon and a corresponding decrease in the organic horizon (Gundale et al. 2005). Earthworm invasion impacts the plant community by removing the forest floor duff layer (Hale 2004) and by reducing regeneration (Kostel-Hughes 1995).

In addition to exotic species, changes in management and land use have led to uncharacteristic expansion of a few native taxa, such that they have become problem species. The most notable example of this is the irruption of the native white-tailed deer population. Browsing pressure by deer has reduced the abundance of certain native plant species (e.g., Canada yew [*Taxus canadensis* Marsh.] (Allison 1990a, b, 1992), eastern hemlock (*Tsuga canadensis* (L.) Carriére) (Mladenoff and Stearns 1993, Rooney et al. 2000), and many broad-leaved forest wildflower species) to a fraction of their previous abundance (Rooney 2001, Russell et al. 2001). Further, overbrowsing by deer is driving change at the community level by promoting the biotic homogenization of Great Lakes forests (Rooney et al. 2004). For these reasons, white-tailed deer is the major problem vertebrate threatening the health of Great Lakes forests.

While direct stressors impart obvious identifiable change to forest structure, indirect stressors can be equally detrimental. This is especially true because the change occurs in a subtle manner over time and causal agents are often not easily identifiable so that reversing this trend is difficult. Regionally, shifts in overstory composition from pine (*Pinus strobus* L. and *P. resinosa* Aiton.) to balsam fir (*Abies balsamea* (L.) Mill) have been documented (Frelich and Reich 1995, MacLean and Gucciardo 2005) and are likely due, only in part, to altered fire regimes. Further, long-term decline of sugar maple (*Acer saccharum* Marsh.) (Auclair 2005), white oak (*Quercus alba* L.) (Abrams 2003), and hemlock (Kizlinski et al. 2002) also pose problems to the health of Great Lakes Network Parks. In these instances, multiple causal agents are believed to contribute to the decline.

Routine monitoring of forest health will provide an understanding of natural variability of vegetation in 'benchmark' areas where direct human disturbance (e.g., logging, development) no longer occurs. In addition, monitoring will provide an early warning of undesirable trends in vegetation, allow adaptive management of forest ecosystems, and allow for inferences about the effects of the above threats on both terrestrial vegetation and overall forest health.

Overview of Vegetation Monitoring at the Great Lakes Network Parks

This protocol is intended to detail a comprehensive monitoring program with consistent methods across all nine Network parks. Prior terrestrial vegetation monitoring efforts have been undertaken at five of the Network parks, although the duration, extent, and scientific credibility have varied immensely among these efforts.

Permanent forest monitoring plots were established in 1997 on four islands at the Apostle Islands National Lakeshore (Meeker 2000). On Outer Island, plots were placed in four areas: 1) an old growth mature hemlock-hardwood stand, 2) an area adjacent to the old growth that was cut in the 1960s, 3) an area cut in the 1940s but not burned, and 4) an area cut in the 1930s and burned. Other plots were established on the smaller islands with more boreal habitat. They include areas recently cut (York, cut in the early 1970s) and less disturbed forests on Devils and Raspberry Islands. Although these sites have been permanently marked, regular monitoring has not occurred since initial assessments in 1997-1998. In addition to Meeker's work, Beals and Cottom (1960) established 75 vegetation survey plots on the islands from 1955 – 1958. While these were not intended to be long-term monitoring points, 28 of these plots were revisited in 2005 to assess 47-year vegetation changes (Mudrak et al. 2009).

At Grand Portage National Monument, a system of permanent vegetation plots was established in 1986 to compare changes over time between interior forests and forests adjacent to clear cuts. Metrics for this study were remeasured in 1992, 1999, and 2004 and an analysis of these data was published in 2005 (MacLean and Gucciardo 2005). On all plots, abundance and basal area of balsam fir (*Abies balsamea* (L.) Mill.) increased, while that of paper birch (*Betula papyrifera* Marsh.) and quaking aspen (*Populus tremuloides* Michx.) declined. The observed pattern is likely due, in part, to succession, although a reduction of fire is also a primary cause. Unfortunately, only two plots were placed in each treatment and the majority of statistics were descriptive (e.g., means, percent change).

Indiana Dunes National Lakeshore is one of the most botanically diverse national parks, located at the juncture of prairie, lake, and forest biomes. Approximately 30% of Indiana's state listed rare plant species occur within the park boundaries (Gucciardo et al. 2005). Not surprisingly, much of the monitoring at the park has focused on rare plant species, rather than forest vegetation.

Isle Royale National Park has the longest history of vegetation monitoring of any of the Network parks. In 1963, Peter Jordan of the University of Minnesota established plots to monitor the impact of moose on vegetation. These plots are arranged linearly into clusters that are oriented along a north – south (180 - 360˚) axis (for those clusters established prior to 1980) or oriented along a 160 - 340˚ axis (for those clusters established in 1980). Data collected include tree species, diameter at breast height (DBH), and percent cover for multiple forest layers. Dr. Lee Frelich of the University of Minnesota is currently working with these data toward producing a synopsis of this project.

At Pictured Rocks National Lakeshore, 146 permanent plots were established over the five year period from 2000 – 2004. The plots were established using the plot layout of the Forest Service's Forest Inventory and Analysis (FIA) program (Bechtold and Scott 2005), and metrics included all of those in the FIA Phase II program, as well as select indices of vegetation and down woody materials that are part of the Phase III program.

The questions addressed by these studies vary, although none have focused on quantifying forest change in response to long-term environmental change. Further, these studies were limited in scope with no attempt to integrate the results with other ecosystem attributes such as soils, insects, or mammals. Doing so will allow us to show associations between vegetation and associated attributes. Collectively, a network-wide monitoring system with clear objectives can answer questions about shifts in forest characteristics in response to increasing environmental pressures, as well as provide an assessment of overall forest health.

Measurable Objectives

The goals of this monitoring program are to detect forest change and to draw inferences about forest health, so that management recommendations can be provided to the parks. To accomplish this, the monitoring objectives are grouped into two tiers. The primary objective, or first tier, is to detect change directly in forest attributes. The specific questions that address this objective follow:

1) What is the rate and direction of change of key species? We will measure species abundance (frequency) and size (basal area) and test for change between and among sample periods. This will allow us to determine whether metrics of individual species are increasing, in decline, or remaining constant.

2) Are plant communities changing? We will measure species richness and diversity and test for change in these variables. We will also test for shifts in the relative abundance and dominance of species groups (native vs. non-native species ratio, annual vs. perennial ratio, forb to graminoid to woody species ratio, and biotically pollinated vs. abiotically pollinated ratio) and determine whether biotic homogenization (Olden and Rooney 2006) is occurring.

3) What is the rate and direction of change of plant community structure? We will examine the size distributions of all trees, as well as individual species to identify shifts in forest structure. This will help us understand both regeneration and succession. It will also allow us to infer potential drivers of change and, thus, potential threats to the biotic integrity of the Great Lakes Parks.

The secondary monitoring objective, or second tier, is to test for change in Vital Signs and other indicators associated with vegetation. We will then attempt to relate these changes to long-term vegetation change. These indicators and specific questions are outlined below:

Terrestrial Pests and Pathogens

- Which pests and pathogens are present on trees in forest vegetation monitoring plots? We will look for signs and symptoms of major causal agents of tree damage.

- What is the extent of pest and pathogen damage on trees? We will calculate the percentage of trees that are impacted, and note the severity of these impact(s).

It should be noted that the GLKN forest vegetation monitoring program uses an evidence-based approach. We look for signs of disease presence (e.g., cankers, mycelial fans) or damage (e.g., insect exit holes, leaf mining) and quantify or qualify this based on the category of disease or damage. The actual causal agent (e.g., anthracnose, emerald ash borer) will only be identified if the crew member is completely certain of it. With instances of repeated and/or widespread disease or damage, samples will be collected and submitted to experts for confirmation of the causal agent. For complete methods and analyses for monitoring terrestrial pests and pathogens, please see Standard Operating Procedure (SOP) 8.

Problem Species

- To what degree are ungulates browsing woody terrestrial vegetation? We will assess the frequency at which woody species are browsed. This can then be used quantitatively as a covariate, or qualitatively as an explanatory factor, to relate browse to changes in plant species, communities, and community structure.

- How are ungulates impacting herbaceous, understory species? We will assess frequencies of key, preferred herbaceous species and relate these to known ungulate densities in the area. We will also look at change over time in these species.

- How are earthworms impacting Great Lakes Network Parks’ soils and plant communities? We will look for evidence of the presence of earthworms and relate this, when possible, to frequencies of understory herbs and of seedlings.

The methods and analyses for monitoring ungulate impacts are detailed in SOPs 6 and 13, respectively. Methods, analyses, and other details on monitoring earthworm impacts are presented in SOP 11.

Succession

- What are the apparent successional trajectories for habitats and forest types within Great Lakes Network parks? We will use density-diameter graphs and seedling densities to project mid-term change in GLKN forests. We will also incorporate known information on species responses to climate change, and current and projected pests and pathogens to project long-term change in GLKN forests.

Overall Sampling Design

Rationale for Selecting this Sampling Design over Others

Sampling sites have been selected using a generalized random-tessellation stratified (GRTS) design (Stevens and Olsen 2004). The reasons for selecting the GRTS design were twofold. First, resulting sample points are spatially balanced, whereby there is a generally even dispersion of sampling sites over the area of interest. This eliminates potential autocorrelation problems that can arise when two or more sampling points are in close proximity (Stevens and Olsen 2000), while also ensuring that all areas within the sampling frame are represented. In addition, the GRTS design allows for sites to be added to or excluded from the original sampling plan, while still maintaining the spatial balance of the overall design. This is important because it is difficult to gauge exactly how many plots can be sampled within a given time period. The second asset of the GRTS method is that it is a probabilistic sampling design, whereby sampling points are randomly chosen from among those in a systematic grid, eliminating site selection bias (Stevens and Olsen 2004). One unfortunate drawback with any random design is that it does not guarantee that plots will be located in areas of key management significance.

Sampling Frame, Plot Design, and Metrics

The sampling frame for this protocol includes all federally-owned lands within the Network parks (Table 1). In addition to federally-owned land, the sampling frame contains partner-owned land at the Mississippi National River and Recreation Area. At this park, federal land represents only approximately 1% of the acreage with partner land composing the rest. Finally, some state and private land will also be included in the sampling frame at Pictured Rocks National Lakeshore. Here, the park is divided into the federally owned “core” area, which directly borders Lake Superior and the “inland buffer zone,” which is composed largely of land owned by the state of Michigan and private entities. In addition to the entire core area, the sampling frame will include land owned by the State and the Heartwood Forestland Group in the buffer zone. Sampling points will be selected from the entire spatial extent of forested areas in the sampling frame.

Table 1. Sampling frame for each of the nine GLKN parks. Within these defined frames, sampling will also be restricted to forested areas. Inholdings are excluded.

Park	Sampling Frame
APIS	Entire park
GRPO	Entire park
INDU	Entire park
ISRO	Entire park
MISS	Entire park, including both federally-owned and partner-owned land
PIRO	Entire core area of the park, and areas of the inland buffer zone owned by the State of Michigan and Heartwood Forestland Group
SACN	All land owned in fee title by either the National Park Service or another agency. This equals 61% of the designated Riverway
SLBE	Entire park
VOYA	Entire park

This protocol details our plans to monitor forested vegetation. We have adopted the guidelines similar to those of the U.S. Forest Service FIA program (U.S. Department of Agriculture 2005) to define what constitutes a "forest," whereby there is a 10% minimum stocking requirement of tree species. The 10% requirement denotes that the site can either have at least 10% canopy cover at the time of sampling, or will likely return to that percentage in the future. As such, areas experiencing a recent burn or blowdown will be included, as will previously managed grasslands now returning to the forested state. Tree species are defined *a priori*, and include, for example, some 'shrubby' species such as striped maple (*Acer pensylvanicum* L.) and paw paw (*Asimina triloba* [L.] Dunal), but not others such as speckled alder (*Alnus incana* [L.] Moench ssp. *rugosa* [Du Roi]). Based on these guidelines, habitats such as oak savannas and tamarack bogs will be included, while alder swamps will not.

Sample sites were selected using the GRTS method described above. While this approach uses spatial stratification to ensure that sample sites are equally distributed within the sampling frame, we did not stratify on any predefined landscape characteristic or qualifiable metric, such as vegetation type. The successional nature of vegetation, coupled with the fact that much of the forested areas in the Network are recovering from logging activity that had occurred prior to establishment of the parks, precludes the use of stratification. Stratifying on a dynamic variable, such as vegetation, will ultimately result in misclassification of sites and consequent analytical error. Further, a stratified sampling design will prevent inferences about those vegetation types not sampled (DeBacker and Morrison 2005).

Although stratification on a dynamic variable will be avoided, it is acceptable to stratify based on a non-changing characteristic. For example, sites at PIRO and SLBE were stratified so that 10% of the plots would occur on sandy, nutrient poor soils. As soil condition is only expected to change on the order of millennia, this practice is statistically valid.

Parks within the Great Lakes Network will use a plot design developed specifically for the Great Lakes I&M Network's long-term vegetation monitoring protocol. This design combines features from two established plots types: the FIA plot, currently used throughout the country by the U.S. Forest Service, and the Plant Ecology Lab (PEL) plot developed by John Curtis and used extensively in the upper Midwest throughout the 1950s and 60s. Consequently, the Great Lakes Network's design has been designated the "Hybrid plot" (Johnson et al. 2006, Johnson et al. 2008).

The Hybrid plot consists of three parallel 50 m east-west transects, spaced 50 meters apart (Figure 2). The species and diameter at breast height (DBH) of all trees ≥ 2.5 cm DBH are recorded in a 6 m wide belt around each transect (3 m on either side of center line, Figure 2, left). Because we are using 2.5 cm as the lower DBH limit, we are thus including "trees" (≥ 12.7 cm (5 in) DBH in FIA standards) *and* "saplings" (≥ 2.5 cm (1 in) and < 12.7 cm DBH (5 in)) within this area. Any evident damage from pests and pathogens or abiotic factors is noted for each tree measured. Coarse woody materials are also assessed along each of these three transects, whereby data are collected on all downed wood which intersects the transect plane, with a diameter ≥ 7.5 cm (3 in) at the point of intersection.

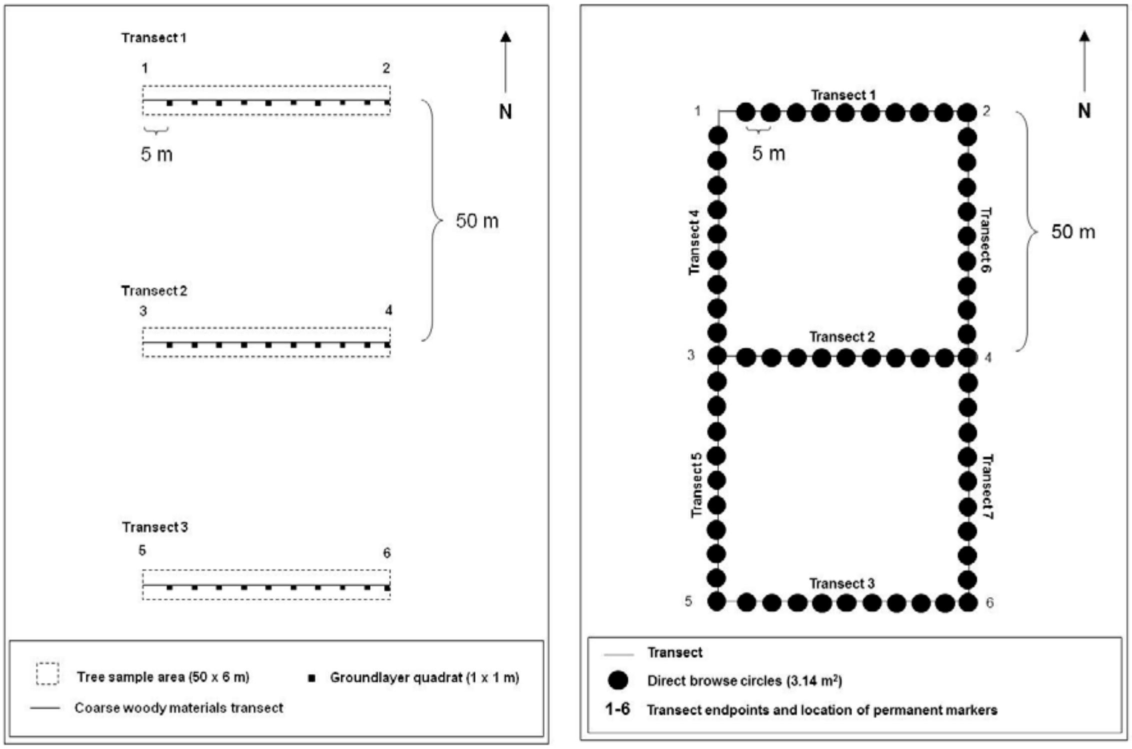

Figure 2. Left: scale diagram of the Hybrid plot, showing three parallel belt transects and areas for data collection of tree, groundlayer, and coarse woody material metrics. Right: Hybrid plot showing where direct browse and shrub data are collected.

The groundlayer is assessed in 1 × 1 m quadrats spaced every 5 meters along each of the transects for a total of 30 quadrats in each plot (Figure 2, left). We record all herbaceous and shrub species present in each quadrat, so that they can be quantified by their frequency of occurrence in each plot. We feel this is a better method for quantifying abundance than percentage of cover, which is highly subjective with a great deal of observer bias, and which also varies throughout the growing season. We also prefer frequencies to direct counts of herbaceous individuals. Even in 1 m^2 quadrats, dozens (and even hundreds) of herbaceous individuals of a given species can exist, making exact counts questionable. Despite the problems associated with direct counts of herbaceous species in the 1 m^2 quadrats, seedlings of woody species are not as abundant and their upright growth habit makes counting these practical. Therefore, seedling (< 2.5 cm DBH and ≥ 15 cm tall, and also exhibiting second-year growth) densities are determined by counts within the 1 m^2 groundlayer quadrats.

Ungulate browse is assessed via two means. First, we quantify the degree of browse directly evident on woody species in each species in each of 68 one meter radius (3.14 m^2) browse circles (Figure 2, right). These are centered on the northwest corner of each of the 30 groundlayer quadrats, and every five meters along transects that flank the east and west sides of the Hybrid plot. We will also quantify browse by changes in the frequency of key herbaceous species. We refer to this as "indirect browse" since evidence is not directly observed as bite marks, but rather, changes in abundance only indirectly over time. Although we will report on indirect browse as a metric, no additional data collection beyond that required for herbaceous species will be made. This is because Frerker and Waller (2013) showed a correlation between the number of individuals of target herbaceous browse species with quadrat frequency. As with herbs, shrubs will be assessed as a frequency of occurrence (Figure 2, right). We will use the presence data from the direct browse assessment to obtain these frequencies.

The methods of permanently marking plots vary somewhat between parks (depending on park needs and wants) but will always be a variation of our standard method. This standard method is to sink a 30 cm (1 ft) piece of rebar flush into the ground at each of the six transect endpoints. A plastic yellow end cap is placed on the end of the rebar to facilitate relocation. We then tag three nearby trees or other distinctive objects (collectively referred to as "reference objects") using a nail and numbered aluminum tag and record the distance and bearing from each witness tree to the rebar. Procedures have also been developed for situations where it is not possible to sink rebar in exactly at the transect endpoint and are detailed in SOP 5: Plot Establishment. In no cases is plot marking noticeable from a trail or other public area. Where this would be the case, suitable alternative methods are developed for each unique situation, and typically involve eliminating the yellow end cap and aluminum tags on one or more trees. A mapping grade GPS (Trimble) will be used to collect a minimum of 60 sets of coordinates at each endpoint. All plots will be relocated with the aid of a metal detector, mapping grade GPS, and map showing the permanently marked endpoints.

Sampling Frequency, Replication, and Timing

Vegetation monitoring is conducted on a nine-year rotation, with each park visited once every nine years (Table 2). Initially, we had planned a five year rotation, with smaller and mid-sized parks sampled together in some years. While this was accomplished during the first sampling rotation, many problems were encountered, relating to species phenology, training the field crew on vegetation at multiple parks, completing the desired number of plots, fiscal constraints associated with having a crew in travel status, and a tight schedule prohibiting the ability to make up lost sampling due to inclement weather. For these reasons, we have modified the sampling rotation to nine years so that only one park will be monitored each field season.

During each visit to a given park, all plots within that park will be resampled. Cycles of forest surveys typically range between five and twenty years. We feel that a nine year rotation is a good balance between sampling too frequently, where trampling of the site can adversely impact the plant community, and sampling too intermittently, which reduces the ability to detect change over a given time period. Sampling at nine year intervals will allow time for some change to occur, yet provide relatively frequent feedback to park natural resource managers about long-term directional change.

We concede that an ideal scenario is to visit one ninth of the plots in each park each year. Thus, the plots at any given park would be sampled throughout the nine-year rotation, not only during one year. This would capture inter-annual variation and better assess the impact of cyclic insects and/or disease cycles. Unfortunately, this scenario is both logistically and financially not feasible. Seasonal field assistants (see Section V, below) are only expected to be familiar with the vegetation in the one park in which they will be working in a given year, and training assistants on the vegetation of all

Network parks is time prohibitive. Further, travel time between parks would result in the loss of valuable sampling time in the middle of the field season. Finally, in the current plan, the seasonal employees are duty-stationed at the park in which they will be working. Under this arrangement, the Network does not pay travel costs or daily costs of meals and incidental expenses. Taking on these additional burdens would be cost prohibitive for the Network.

Table 2. Park rotation schedule for the first two monitoring rotations.

Park	Year													
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
INDU	X					X								
SACN	X						X							
GRPO	X							X						
VOYA		X							X					
PIRO			X							X				
SLBE			X								X			
ISRO				X								X		
MISS					X								X	
APIS					X									X

Recommended Number of Sampling Sites and Frequency

The division of sampling effort between the parks was originally determined by both top-down and bottom-up approaches. For the top-down approach, the forested acreage in each park was used to calculate the percentage that this represents, of the total Network forested area (Table 3). These percentages were then used as a basis to assign the percentage of sampling effort (i.e., time) at each park. The bottom-up approach used statistical power analyses to estimate the degree of change that can be detected. The target of the GLKN monitoring program is to be able to detect a 20% change in metrics over a given time period with 80% power and $\alpha = 0.1$. (National Park Service 2009). This approach projects whether there is an adequate sample size in each of the parks.

During the initial sampling cycle (2007-2011), we incorporated both approaches, sampling all parks within a five year period. This necessitated sampling multiple parks in some years. As noted above, however, unforeseen logistical and phenological hurdles render this sampling schedule unsustainable. Beginning with the second sampling rotation (2012), we are now sampling one park per year. This will facilitate us reaching our target number of plots in each park, during each visit (Table 3).

Table 3. Sampling effort and minimum expected sample number at each park, calculated by a top-down approach.

Park	Forested area (hectares)	Percentage of total network forested area	Current (2013) number of active plots	Target number of active plots
APIS	17,037	7.75	48	50
GRPO	281	0.13	20	20
INDU	6,095	2.77	50	50
ISRO	53,823	24.48	53	53
MISS	5,581	8.99	32	50
PIRO	24,724	11.25	59	59
SACN	26,828	12.20	50	50
SLBE	25,981	11.82	50	50
VOYA	45,325	20.61	38	50
Total	219,862	100	400	432

Sample Method Selection and Level of Change That Can be Detected

In a direct assessment of the Hybrid plot design, data from 20 sites showed that there was greater than 99% power to detect a 20% change in both tree basal area and tree density between sampling events (Johnson et al. 2006). For herbaceous species, the Hybrid plot design had greater than 80% power to detect changes in fern frequency and forb species richness (87.2 and 89.9, respectively) between sampling events (Johnson et al. 2006). Clearly our target (and active) number of plots in each park (Table 3) should be sufficient to be able to detect a 20% change in metrics over a given time period with 80% power and $\alpha = 0.1$. However, we will rarely (if ever) group all plots within a park together for an analysis. Forest types will respond uniquely to environmental stressors and change. We will likely extract data from subsets of plots for any analysis of change. While it is not possible to know how many plots will be needed to detect the desired level of change, it should be assumed that fewer than 20 plots per grouping will result in less power than that detailed in the study above.

Field Methods

Field Season Preparations and Equipment Setup

Preparations for the field season are numerous, and must begin before the calendar year. Many of these preparations will necessarily overlap with the duties associated with concluding the previous season, such as report writing (see SOP #15, Procedures after the Field Season). Because of these demands, meticulous care must be taken to ensure all pre-season procedures are followed in a timely manner.

Early pre-season preparations (October – February) are primarily of an administrative nature. The vegetation monitoring budget must be developed in October as it is a component of the general GLKN budget. Position announcements for seasonal employees must be submitted in November so that they can be posted in early January. Also during this time, the park where the GLKN field crew will be working should be contacted. A preliminary field schedule should be developed and submitted to the park so that plans for accommodating the GLKN field crew can begin. In addition to submitting the preliminary field schedule, the project manager should also make park managers aware of needs for park housing, permits (camping, research, etc.) and any other special requests (e.g., boat transportation). Once this schedule is finalized, the project budget for the season should be refined. Typically, interviews of field crew candidates and selection of employees are completed in February. At this point, arrangements should be made for any needed training for the crew members, including boat operation and first aid.

Later pre-season preparations (March – April) focus on equipment preparation and field readiness. The equipment list should be reviewed and all equipment should be inspected, with repairs made and new equipment ordered as needed. This includes checking all tapes for worn parts, assembling tents and looking for torn material, checking backpacks, and inspecting personal protective equipment. In addition to equipment, data collection procedures should be readied. Plot coordinates and digital park maps should be loaded into the field GPS units, and paper park maps should be obtained and notated if needed. The plant lists for parks visited should be reviewed and printed and taxonomy changes addressed at this time. Finally, local experts in botany, entomology, and soils may be contacted and notified of the field crew's work plans for the summer. This will open up a line of communication between the field crew and local experts as identification or other questions arise during the summer.

Sequence of Events During Field Season

Final pre-season preparations involve training the field crew in preparation for sampling plots. Depending on the park sampled in a given year, two to five GS-0404/4-6 Biological Science Technician seasonal field assistants will commence work approximately three weeks prior to the start of field sampling. During this initial three week period, the crew will take part in mandatory federal computer training as well as first aid training. Crew members will also participate in practice plots, learning how plots are established, and data are collected and entered into the database. During this time, crew members will also undergo taxonomic training as well as learn how to use the Trimble and Garmin GPS units, park radios, and be briefed on work etiquette. This latter point will address how to interact with other park employees and how to answer questions from the public about the work of the vegetation monitoring program specifically, as well as the Inventory and Monitoring Program in general. Finally, all field crew members will be required to pass a test in GLKN-specific field techniques before sampling can begin.

The field crew (excluding the Terrestrial Ecologist and Botanist) will be duty stationed at the park where they are sampling. Throughout the field season, the field crew, along with the Terrestrial Ecologist and/or Botanist, will work a schedule of eight consecutive 10-hour days, followed by six days off. This schedule will accommodate for travel time between Ashland and the parks by the Terrestrial Ecologist and/or Botanist, allowing him/her to accomplish necessary administrative duties at the Network office. Although there is not a great deal of flexibility in the schedule, at all parks there are sufficient numbers of planned sampling sites that the loss of some due to poor weather or unforeseen circumstances will not compromise statistical power.

Details of Taking Measurements

We will be following many of the same measurement criteria and standards as the FIA program. This includes details such as how to measure forking trees and how to treat leaning or down live trees. For more details on this, please see the Forest Service Phase 2 Field Guide (U.S. Department of Agriculture 2005) and SOP 6: Field Methods and Data Collection. This will allow comparability between data collected using the GLKN Hybrid plot with that collected by the FIA program in the area surrounding the parks, provided appropriate statistical measures are taken to account for differences in plot area and sample size. Standard paper field forms printed on Rite-in-the-Rain® paper will be carried to the site and used for all data collection.

Post-Collection Processing of Samples

The nature of this protocol is such that there will be minimal samples collected. One exception to this will be when unknown plant specimens are collected for identification. When this occurs, the field crew will be responsible for following established guidelines for collecting, labeling, photographing, and transporting it for later identification. For more detail on this, see SOP 7: Procedures for Handling Unknown Species.

End-of-Season Procedures

The procedures associated with completing the sampling season must be performed in earnest in the weeks immediately following the conclusion of sampling, and continued through the following April. Early post-field season procedures focus on administrative tasks, equipment inspection, repair, and organization, and data archival procedures. Immediately following the completion of sampling, field equipment should be inspected, cleaned, repaired as needed, and notes should be made as to what needs to be replaced. Throughout the month of September, data archival procedures should be carried out and park species lists updated with new records.

During October through January, data analysis and report writing are the focus. Drafts of annual summary reports are due to the parks for a four-week review by March 15 of the year following monitoring (see SOP 14: Reporting). Revisions should be incorporated, and the report finalized, by June 1. Every nine years, drafts of analysis and synthesis reports will also be due to the parks, on May 31st. The revised final versions of the analysis and synthesis reports are due September 1. An annual presentation will be made, if possible, in late winter or early spring. Detailed post field season procedures are spelled out in greater detail in SOP 15: Procedures After the Field Season.

Data Handling, Analysis, and Reporting

Metadata Procedures

Metadata allows potential data users to evaluate the quality and usefulness of the data based on an understanding of the complete process under which it was collected and maintained. The GLKN data manager has established a standard operating procedure for metadata generation and maintenance. A metadata document was created during the design and planning stage of this project and will be kept current. Metadata are saved on the primary GLKN server along with data and copied to the NPS IRMA data store.

The database design for GLKN data will include a means for recording the protocol version under which each piece of data is collected. The metadata document will, therefore, also contain information about protocol versions used to collect the data.

For metadata associated with geospatial data, we will abide by Executive Order 12906, which mandates that every federal agency document all new geospatial data it collects or produces using the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata. All GIS data layers will be documented with applicable FGDC and NPS metadata standards. The Network will also generate FGDC-style metadata for non-spatial datasets that meet this standard, absent only the geospatial-specific elements.

Data which are generated and/or managed outside of the I&M Program, but used in analyses with GLKN data or distributed in any manner by the NPS, require the same level of documentation as GLKN-generated data. This includes data produced under contract with the NPS. For non-Program data, the project manager will ask the originating entity for metadata. Any contract entered into by the GLKN with data producers will stipulate that FGDC-compliant metadata in HTML, ASCII, or XML format, or in a format specified by the project manager and approved by the Network manager. The Network data manager will assist the project manager in metadata acquisition by providing tools, format protocols, and file transfer services.

Overview of Database Design

The vegetation monitoring database is a complex MS Access database made of two components, a front-end database and the back-end database. The front-end contains a user interface portion along with various queries, forms, reports and visual basic code for underlying function of the database as a whole and use with the user interface. The user interface consists of various forms to help the user enter and validate data, along with the ability to query, through forms, the data for various quality assurance/quality control (QA/QC) and final reports. The back-end database consists of numerous lookup and data storage tables, which are linked to the front-end database.

The Great Lakes Network will maintain one master copy of the vegetation database at the Ashland office on a central server. This is the only copy that can be used to export data to other locations. Additional copies of the database will be used by GLKN personnel stationed at parks, but they can only be used as a conduit for data entry. For analysis, the data from the master copy at the Network, that has passed all QA/QC procedures, must be used.

For a complete description of the GLKN database, please refer to SOP 12, Data Management, or Supplemental Document 2: Great Lakes Network General Vegetation Database Structure and User Guide.

Data Collection, Entry, and Editing

We will use paper data sheets to record data when in the field. The data will be collected by a team of two with one crew member recording data primarily on overstory trees, coarse woody materials, and earthworm assessments. The second member of the field crew will primarily record data on herbaceous species and browse. The datasheets will be photocopied at the earliest possible date. The original datasheets are stored at the GLKN office, and the photocopies are temporarily stored at the park where sampling is being done in a given year. Photocopies of the data are not maintained beyond the field sampling season. Original datasheets will be scanned and converted to PDF files that are stored on the Network's server, which is backed up regularly and stored offsite in a fire-proof safe.

Once entered, all data will be printed and verified by comparing it with the original field recorded data sheet. Two people will perform this duty with one person reading the values from the original datasheet and the second person checking the values on the printout.

Recommendations for Routine Data Summaries and Analyses to Detect Change

After each field season, all data are analyzed to produce annual summaries on the status of terrestrial vegetation in the park(s) sampled that year. These annual summaries provide the Network with current status information relevant to policy and management decisions. A variety of analytical approaches are used to assess the status of 1) environmental variables associated with terrestrial vegetation, 2) population (species-level) variables, 3) community structure variables, and 4) community composition variables at each park and across parks in the Great Lakes region. Because the procedures for this are detailed extensively in Standard Operating Procedure 13: Data Summary and Analysis, we are not presenting them here.

Recommended Reporting Schedule and Format

Two types of reports will be produced for the General Vegetation Monitoring protocol. Annual summary reports will be produced yearly for the Vital Signs associated with the vegetation protocol that were monitored during the previous year. The primary audience for the annual summary reports will be parks. These summaries will be communications to document our efforts and convey the findings of the previous field season. At a minimum they will provide an introduction that describes why that Vital Sign is being monitored, an outline of the sampling strategy, including the number of sites sampled, parameters measured, and analyses performed, data summaries and a text explanation of the findings, and limited discussion section in which important results are interpreted. The Ecologist and/or Botanist will take the lead in writing the report and will coordinate an internal review. Drafts of annual summary reports will be completed by March 15th for a four week review period by the parks. The final reports will be provided to parks by June 1st of the year following the monitoring.

In addition to annual summary reports, detailed reports in which data are analyzed and synthesized will be produced on a periodic basis. For the vegetation protocol, analysis and synthesis reports will be written every nine years, after each completion of the sampling rotation. They will be written in the format of a scientific journal article (abstract, introduction, methods, results, discussion, literature cited) and will contain in-depth analyses as outlined in this protocol. Further, these comprehensive reports will place the observed results in both a regional and historical context by relating them to other published literature, discuss the significance of the results in terms of environmental change, and provide management recommendations based on the findings.

The Ecologist and/or Botanist will take the lead in writing the analysis and synthesis reports, and will coordinate an internal review. The target audience of these reports will be the parks (primarily the natural resource managers), the Network, and both regional and Servicewide I&M. Outside of the park service, the target audience includes the four state departments of natural resources (Indiana, Michigan, Minnesota, and Wisconsin), the Northeastern Area Forest Health Protection unit and the North Central Research Station, both of the National Forest Service, and the broader scientific community.

Drafts of analysis and synthesis reports will be completed by May 31st of the year that follows completion of the nine-park monitoring cycle. The parks will have a 30 day period for comment and input. In addition, these drafts may also be sent to outside sources for further review. The extent of review will depend on the analytical complexity of the methods and the gravity of inference and recommendations. The final reports will be due on September 1 of the year following completion of the monitoring cycle.

The first analysis and synthesis report will be written following a full rotation of monitoring. At this time, vegetation and the associated Vital Signs will have been monitored in each park for one season, allowing a comparison of vegetation characteristics across parks. In subsequent years, as parks are monitored repeatedly, more in-depth analyses will be conducted for individual parks as well as across parks.

Recommended Methods for Long-Term Trend Analysis

Each park will be visited and surveyed every nine years. Once a given park has been sampled a second time, tests for changes in metrics can commence. It will be possible to test for trends with more sensitivity and to evaluate changes in trends once the third sampling event for any given park is complete. In addition to investigating changes in environmental variables and population and community vegetation variables, we also will be assessing the relationships among all of these variables. All long-term change and trend analyses are detailed extensively in Standard Operating Procedure 13: Data Summary and Analysis. Please refer to this for specific details.

Data Archival Procedures

The Access database file which houses the vegetation monitoring database is stored on the network server and backed up monthly, with differential backups weekly. The monthly backups are stored offsite. In addition, front- and back-end portions of the database are backed up periodically (with the frequency dependent on how often it is modified) with the backups stored on CD/DVDs in the GLKN offices.

Personnel Requirements and Training

Roles and Responsibilities

The project manager (Terrestrial Ecologist) for this protocol, is a liaison between the permanent Network staff, seasonal Network staff, and the park. The project manager is charged with organization and facilitation of all aspects of the long-term vegetation monitoring protocol. This includes the following:

- hiring seasonal staff
- developing an annual field schedule
- acquiring the appropriate permits (research and collecting, camping, etc.)
- arranging training (first aid, CPR, etc.)
- refining the budget for the season
- ushering crew members through administrative training (credit card use, etc.) and park specific plot work
- overseeing seasonal staff during field season
- identifying plants accurately and processing unknown plants for later identification
- ensuring plot work meets the desired standards of quality
- ensuring an adequate number of plots get measured each season and at each park
- ensuring effective communication between park staff, the field crew, and other GLKN staff
- reviewing and terminating the seasonal field crew members
- reviewing and revising protocol
- data analysis and report writing
- presenting finding of previous season to the technical committee

The Botanist will be responsible for field aspects of monitoring. This included both pre- and post-season support. The Botanist will also be responsible for supervising the seasonals when the project manager is not present. Specific duties include:

- preparing, repairing, and purchasing equipment
- preparing the database for the upcoming season (review species lists, add names of seasonals, etc.)
- developing GIS maps pre-season for navigation to plots and post-season for archival purposes
- completion of mandatory training including first aid, boat training, and plot establishment
- assisting with navigation to sampling points
- identifying plants accurately and processing unknown plants for later identification
- ensuring plot work meets the desired standards of quality
- collection of plot data
- scheduling and timekeeping for seasonals
- ensuring equipment is clean and functional prior to each trip
- ensuring all needed equipment is collected and readied prior to each trip
- interact with park staff as needed to organize transportation and equipment needs
- data entry and error checking

The GS-4/5/6 seasonals will be responsible for day to day completion of plot establishment and monitoring. Specific duties include:

- completion of mandatory training including first aid, boat/canoe training, and plot establishment
- assisting with navigation to sampling points
- identifying plants accurately and processing unknown plants for later identification
- ensuring plot work meets the desired standards of quality
- collection of plot data and entry into a computer
- ensuring equipment is clean and functional prior to each trip
- ensuring all needed equipment is collected and readied prior to each trip

Crew Qualifications

The project manager must have an advanced degree in botany, plant science, or biological science with an emphasis in plants. He/she should also have demonstrated experience identifying the flora of the Great Lakes and surrounding region, acquired through a combination of work experience, education (graduate school research), and/or workshops and other training. The project manager must also have a minimum of one year experience leading a field crew.

In addition to botanical and leadership skills, the project manager must be knowledgeable about multiple aspects of forest health. This includes identification of forest pests and pathogens, and the ability to identify (tree) diseases. The project manager should also be familiar with basic soil collection and classification techniques and be able to infer whether earthworms are present based on soil characteristics. Finally, the project manager must also have experience establishing permanent plots.

The Botanist will oversee the other seasonal employees at the GS-4/5/6 level, when the project manager is not present. The Botanist must have at least a four-year degree in botany, plant science, or biological science and have at least one year of vegetation based work experience equivalent to the GS-6 level. Alternatively, the Botanist may have an advanced degree with an emphasis in vegetation. The Botanist must also have at least one season (three months) of supervisory experience of field personnel and have demonstrated experience (work or education) identifying flora of the Great Lakes region. Finally, they must demonstrate the ability to navigate with map, compass, and GPS.

The GS-4/5/6 seasonal employees must be working toward, or already possess, a four-year degree in biology, botany, natural resources, forestry or related major. These employees must also have demonstrated experience (work or education) identifying either overstory or understory vegetation of the region.

All people on the crew (Terrestrial Ecologist, Botanist, and seasonals) must be physically fit and able to work in adverse environments. This includes working in extreme heat and cold, and in the presence of biting/stinging insects and poisonous plants.

Training

The Terrestrial Ecologist and Botanist will be expected to attend regular training opportunities to further their ability to oversee the vegetation monitoring program. These can include, but are not limited to Wilderness First Responder certification, motorboat operator certification, statistical courses, and botanical and ecological training.

The seasonal field crew will start in May or June. During the three-week training period, they will undergo training in administrative procedures, plant identification, plot establishment, data collection, data entry, and first aid/CPR.

Administrative training procedures will be performed over the first two days of employment. This will cover issues associated with computer use, credit card use, and timesheets. This training will be provided by the Terrestrial Ecologist and Botanist.

The bulk of the three week training time will be devoted to multiple aspects of vegetation monitoring. The seasonal employees will be instructed on how to establish the Hybrid plots, with emphasis placed on the high degree of accuracy required with the distances, bearings, and metrics measured. During this time, the crew will also be instructed on use of the vegetation monitoring database for data entry. During training, the crew members will also familiarize themselves with the vegetation of the park in which they are working. Plants that are encountered but cannot be readily identified during this time will be learned so that, when they are encountered in actual plots, they can be quickly identified. This training will be provided by the Terrestrial Ecologist and Botanist.

The crew will also participate in any first-aid and CPR training. This is usually arranged to occur during the first week of employment. The Terrestrial Ecologist and Botanist may also elect to take this course. Finally, the crew will be instructed on etiquette for interactions with the general public visiting the parks. The Terrestrial Ecologist and Botanist will explain how to answer questions about their work, and the Network's work.

Operational Requirements

Annual Workload and Field Schedule

Employment for the seasonal staff will typically begin between early May and early June, depending on the park. This will allow time for administrative and first aid training. Also during this period, the network Botanist will be training the seasonal staff on plot establishment, data collection, and the local flora. In general, we will plan to begin actual plot sampling approximately three weeks after the first day of employment.

Facility and Equipment Needs

We will conduct this protocol in a manner as independent of the parks as possible. Despite this, logistics in general, and boat transportation specifically, remain features for which we need to rely somewhat on parks. In addition to boat transportation, we will rely on the parks to, wherever possible, provide housing for the field crew.

At all parks, regardless whether they are remote or not, we will depend on the park staff for assisting with basic security and safety precautions. Each two-person field crew will be equipped with a radio (supplied by the Network) and the program manager will arrange with the park staff to obtain radio call numbers prior to beginning sampling.

Budget Considerations

The annual operating costs for the vegetation monitoring protocol are estimated to range between $90,000 and $110,000 (excluding salary for the Botanist and Terrestrial Ecologist). The majority of these expenses (approximately 70%) are for salary of the GS-4/5/6 field crew members.

Besides salary, the other primary expense of the vegetation monitoring program is travel. Travel expenses include the rental of minivans and meals and incidental expenses (M&IE). This typically ranges from 12-18% of the budget. Field supplies (equipment replacement and repair, plot marking materials, etc.) is approximately 5% of the budget. Finally, may require the services of an expert botanist to assist with plant identification. This is approximately 2% of the budget.

Procedures for Revising the Protocol

The long-term nature of the NPS monitoring program necessitates the need for flexibility to incorporate change. Refined field methods, advances in analysis techniques, and feedback from field crews and project managers can all contribute to improving the monitoring protocol. To systematically identify areas and procedures needing revision, we will review the protocol each year at the end of the field season (see SOP 15: Procedures After the Field Season). To minimize the changes to the protocol narrative, an attempt will be made to first revise SOPs without making changes in the protocol itself. However, if it is clear that changes will also be needed on the narrative, then it will also be revised. All changes will be agreed upon by both the Terrestrial Ecologist and Botanist, and substantial changes (e.g., revised analysis techniques, significantly altered field methods) may also be sent to outside sources for input. The changes will be recorded in the revision history log of the appropriate SOP and/or narrative, copies of the revised material will be distributed to all relevant parties, and subsequently posted on the Network website. Further, the data manager will be notified of the change(s) so that the metadata of the project database will be updated. For a detailed description of protocol revision procedures, please see SOP 16: Procedures for Revising the Protocol.

Literature Cited

Abrams, M. D. 2003. Where has all the white oak gone? BioScience 53:927-939.

Allison, T. D. 1990a. The influence of deer browsing on the reproductive biology of Canada yew (*Taxus canadensis* Marsh.) I. Direct effect on pollen, ovule, and seed production. Oecologia 83:523-529.

Allison, T. D. 1990b. The influence of deer browsing on the reproductive biology of Canada yew (*Taxus canadensis* Marsh.) II. Pollen limitation: an indirect effect. Oecologia 83:530-534.

Allison, T. D. 1992. The influence of deer browsing on the reproductive biology of Canada yew (*Taxus canadensis* Marsh.) III. Sex expression. Oecologia 89:223-228.

Auclair, A. N. D. 2005. Patterns and general characteristics of severe forest dieback from 1950-1995 in the northeastern United States. Canadian Journal of Forest Research 35:1342-1355.

Beals, E. W., and G. Cottam. 1960. The forest vegetation of the Apostle Islands, Wisconsin. Ecology 41:743-751.

Bechtold, W. A., and C. T. Scott. 2005. The forest inventory and analysis plot design. Pages 27-43 *in* W. A. Bechtold and P. L. Patterson, editors. The enhanced forest inventory and analysis program - national sampling design and estimation procedures. U.S. Forest Service Southern Research Station General Technical Report SRS-80.

Bohlen, P. J., S. Scheu, C. M. Hale, M. A. McLean, S. Migge, P. M. Groffman, and D. Parkinson. 2004. Non-native invasive earthworms as agents of change in northern temperate forests. Frontiers in Ecology and the Environment 2:427-435.

Côte, S. D., T. P. Rooney, J. Tremblay, C. Dussault, and D. M. Waller. 2004. Ecological impacts of deer overabundance. Annual Review of Ecology, Evolution, and Systematics 35:113-147.

DeBacker, M., and L. W. Morrison. 2005. Sample design. National Park Service Inventory and Monitoring Program national conference. Austin, TX. http://science.nature.nps.gov/im/monitor/meetings/Austin_05/lmorrison_samplingdesign.ppt#409,1,Sample Design. Accessed 18 April 2006.

Dymond, P., S. Scheu, and D. Parkinson. 1997. Density and distribution of *Dendrobaena octaedra* (Lumbricidae) in aspen and pine forests in the Canadian Rocky Mountains (Alberta). Soil Biology and Biochemistry 29:265-273.

Fortin, D., H. L. Beyer, M. S. Boyce, D. W. Smith, T. Duchesne, and J. S. Mao. 2005. Wolves influence elk movements: behavior shapes a trophic cascade in Yellowstone National Park. Ecology 86:1320-1330.

Frelich, L. E., and P. B. Reich. 1995. Spatial patterns and succession in a Minnesota southern-boreal forest. Ecological Monographs 65:325-346.

Frerker, K. and D. W. Waller. 2013. Comparing and evaluating methods used to assess the impacts of ungulate browsing in the Great Lakes Network National Parks. Natural Resource Technical Report NPS/GLKN/NRTR—2013/680.

Gucciardo, L. S., S. M. Sanders, and J. E. Elias. 2005. Supplemental Document 4: Summary of Terrestrial Resource Studies in Great Lakes Inventory and Monitoring Network Parks.*in* B. Route and J. Elias, editors. Phase 3 Report: Long-term Ecological Monitoring Plan for the Great Lakes Network. U.S. National Park Service, Great Lakes Inventory and Monitoring Network. Technical Report GLKN/2005/19.

Gundale, M. J., W. M. Jolly, and T. Deluca, H. 2005. Susceptibility of a northern hardwood forest to exotic earthworm invasion. Conservation Biology 19:1075-1083.

Hale, C. M. 2004. Ecological consequences of exotic invaders: Interaction involving European earthworms and native plant communities in hardwood forests. Dissertation. University of Minnesota, St. Paul, Minnesota.

Hale, C. M., L. E. Frelich, and P. B. Reich. 2005. Exotic European earthworm invasion dynamics in northern hardwood forests of Minnesota, USA. Ecological Applications 15:848-860.

Hendrix, P. F., and P. J. Bohlen. 2002. Exotic earthworm invasions in North America: ecoological and policy implications. BioScience 52:1-11.

Houston, D. R. 1994. Major new tree disease epidemics: beech bark disease. Annual Review of Phytopathology 32:75-87.

Johnson, S. E., E. L. Mudrak, E. A. Beever, S. Sanders, and D. M. Waller. 2008. Comparing power among three sampling methods for monitoring forest vegetation. Canadian Journal of Forest Research 38:143-156.

Johnson, S. E., E. L. Mudrak, and D. M. Waller. 2006. A comparison of sampling methodologies for long-term monitoring of forest vegetation in the Great Lakes Network National Parks. GLKN 2006/06. National Park Service, Great Lakes Network Office, Ashland, Wisconsin.

Kizlinski, M. L., D. A. Orwig, R. C. Cobb, and D. R. Foster. 2002. Direct and indirect ecosystem consequences of an invasive pest on forests dominated by eastern hemlock. Journal of Biogeography 29:1489-1503.

Kostel-Hughes, F. 1995. The role of soil seed banks and leaf litter in the regeneration of native and exotic tree species in urban forests. Dissertation. Fordham University, Bronx, New York.

MacLean, D. B., and L. S. Gucciardo. 2005. Vegetational analysis of the Grand Portage National Monument from 1986-2004. GLKN/2005/07. National Park Service Great Lakes Network Office, Ashland, Wisconsin.

Marinissen, J. C. Y., and F. van den Bosch. 1992. Colonization of new habitats by earthworms. Oecologia 91:371-376.

Meeker, J. E. 2000. Rationale, protocol, and record of establishment for forest vegetation monitoring plots for Outer, Devils, Raspberry and York Islands, Apostle Islands National Lakeshore. Report to Apostle Islands National Lakeshore.

Mladenoff, D. J., and F. Stearns. 1993. Eastern hemlock regeneration and deer browsing in the northern Great Lakes region: A reexamination and model simulation. Conservation Biology 7:889-900.

Morin, R. S., A. M. Liebhold, P. C. Tobin, K. W. Gottschalk, and E. Luzader. 2007. Spread of beech bark disease in the eastern United States and its relationship to regional forest composition. Canadian Journal of Forest Research 37:726-736.

Mudrak, E. L., S. E. Johnson, and D. M. Waller. 2009. Forty-seven year changes in vegetation at the Apostle Islands: Effects of deer on the forest understory. Natural Areas Journal 29:167-176.

Muirhead, J. R., B. Leung, C. van Overdijk, D. W. Kelly, K. Nandakumar, K. R. Marchant, and H. J. MacIssac. 2006. Modelling local and long-distance dispersal of invasive emerald ash borer *Agrillus planipennis* (Coleoptera) in North America. Diversity and Distributions 12:71-79.

National Park Service. 2009. Guidance for Designing an Ingegrated Monitoring Program. http://science.nature.nps.gov/im/monitor/goalsobjectives.cfm.

Ojima, D. S., T. G. F. Kittel, T. Rosswall, and B. H. Walker. 1991. Critical issues for understanding global change effects on terrestrial ecosystems. Ecological Applications 1:316-325.

Olden, J. D., and T. P. Rooney. 2006. On defining and quantifying biotic homogenization. Global Ecology and Biogeography 15:113-120.

Papaik, M. J., C. D. Canham, E. F. Latty, and K. D. Woods. 2005. Effects of an introduced pathogen on resistance to natural disturbance: beech bark disease and windthrow. Canadian Journal of Forest Research 35:1832-1843.

Randerson, J. T., F. S. Chapin III, J. W. Harden, J. C. Neff, and M. E. Harmon. 2002. Net ecosystem production: a comprehensive measure of net carbon accumulation by ecosystems. Ecological Applications 12:937-947.

Rooney, T. P. 2001. Deer impacts on forest ecosystems: A North American perspective. Forestry 74:201-208.

Rooney, T. P., R. J. McCormick, S. L. Solheim, and D. M. Waller. 2000. Regional variation in recruitment of hemlock seedlings and saplings in the upper Great Lakes, USA. Ecological Applications 10:1119-1132.

Rooney, T. P., S. M. Wiegmann, D. Rogers, A., and D. M. Waller. 2004. Biotic impoverishment and homogenization in unfragmented forest understory communities. Conservation Biology 18:787-798.

Route, B., and J. Elias (editors). 2007. Long-term ecological monitoring plan: Great Lakes Inventory & Monitoring Network. Natural Resource Report NPS/GLKN/NRR-2007/001. Fort Collins, Colorado.

Russell, F. L., D. B. Zippin, and N. L. Fowler. 2001. Effects of white-tailed deer (*Odocoileus virginianus*) on plants, plant populations and communities: A review. The American Midland Naturalist 146:1-26.

Stevens, D. L., and A. R. Olsen. 2000. Spatially-restricted random sampling designs for design-based and model-based estimation. Pages 609-616 *in* 4th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences. Delft University Press.

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

U.S. Department of Agriculture. 2005. Forest Inventory and Analysis National Core Field Guide. U.S. Department of Agriculture, Forest Service, Arlington, Virginia.

SOP 1: Preparations and Equipment Setup Prior to Field Season

Version 2.0 (6/1/12)

Sarah Johnson
University of Wisconsin – Madison

Suzanne Sanders and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Revised to reflect new equipment needed for revised methods and new administrative requirements associated with HR	Field methods have changed slightly most years since the inception of the program.	2.0

1.0 Introduction

Preparations for the field season are numerous, and must begin early in the calendar year. Many of these preparations will necessarily overlap with the duties associated with concluding the previous season, such as report writing. The purpose of this SOP is to enumerate pre-season duties, so that none are skipped and important deadlines in this regard are not missed. This SOP specifically addresses 1) administration associated with hiring field staff, 2) field work schedules, 3) organization of field season equipment and supplies, and 4) data forms.

1.1 October

- Develop budget for the following year. In doing this, the duty station must be determined and a preliminary field schedule developed.
- Begin a dialog with parks for sampling the following season. Topics discussed should include housing needs for seasonals and work space and computer needs of the monitoring program.

1.2 November

- Prepare position announcements for seasonal employees and send these to the Servicing Human Resource Office (SHRO) for posting. Positions may not be posted more than 120 days before expected entry on duty date.

1.3 December

- Check in with the SHRO, as appropriate, to ensure that hiring activities are proceeding.

1.4 January

- Check in with the SHRO, as appropriate, to ensure that hiring activities are proceeding.
- Once field crew members have been selected, make sure that all activities pertaining to their anticipated entry on duty data (EOD) date are on schedule.

1.5 February

- Communicate with parks to go over field schedule. Also during this time, submit park requests (e.g., research and collecting permits, camping permits, and boat transportation).
- Arrange any needed pre-season training that is conducted outside of the Network (e.g., boat operation, first aid).
- Confirm that the network will have enough vehicles for all field season activities. If not, plans for obtaining additional vehicles should be made.
- Make arrangements for a first aid/CPR class. This class will typically be done through the park and held at the location where the field crew is stationed. The Network Safety Officer may also be able to provide the training on-site at the parks if it is not available otherwise. Alternatively, Wisconsin Indianhead Technical College can also provide the training. Our specific contact is Connie Wickingson at (715) 682-4591, ext. 3143.

1.6 March

- Review equipment list and organize and prepare equipment. Repairs should have been completed in the fall, but equipment should be rechecked in the spring and any needed equipment can be ordered. Once the field crew is known, the sizes of the cruiser vests and backpacks should be checked to make sure there are an adequate number of necessary sizes. A list of field equipment needs for three 2-person crews is listed in Table 1; if more or fewer than six people work on a crew, then equipment needs will change accordingly.

- Check diameter tapes for proper function and replace worn parts as needed. Review field season notes and datasheets from previous surveys to identify any unique events that may be encountered within specific parks.

- Review existing species lists and ensure that guides and reference materials cover the likely species to be encountered.

- Once the names of all crew members are known, contact the park(s) and request radio call numbers.

- As appropriate, check in with SHRO to ensure that hiring activities are proceeding.

- Contact the IT specialist in the park where the field crew will be based. Make sure that they know all of the resources that we need. Also, make sure they are aware of all of the equipment we will be using, including the network switch.

Table 1. Field equipment list for vegetation sampling.

Item	Quantity
Laptop computer for entering data and downloading Trimble GPS units	2
List of plant species known or thought possible to exist in park	7
Protocol narrative and SOPs	1
Field guide detailing data collection procedures	7
Pest and pathogen field guide	4
Site maps showing coordinates	1 set
50 m tape	12
Diameter (D) tapes (30 m auto retractable with nail at the end)	8
Replacement D tapes	4-8
1m^2 quadrats	5
Binoculars for looking at leaves in the canopy	3
Chaining pin for holding end of 50 m transect tape	12
Calipers for measuring sapling diameters	5
Compasses for navigation and plot layout (adjust/check declination)	7
Clipboards	7
Rite-in-the-Rain© pens (black) for recording notes and data	20
Trimble GPS unit for recording transect endpoints	4
Spare Trimble batteries	3
Garmin GPS for navigating to site coordinates and recording notable features	4
Digital camera for photopoints, unknown species, etc.	5
Solid black cardstock for use as a photographic background	4
Cell phone	4
Hammer for pounding in rebar	4
Sonar distance measurers	5 pair
Batteries (9 volt and AA)	several
Cruiser vest (14 pocket deluxe vest from BAP Equipment, Nova Scotia)	7
Quiver for holding flags	4
Flags (pink and orange)	100-200
Hand lens for close-up viewing of vegetation	7
Copies of datasheets (all on Rite-in-the-Rain© paper)	100
Reference books for plant, insect, and disease identification	several
Park radio	3
Spare radio batteries for backcountry	15
Yellow rebar end caps (from Forestry Suppliers, for 3/8" rebar, yellow with "NPS Study" stamped on them)	several hundred
Aluminum tree tags (from Forestry Suppliers, 1 ¼" diameter, numbered 1 -1000)	300
Nails for witness trees (steel, 1 ½ " lengths)	300
Rebar (from Chicago Iron, Ashland, WI, 3/8" diameter, 1 ft. lengths)	100
Rebar pouches (sewn from red canvas)	25
Small red canvas pouches (for nails and tags)	4

Table 1. Field equipment list for vegetation sampling, continued.

Item	Quantity
Multitool	4
Small screwdriver (for changing diameter tapes)	4
Unknown plant ID tags	~300
Plastic bags for unknown plants (Ziploc – quart and gallon sized)	~300
Pruning shears for checking pith and collecting samples	4
Trowels	4
Internal frame packs (varying sizes, men's and women's)	At least 10
Pack covers	1 per pack
Dry bags for hanging food and misc.	10+
Bear-proof canisters for storing food in the backcountry	12
Tents (solo with footprints)	7
Sleeping pads (Thermarest Prolite 4)	7
Sleeping pad repair kit	4
Backcountry cookset	3
Stoves (MSR Dragonfly)	4
Fuel canisters	6
Hydration packs (100 oz.)	8
Hydration pack filter adapters	8
Compasses (Silva Ranger Ultra)	8
Water filters (Katadyn hiker pro and Katadyn pocket filter)	4
Water filter cartridges (for both the hiker pro and pocket)	8-12
Insect repellent	Several cans
Head nets	8
Rulers (Flexi-rulers)	8
Sharpies – fine point and regular	8 of each
Insect-proof leather gloves	7 pair
Sunscreen	3+
Safety glasses	7 pair
First Aid kit	4
Carabiners for hanging food	7
Bear rope	3 100ft. pieces
Plant press	2

1.7 April

- Purchase service and program Spot Locators. Go to www.findmespot.com. The username is GLKN and the password is "vegmonitoring". Program in the mobile phone numbers that will receive text messages. You may also need to program in the time zone of the park in which you will be working.

- Purchase minutes for satellite phone if it will be used.

- Site coordinates and topographic maps must be loaded onto the Trimble and Garmin GPS units. This should also include any practice or test plots. The data dictionary should also be updated on the Trimbles. Check GPS units to ensure accuracy, working order, and that the proper settings are loaded and all software is updated (see SOP 4: Using the Global Positioning System).

- Mark the estimated location of plots on each of three durable, hardcopy, park-wide maps, if available. In addition, some parks (including SACN and SLBE) have smaller (8.5 x 11 inch), printable PDF maps of certain areas within the park. It is typically beneficial to mark estimated plot locations on three copies of these as well.

- Put binders together. Each 1½ inch binder contains: GLKN trifold brochure, latest issue of Network newsletter, copies of resource briefs from the previous parks in which work was conducted, sheets and forms on remote network access/using the VPN, time and attendance administrative training sheet, current year's payroll schedule, work record, request for leave, request for comp time (travel and non-travel), directions for using the Concur travel management system, request for travel, travel voucher checklist, administrative issues (charge card and travel), SMIS quick reference, SMIS User Guide, deer tick documentation sheet, motor vehicle operation rules, government vehicle use frequently asked questions, SOP 3 (Safety), SOP 6 (Field Methods and Data Collection), SOP 7 (Procedures for Handling Unknown Specimens), SOP 8 (Pests and Pathogens), park specific material (radio call information, backcountry procedures, etc.), directions for changing diameter tapes, compass use, Trimble GeoXT use, Garmin use, database user guide, and EPAP.

- Put clipboards together: radio call number sheet taped in, phone contact information taped in (relevant to park and season), tree/shrub list for tree recorders, complete species list and photographic background for groundlayer recorders, SOP 6: Field Methods and Data Collection (on Rite-in-the-Rain© paper, tree recorders), unknown plant ID tags, two Rite-in-the-Rain© pens, one fine-tipped Sharpie, and park-specific plant guides. In addition, the clipboards of the Botanist and Ecologist should also have one copy each of the CA-16 form and the instructions to the treating physician. This is in the event of an emergency hospitalization.

- Prepare electronic training materials. This includes acquiring the CD for FISSA and whistleblower training for seasonals who have never worked for the federal government. For new federal employees, the supervisor must log onto DOI Learn and approve the training for these employees.

- Request to the GLKN Network Coordinator any foreseen additional hours needed over the summer by both permanent and seasonal staff.

- Set declination on compasses.

- Make paper copies of timesheets for each crew member for all pay periods. These can then be filled out and mailed back to the Administrative Technician at GLKN.

- Fill out a NPS GSS New User Account Form for each employee. This is available from the Midwest Region website and on the shared drive (M:\admin\NPS forms\personnel). Submit these to the IT manager. Make sure to request a VPN account and government email address for each employee.

- Update the database: forest type (Kotar type, NVCS, MLCCS), indirect browse species, and new employee names. Update any changes to datasheets.

1.8 May

- Program all cell phones with the personal phone numbers of all crew members and with all relevant phone numbers in the parks where work will be conducted.

- Ensure there are vehicle logs for each month and for each vehicle and that there is a stamped and labeled envelope in the glove compartment of each field vehicle.

- Field crew typically arrives at duty station (although this starting date varies, depending on the park where sampling will occur). There will be a three-week training period following their arrival but prior to sampling the first plot. During the first three days of this period, the crew will have two (or three) federally mandated training courses: Federal Information Systems Security Awareness computer training (FISSA) and discrimination and whistleblowing in the workplace ("No Fear"). In addition, all seasonal employees who will be in travel status at any point will be required to carry a government charge card and complete that training. For all courses, the crew members will be required to meet minimum proficiency scores. Official certificates for each course must be saved in a Word document and sent to GLKN to be kept in each employee's official records. In addition, the crew members will be required to pass an American Heart Association approved CPR and first aid training course. If applicable for the sampling requirements in a given year, the crew will also attend canoe safety training.

- Train the field crew in plot establishment, data collection, and general field season techniques. This will include establishing test plots, plant identification, use of park radios, and general park etiquette. This last point will focus on interactions with other park employees and the general public, and will include how to answer questions about the work of the field crew specifically and the Inventory and Monitoring Program in general. Prior to initiating sampling, all field crew members will be required to pass a proficiency test on field techniques.

SOP 2: Training

Version 2.0 (6/1/12)

Suzanne Sanders and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Appendices A, B, and C were added. The SOP now includes all aspects of training, not just plot establishment and plant ID.	The previous version was not as thorough as is desired for a long-term monitoring program.	2.0

2.0 Introduction

This Standard Operating Procedure explains the training procedures to prepare seasonal employees for summer work.

2.1 Administrative, First Aid, and Safety Training

The initial two days of employment will focus heavily on administrative training. This includes mandatory credit card and computer training, as well as introductions to the GLKN long-term vegetation monitoring program and the Department of the Interior Safety Management and Information System (SMIS). Complete check lists for all administrative procedures are included in Appendices A and B of this SOP.

The seasonal employees are also required to complete a first aid and CPR class during the initial three weeks of employment. Whenever possible, they will attend a park-sponsored class given for the seasonal employees in the park where they will be based. If this is not possible, the Ecologist will arrange training through another source.

2.2 Familiarization with Species, Keys, and Sampling Rules

Following the initial two days of administrative training, the crew members will spend two days becoming familiar with the field-based aspects of the program. This will focus largely on species identification and use of dichotomous keys of the region. It is expected that all seasonals will already have an advanced understanding of their respective areas of expertise: either trees or herbs. Nonetheless, we have found that additional time allotted to plant identification is essential. Seasonals have not been out in the field for nine months so time to become reacquainted with the plants is needed. In addition, many of the seasonals may have a solid knowledge of a large percentage of the plants of a region, but not all. This period will help them fill in their knowledge gaps. This is also a good time to work through identifications, as a group, via the commonly used dichotomous keys of the region. Many clues are subjective (e.g., “spines and prickles weak, broad or roundish but not fan-shaped,” and, “leaves villous, at least when young”). Discussing these as a group will alleviate the subjectivity and ensure that all seasonals have worked through the common keys.

Herbaceous data collectors will likely spend a greater amount of time on pre-season plant identification, as there are exponentially more herb species than trees at any given park. While the Botanist is spending this time with the herbaceous specialists, the Ecologist can begin to acquaint the tree data collectors with the sampling rules. This includes teaching them how to measure forking and leaning trees and all other unusual circumstances. All aspects of coarse woody material data collection will be discussed at this time as well.

In addition to species identification and sampling rules, the seasonals will also be trained on compass use during the first two days of field training. An understanding of using the mirror for proper sighting, declination, and the high degree of precision necessary for plot establishment will be stressed.

2.3 Establishing Initial Test Plots

On approximately the fourth day of employment, the seasonals will begin the process of establishing the first test plot. Areas for test plot sampling will be selected by the Botanist and Ecologist prior to the start of the season, using aerial imagery and GIS. The UTM coordinates can then be loaded into the Garmin GPS for navigation and the Trimble GPS for endpoint data collection, simulating a regular plot.

Typically, two to three seasonals will establish one plot, trading off on duties so that everyone gets to practice all aspects of plot establishment. Thus, two practice plots are being established at the same time; the Botanist will oversee one of these and the Ecologist will oversee the other. The seasonals will navigate to the plots, establish the endpoints, record the endpoints in the Trimble GPS, take photographs, select witness trees, and run out transects. Witness trees will not be tagged and rebar will not be hammered into the ground, but the permanent staff will make sure that the seasonals understand that this is a normal part of plot establishment. While this process normally takes two to three hours by mid-summer, during training this process can take as long as four to five hours. During this time, there is typically a great deal of questions and discussion between the seasonals and permanent staff on methodology.

Once the practice plots have been established, the seasonal crew will begin their training on sampling. The Botanist and/or Ecologist will go back and forth between the seasonal(s) collecting herb data and those collecting tree data. This process can take anywhere from three to six (or more) hours by mid-summer. During training, it will likely take the rest of the day and half or most of the following day.

During data collection, the Botanist and Ecologist must stress several points to ensure the integrity of the data. These include several obvious things such as 1) making sure the diameter tape is level when wrapped around trees for measurement, 2) making sure to check the distance from the transect for all trees estimated to be between 2 and 4 meters from the transect line, and 3) making sure that the herb quadrat is lying flat on the ground with one end directly in line with the transect. In addition to these obvious sources of error, there are a number of less obvious sources, and other places where details can be emphasized to promote consistency. These are listed in Appendix C of this SOP.

2.4 Data Entry

The overwhelming majority of seasonal employment time will be spent sampling plots. Despite this, situations arise where there are an odd number of people available to sample and it is more efficient to have the odd person enter data, rather than be a third person sampling a plot. During training, each seasonal will enter the data from the test plot that was recently completed. As with all aspects of training, there are typically multiple questions from all seasonals related to database use. The Ecologist and Botanist will answer these questions and make sure that certain key topics related to data entry are addressed. These include treatment of unknown specimens in the database, writing the plot description and directions, and navigating between transects, quads, etc. within the database.

Data entry, as well as the error checking of entered data, and fixing incorrectly entered data, are time-consuming processes. Following seasonal data entry training, the Botanist and Ecologist will then check the data entry of the seasonals and go over with them any errors that were encountered. This is an important step as, this is when issues in field data collection often become evident. Such issues include the incorrect treatment of a species as either a tree or shrub, failing to consistently collect direct browse data, and recording indirect browse data in incorrect columns. Addressing these problems pre-season will save a great deal of time at the end of the year when data entry is thoroughly checked by the permanent staff.

2.5 Establishment and Data Collection on Second Test Plot

Following data entry and addressing any apparent problems, the seasonals will spend a day establishing the second test plot and collecting data on it. This will be accomplished with minimal input from the Botanist or Ecologist, although they will be carefully watching every detail of the process. The minimal input from supervisors will allow the seasonals to think through the processes and develop their own individual systems for the necessary tasks (how/where to carry sampling gear, what to keep in/out of the clipboard, etc.). Typically there are numerous mistakes made during this process (forgetting to bring to flags to endpoint 1, failing to sum the distances when using Sonins, etc.). These problems are part of the learning process and the seasonals work through them. There are generally a lot of questions asked during the second test plot. Typically, completing the second test plot takes a full day or more.

2.6 Quiz

Following the second test plot, the seasonals will take a quiz covering multiple aspects of the protocol, but focusing on field sampling procedures. Supervisors will grade these, then go over them individually with each crew member to ensure that the seasonal understands any questions missed. These quizzes are presented in Appendix D of this SOP.

2.7 Training on Specialized Equipment

In addition to the general equipment used for field sampling, seasonals will also be using some specialized equipment, including two-way radios, Spot Locators (see SOP 3: Safety), and both Trimble and Garmin GPS units (see SOP 4: Using the Global Positioning System). All seasonals will be taught the use of these in small groups and their understanding will be assessed during one-on-one meetings with either the Botanist or Ecologist.

2.8 First Official Plot

Following the quiz and equipment check out, seasonals are ready to begin field sampling. For the first day of sampling, the seasonals may be divided into two groups so that two plots can be sampled. When this happens, the Botanist will work with one group and the Ecologist will work with the other.

SOP 2, Appendix A: Checklist of Instructions for Seasonal Employee Administrative Training

☐ Complete the I-9 with park-based administrative/human resources contact. For this, seasonals will need to present either a passport or two forms of ID from a list that includes driver's license, birth certificate, and social security card. However, since we always need a copy of their driver's license, they must bring that and either a birth certificate or social security card. The I-9 form will be scanned at the park and emailed to the GLKN Administrative Technician. S/he will upload this to the SHRO website. The original will then be mailed/delivered back to GLKN where the Administrative Technician will file the original.

☐ Complete the Appointment Affidavit, scan, and email it to the GLKN Administrative Technician. S/he will upload this to the SHRO website. The original will then be mailed/delivered back to GLKN to the Administrative Technician, how will forward it on to the Midwest Region.

☐ Sign the OF306 Declaration for Federal Employment as the "appointee." Employees will have filled this form out and signed as the "applicant", but must sign and date again when they start. This form will be scanned at the park and emailed to the GLKN Administrative Technician. S/he will upload this to the SHRO website. The original will then be mailed/delivered back to GLKN where the Administrative Technician will file it.

☐ Complete the 05-04 Self-Certification motor vehicle form. If they use a passport for the I-9, please record their driver's license number and expiration date on the 05-04 Self-Certification motor vehicle form. Inspect the driver's license to confirm that it is valid.

All four forms, above, should be sent to the appointee prior to commencing work. It is their responsibility to bring this, along with the proper identification, on the first day of employment.

☐ Computer training

> Seasonals are required to take the FISSA (Federal Information Systems Security Awareness) training first before they do anything else on the computer. FISSA now includes Security Awareness, Records Management, and Privacy training.
>
> The FISSA training and Whistleblower/No Fear training are on a CD supplied by the GLKN IT Manager for new (first time) federal employees. When this route is taken, the supervisor must log into DOI Learn and approve the course for the new employee first. If the person is a returning federal employee, they must take these courses in DOI Learn. If they do not know their username/password, they need to call the DOI Learn help line.
>
> If the seasonal will be traveling at all (including backcountry), it is mandatory to issue them a charge card. They will need to take internet-based charge card training before completing the charge card application.
>
> GLKN will need to have certificates of all training completed. If the certificate cannot be printed immediately, it should be copied and pasted into individual MS Word documents (one document

for each certificate for each person). These are then emailed to the GLKN Administrative Technician.

☐ FISSA (required annually)

After they take FISSA, print out the two forms that come on the CD supplied by the IT Manager and have the seasonal(s) sign them. These two forms are:

1) Internet Acceptable Use Agreement

2) Policies on Limited Personal Use of Equipment and Telephone Use Acknowledgement

Copies of the FISSA certificate and the two forms from the CD are sent to both the IT Manager and the GLKN Administrative Technician .

***Once FISSA training is completed, the seasonals should initiate the process to become established in the travel management system if they will be in travel status at all during the season.

☐ Whistleblower training. Print or save the certificate for GLKN Administrative Technician. Note: this only needs to be taken every two years. If a seasonal is returning or has worked at another park the previous summer and took this, there is no need to retake it. However, they will have to provide a certificate as proof.

☐ Charge card training. Note: The charge card training cannot be initiated until the employee's FPPS actions have been finalized by the regional office. Ideally, this will happen by the first day of employment, however it may be delayed for up to two weeks after the employees' EOD.

Charge card training is available online at https://chargecardtraining.nbc.gov/index.htm. Seasonals should complete modules A (General) and B (Travel Purchase Line) and the assessments. Print certificates with verification that each module was completed with a score of 80% or better. The Administrative Technician will start the charge card applications. Employees will sign and date their application, initial on the application that they authorize a credit worthiness certification, and have their supervisor sign and date at the bottom of the application. The original application is sent to the GLKN Administrative Technician

☐ The GLKN Administrative Technician will send in the applications with proof of training and the charge cards will be sent to the GLKN office within approximately two weeks. PIN numbers will be mailed separately to the GLKN office.

☐ Have each person log into both field computers while they are on an NPS network. Because these computers are encrypted, each seasonal has to enter a user name and password once per computer to get past the encryption. The user name will be their standard network login minus "@nps.gov". The default password will be either "12345", "Password12345", or "Password12345!". The will be required to create a new password for the encryption, then they may login normally to the network.

☐ Have everyone check their NPS email

☐ The Ecologist will give the GLKN long-term monitoring presentation.

☐ Go through binders

  ☐ Make sure to note that they will be able to view their pay stub electronically on the Employee Express website (www.employeeexpress.gov) but the PIN for this is mailed to their permanent address. They need to make sure that there is someone at their permanent address to forward this to them, or to open their mail and verbally give them the PIN.

☐ Performance plans: Go over their EPAP and have them sign that they understand how they will be rated. EPAPs are then sent/brought back to the GLKN office and kept by the Network Coordinator.

☐ SMIS presentation

☐ Basic work schedule – fill out and turn in to the GLKN Administrative Technician.

☐ Complete Receipt of Property forms

☐ Sign Job Hazard Analysis forms

☐ Medical information form

SOP 2, Appendix B: Instructions for What the Supervisor Needs to Complete and Do

☐ Bring a copy of the charge card application. The GLKN Administrative Technician will supply this. It will be in electronic format unless we know the employee's email address beforehand. If this is the case, enter the email address on the electronic copy and print it out beforehand. Once the training is complete, have the employee initial the form to authorize a credit worthiness certification and sign and date it. The supervisor then signs and dates it and sends it back to GLKN.

☐ Forms to go back to GLKN:

- Key hiring forms: I-9, SF61, OF306, and 05-04 (These are scanned at the park and emailed to the GLKN Administrative Technician who will upload them to the SHRO. The originals are then returned to the GLKN Administrative Technician.)
- Basic work schedule
- Receipt of Property forms
- Signed and initialed copies of the credit card application
- Credit card training certificates
- Certificates for both CD-based training classes (FISSA and Whistleblower)
- Emergency contact form
- Motor vehicle operation form
- Copies of all training certificates
- Limited Personal Use and Acceptable Use forms
- Job Hazard Analysis forms

☐ Forms to go back to the IT Manager:

- Internet Acceptable Use Agreement
- Policies on Limited Personal Use of Equipment and Telephone Use Acknowledgement
- Copy of the FISSA completion certificate

SOP 2, Appendix C: Training Details to be Emphasized

Plot Establishment

If a transect line is shorter than the Sonin distance due to topography, pull the line taut, place the flag/rebar in the appropriate place, then release the line for sampling.

Reestablishment of a Plot

If the rebar is offset, re-check all distance and azimuth measures (as well as you can, using the GPS coordinates for the 'on' point). If the data on the print-off datasheet is incorrect, cross it out and write the correct numbers in. If the data on the print-off datasheet is correct, put a check mark next to the number so we know you confirmed it.

For all reference points, re-check the DBH, species, tag number, distance, and azimuth. If any values are incorrect, cross them out and write in the correct number/name (use the notes column if you run out of room). If a tree cannot be located, has died, is near death, or has fallen over, write the status code in the status column, and cross that entire line out on the datasheet. Use the blank lines at the bottom of the sheet to replace that reference object, remembering to specify which endpoint it is.

Photos

- Do not take the picture (or take another later) if there is a glare.
- Take the picture in landscape, rather than portrait.
- Do not delete pictures in the field.
- Use default settings (with steady hand feature if needed). Do not use macro for photopoints.
- Check and enlarge all to see if blurry.
- Check the date and time each time the battery is put back in.
- Do a practice where each crew member takes a picture at a given point and bearing.
- Do record all photos that are photopoints, even if you take six and three are bad.

Tree Sampling

If a witness or tally tree is leaning, the distance is taken from the **center** of the tree's **base**.

Make sure for training that we stress that damage agent and severity is for live trees only. If it is dead, it is dead. However, if it is obvious or there are a number of trees experiencing the same condition, that should be noted on the data sheet but the severity is not needed.

When keying out a species, if it is something you have never seen before, make sure it is on the park list, and collect a sample for ID if you are not 100% sure. This is a common mistake with tree sampling – we end up with rare trees identified (which may or may not actually be there), or *Salix* species that do not exist in the region of sampling.

If the actual species of insect or damage agent is known (and obvious), record it on the datasheet. This will be entered as Notes in the database.

Coarse Woody Material Sampling

When measuring a piece of CWM, measure the diameter to the tenth of centimeters. However, in situations where it is not possible to get the tape around a tree, just estimate to the nearest whole centimeter.

Address how birch decays differently from other species (basically from the inside out). Multiple criteria need to be considered when assigning a decay class for birch.

Groundlayer Sampling

Make sure to ALWAYS record the counts on tree species that are in the groundlayer quadrats.

If a quadrat to be sampled as no plants within it, record it on the notes line at the top of the datasheet as such. with "ND" for **Sampled, No Data**. If more than one transect is on that side of the page, write "ND T1 Qx" to indicate no data in that quad for Transect 1. No data is still data. If there are many quadrats with no data, write down "S**ampled, No Data,"** or "ND" in the species field to keep track of them, checking the corresponding boxes for quadrats that have no data.

If a quadrat is **Not Sampled** (NS), make sure this is clearly noted on the datasheet, following the details for Sampled, No Data (ND).

Direct Browse Sampling

If a quadrat to be sampled has no plants within it, record it on the notes line at the top of the datasheet as such, using "ND" for **Sampled, No Data**. If more than one transect is on that side of the page, write "ND T1 Qx" to indicate no data in that quad for Transect 1. If there are many quadrats with no data, write "**Sampled, No Data,"** or "ND," in the species field to keep track of them, and check the corresponding boxes for circles with no data. Preferably, you would still write these in the notes section at the top of the datasheet as well.

If a quadrat is **Not Sampled** (NS), make sure this is clearly noted on the datasheet, following the details for Sampled, No Data (ND).

Indirect Browse Sampling

If there are no target species for indirect browse, cross out that quadrat on the datasheet while you are still physically at the quadrat. It is common for crew members to record these measurements in the wrong quadrat on the indirect browse datasheet (this is difficult to deal with post-season). Also, pay close attention to the species, and make sure you are recording measurements/counts for *Aralia nudicaulis* on the line for *Aralia nudicaulis*. This seems straightforward, but is done incorrectly with surprising regularity.

If you are the person recording the groundlayer data, you should also be the person recording indirect browse data. If these tasks are split between two people, there are discrepancies in the data.

Safety

It is the responsibility of all working to know where they are. There are two important reasons for this. First, electronics can fail, in which case, you need to be able to get out with a map and compass.

Also, you need to be prepared to answer the question “Where are you?” if you need to place a 911 call, or urgent ranger request.

When towing the canoe or motorboat trailer, it is ultimately the driver of the vehicle who is responsible for safe hookup of the trailer and safe attachment of the canoes or motorboat onto the trailer. Do not rely on the verbal OK from the person who attached them.

Data Recording

For any value less than 1, such as 0.9, make sure to put a zero before the decimal point. Similarly, for any value requiring a one-tenths position, make sure to put a zero after the decimal point even if is a whole number (such as 23.0).

When you have written the wrong number or word, do not simply write the correct value or word darker over the original value. Instead, clearly cross out the incorrect value and write the new value next to it or in the margin with an arrow drawn to it.

When more than one person is collecting data on herbs, both people will have an “unknowns” data sheet. To avoid overlapping “Unknown” ID numbers, add an initial after the plot number on each unknown. For example, if Suzy and Jess are both collecting herb data on plot 6015, Suzy’s first unknown will be 6015S-1 and Jess’s will be 6015J-1.

If any transect is short (including the browse transects on the north-south lines), include details about this on the main datasheet, and document on the metric-specific datasheet.

Ditto marks are only permitted on the Tree datasheet (for both the species and disease fields) and the Coarse Woody Material datasheet (in the species field only).

When using the six letter codes, letters should be in ALL CAPS.

Six-letter codes are only permitted on the trees, forest canopy, coarse woody materials, and direct browse datasheets.

On the tree datasheet, do not add trees below the bottom line. They are difficult to read and frequently do not make it onto the photocopy.

Data Entry

When entering the data for plot access and plot description, please use complete sentences and check over what you wrote for spelling and grammar. Also, please spell out anything that was written in shorthand in the field (such as Latin names in six-letter code) and always capitalize genus names.

If you are entering data and notice a problem (incorrect species names, illegible data, spilling over the lines, etc.), please let the Botanist or Ecologist know.

If you get an error message when entering data, make sure you note what the steps are that you took to get to that error. Also, please note the exact wording of the error itself.

Photocopies

When making photocopies, please make sure: 1) that all information made it onto the copy. This includes plot info on the top of the sheets and any notes along the sides; 2) that the data on the copy is readable. Sometimes you may need to make another copy and make it darker; 3) that all sheets are present and that they are placed in the proper order (or at least reasonably close to it, since things get mixed up when copied on two-sided paper). Also, do not copy back sides of tree, CWM, unknown, herb, and direct browse datasheets if there are no data on them.

If you are making photocopies and notice a problem (spilling over, crossing out that comes out funny on the copy, etc.), please let the Botanist or Ecologist know.

Unknowns

Be detailed in the procedure for collection and documentation of unknown plants. **Always** get a picture of the plant when collecting a sample of it. If you don't have the camera on you, take the collected sample back out at the end of the day and take pictures – it is *incredibly* useful to have pictures of all the unknowns post-season, so please take the time to do this. Also, use the provided card stock as the background when taking pictures, and include the Unknown ID tag in one of the photos so we can confirm the unknown number and plot. On your unknown plants datasheet, be sure to leave plenty of white space and draw lines between your records for each unknown, as there will be notes written on this sheet later.

If you reference an unknown from a plot you previously sampled, still give it an unknown number for the plot you are currently on. Then, on the Unknowns Datasheet, in the description, write the Unknown identifier that you are referring to. For example, if you are on plot 6008, and you have an unknown that you documented the previous day at a different plot, call the unknown 6008-1, and on the Unknowns Datasheet for 6008-1, in the description, write "same as 6012-3, Carex sp., additional sample not collected," and include the picture numbers taken while at plot 6008. Only do this if you know the **exact unknown ID** of the plant you are referring to. If you cannot remember the exact unknown ID, **re-collect the plant**. People often collect and leave things blank with the intention of filling in the details at the end of the day or the next day – they often forget, and then we are missing data.

We require that you still take good photos of the plant, even if you don't re-collect, to confirm that it is indeed the same plant as a previous unknown. If you don't collect an unknown plant because you are referring to another plot's unknown, you should write "**additional sample not collected"** on the Unknown Datasheet, just so there is no confusion.

If there are not any unknown plants, write NONE on that sheet and make sure it is still included and is photocopied.

Herbarium Specimens

Make sure to record the location of collected specimens so that the population can be relocated. This may not be so essential for common plants, and maybe a little personal judgment can be used, but this is very important for less common plants. Location information should include things like how far and in which direction off of a particular trail or road the species was found.

GPS

If any large or notable populations of exotic species (or rare species) are located on hikes to or from a plot, take the GPS coordinates and report the species and location to the park.

Trimble TEp – if the map looks oddly shaped and you are confident the plot is not shaped that way, go back and recollect questionable waypoints. The odd-looking map probably means there will be a large standard deviation associated with that point. You can still call it the same TEp in the data dictionary, and it will not write over the original point you collected there. If you're sure the second point is the preferred one, delete the original waypoint from the file (seasonal employees will be shown how to do this).

All plot data should be saved to the SD card on the Trimbles – this gives us extra security if the unit misbehaves and we have to do a hard reset.

Earthworms

When looking for earthworm middens and castings, make sure that the area where you are looking is a full 1 meter x 1 meter. Measure it with a diameter tape to be sure.

Equipment

Make it clear to the crew that if they notice equipment starting to break (e.g. diameter tapes getting bad, screws coming out or loosening), that they need to either fix it, or mention it to the Botanist or Ecologist. Checking screws and diameter tapes should be a part of normal end-of-hitch maintenance.

If you take something major from the first aid kit (e.g., the Ace bandage, the last of the ibuprofen), let the Ecologist or Botanist know so that it can be replaced, or resupply the first aid kit yourself from the first aid equipment bin, following the guidelines inside the bin on what should be in each kit.

Misc.

Please do not eat plants, berries, or mushrooms within, or immediately surrounding, the plot. This hinders reproduction and does not give a true indication of long-term change.

Make a habit of cleaning hiking boots and equipment after and/or before each sampling hitch or between working in different regions of a park.

Employees cannot bring parents/friends/significant others/dogs to the plot with them. If people are visiting you, they will just have to wait until you are done with work to spend time with you. Reasons for this include trampling at the plot, integrity of the data, and safety/liability.

SOP 2, Appendix D: Quizzes

Herb/Browse Sampler Quiz **Name:**________________________________

What is the radius of the direct browse circle?

If branches from a shrub that is rooted outside of the browse circle grow into the circle, do you count this as a species present in the circle?

If branches from a shrub that is rooted inside of the browse circle grow out of the circle, and browse is observed outside of this circle, do you tally this is as browse on the data sheet?

What is the molar zone for direct browse measurements?

What is the minimum height of seedlings on which we collect data? What other requirement must seedlings meet to be counted?

If a plant is rooted outside of the herb quadrat but is growing/arching over into the quadrat, is it counted?

In what situation(s) would you erase pictures on the field cameras?

How high is “breast height”?

Under what conditions would you be permitted to eat berries or dig roots from either a plot or the area surrounding a plot?

If rebar is offset, do you take the azimuth from the rebar to the actual endpoint, or do you record the azimuth from the actual point to the rebar? Why?

When recording witness tree azimuth, do you record the azimuth from the tree to the endpoint, or from the endpoint to the tree? Why?

How many individuals of a given unknown species must be present to collect a specimen?

You encounter an unknown plant at plot 1003 that you've documented and collected at your two previous sampling plots (1002-3 and 1001-1). Provide a detailed description of how you would record the unknown if you don't want to make yet another collection.

In the example given in the previous question, what would you do if you didn't remember the exact unknown numbers of 1002-3 or 1001-1?

What do you need to make sure before you take endpoint pictures? Please list at least two things.

Which datasheets should you make sure you have extra copies of in your clipboard?

For the following scenarios, write down whether the quadrat should be Sampled with No Data (ND), or Not Sampled (NS):

Quadrat lands on a paved trail:

Quadrat lands on a dirt path with no plants:

Quadrat lands on an area with water > 3' deep (can't tell if there are plants):

Quadrat lands on muddy area with some shallow standing water and no plants:

Quadrat lands on steep cliff that you cannot access:

There is a yellowjacket ground nest where the quadrat lands:

There is a pile of coarse woody material (CWM) where the quadrat lands:

Quadrat lands on area with a big tree trunk and no plants that fit our criteria:

Draw an outline of the plot, and write down all the endpoint numbers and transect numbers (including those for direct browse). Which direct browse transects are shorter, what is their length, and why are they shorter?

Tree/CWM Sampler Quiz   Name:_________________________________

What is the minimum diameter of tree recorded?

How high is “breast height”?

For a tree growing on a hill, where does one stand to record DBH?

For a leaning tree, where does one stand to record DBH?

When one wants to determine whether a leaning tree is within 3 meters of the transect line, is the distance measured between the two taken from the tree at A) breast height or B) the base?

You encounter a tree in the 6 meter wide belt transect that has healthy looking green leaves at knee level. Outside of that, there are no obvious signs of life. Do you record it as live or dead? Why?

What is the minimum diameter at transect recorded on coarse woody material pieces?

What is the minimum length a piece of coarse woody material must be to be tallied?

What is different about collecting data on decay class 5 pieces?

What do you need to make sure before you take endpoint pictures? Please list at least two things.

In what situation(s) would you erase pictures on the field cameras?

What do you do when you can’t figure out a tree or shrub to species but only genus?

Under what conditions would you be permitted to eat berries or dig roots from either a plot or the area surrounding a plot?

If rebar is offset, do you take the azimuth from the rebar to the actual endpoint, or do you record the azimuth from the actual point to the rebar? Why?

When recording witness tree azimuths, do you record the azimuth from the tree to the endpoint, or from the endpoint to the tree? Why?

Where along the transect does the herb sampler collect data? List specific meter locations, and whether they are on the north or south side of the transect.

Which datasheets should you make sure you have extra copies of in your clipboard?

If there is no CWM on a transect, what do you write on the datasheet?

If you do not have time to sample a transect for CWM, what do you write on the datasheet?

SOP 3: Safety

Version 2.0 (6/1/12)

Jessica Grochowski and Suzanne Sanders
NPS – Great Lakes Network

Sarah Johnson
University of Wisconsin – Madison

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Mandatory requirement of first aid training was added, as was a job hazard analysis, and detail on working in various conditions	We realized the need for greater detail and more specific policies related to safety.	2.0

3.0 Introduction

Safety of the field crew is the foremost concern during monitoring and travel to and from monitoring sites. The purpose of this SOP is to state the safety policies of the Great Lakes Network as they relate to the forest monitoring protocol.

3.1 First Aid

The Botanist and Ecologist are expected to obtain a Wilderness First Responder certification at the earliest possible time following the start of employment, and to maintain this throughout their duration of employment at GLKN. At a minimum, all members of the field crew must have basic first aid and CPR certification. This will be provided either by the park where the field crew is duty stationed, by a certified trainer with GLKN, or by an independent instruction program. The Network will attempt to provide this training during the two- to three-week time period after the field crew arrives, but before sampling begins. If it is not available during this time, seasonal technicians will attend a first aid and CPR course at the earliest possible date thereafter.

3.2 Vehicle Use (Cars/Vans, Motor Boats, Canoes)

Operation of National Park Service cars, vans, and trucks is limited to National Park Service employees and official volunteers only. Further, all members of the field crew must possess a valid driver's license and sign the NPS motor vehicle operation waiver stating that they understand the rules of motor vehicle operation and alcoholic consumption. Vehicle operators are expected to abide by state and local laws; this includes all regulations within the park units. Specifically, seat belts must be worn at all times when the vehicle is being operated. In addition, cell phone operation (calling, talking, texting, or any other use) while driving a government vehicle is strictly prohibited. Finally, employees should inform their supervisor if, at any point, they do not feel safe in the vehicle, either as a passenger or driver.

Motorboat operation will be limited to those employees who have passed the Department of Interior Motorboat Operator Certification Course (MOCC). Employees must also demonstrate familiarity with the park, or the area within the park where they will be boating. This is typically accomplished via conversations with park employees. If time and opportunity permit during the two- to three-week training period, crew members who have not undergone the training may be allowed to participate in it. All employees are required to wear a PFD while in a boat. The boat operator must ensure that all boat passengers are wearing the PFD properly (e.g., zipped and buckled for a tight fit) before leaving the dock.

The Botanist and Ecologist will attend an American Canoe Association (ACA) instructor training course at the earliest possible opportunity. This will allow them to provide seasonals with an ACA-certified skills course when working at parks where there will be significant time spent canoeing. This will occur during years when sampling at SACN, VOYA, and ISRO. During years where there will be only limited canoeing and/or by only a subset of seasonal employees, the Botanist or Ecologist will perform a skills assessment of those employees expected to canoe. Additional training will be provided to them if needed. All employees are required to wear a PFD when in a canoe. A job hazard analysis for canoe use is presented in Appendix A of this SOP.

3.3 Daily Work

Long hours are a fact of field work, and field crew members should expect that a fair percentage of work days will be greater than 10 hours. It is the responsibility of each crew member to be ready for work each day with his or her own adequate supply of food and water and wearing appropriate footwear, clothing, and raingear for the terrain and weather. In the event of extreme temperature, wind, rain, or other storms, sampling for the day will not be initiated or will be terminated if it has already begun.

The minimum crew size allowed is two people. No individual is allowed to navigate alone, even when on a trail. For travel on a trail, all crew members must be in yelling distance of one another. For travel off trail, all crew members must maintain visual contact with one another. This will limit crew travel time to a speed that is comfortable for everyone. All crew members will be equipped with an emergency whistle in case they become separated from other crew members.

Crew members should be particularly mindful of high temperatures, particularly when coupled with high humidity. GLKN will use the National Weather Service heat index chart (Figure 1) as a guide during hot conditions. All field work is prohibited when the heat index is at or above 130° F. When values range between 90° F and 130° F, breaks and water consumption are encouraged. Crew members should monitor one another for signs of heat fatigue. At the supervisor's discretion, field work may be suspended under hot conditions.

NOAA's National Weather Service

Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	126	130					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Streuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Figure 1. National Weather Service heat index chart.

A first aid kit will be supplied to each two-person crew. The crew members should familiarize themselves with them so that they know what can be treated in the field.

In general, follow these guidelines for preventing injury:

- Use sunscreen, hat, and lip balm to prevent sunburn and reduce the potential for skin cancer.
- Wear insect repellent or long sleeves, gloves, gaiters, and a headnet to reduce exposure to mosquitoes (which carry West Nile virus) and ticks (which carry Lyme disease and other infectious agents).
- Although they may be small, take care of cuts and scrapes, as they are invitations for infection in an outdoor environment. This is particularly true during multi-day backcountry trips.
- To the extent possible, avoid bee stings, fly bites, and contact with poison ivy.
- Drink plenty of fluids to stay hydrated and prevent heat exhaustion.
- Maintain your energy level and prevent fatigue by bringing enough food to the field site.

A job hazard analysis for working in forested environments is included as Appendix A of this SOP.

3.4 Alcoholic Consumption, Smoking, and Drug Use

Consumption of alcoholic beverages during the work day is strictly forbidden. Use of alcoholic beverages during off time by those 21 years of age or older is permitted. However, consumption occurring on National Park Service property (e.g., park housing, backcountry campsites) must be within compliance of park rules (e.g., no glass containers).

If a field crew member is deemed unfit for work due to excessive alcoholic consumption, he/she may, at the discretion of the Ecologist or Botanist, be given the day off without pay. Further disciplinary action may also be taken.

Smoking is not allowed in or near vehicles, boats, or docks. Smoking is not allowed while sampling in the plot, and if an employee chooses to smoke during a lunch or other break, they must go 100 meters outside the perimeter of the sampling plot, and all cigarette butts must be packed out.

Smoking occurring on National Park Service property (e.g., park housing, backcountry campsites) must be within compliance of park rules. Generally this means 25 – 100 feet away.

Use of illegal drugs on National Park Service property at any time, whether work time or off hours, will not be permitted. Violation of this rule will result in disciplinary action and, potentially, loss of employment.

3.5 Pre-Existing Medical Conditions

Crew members with pre-existing medical conditions are encouraged, with discretion, to discuss these with their supervisor or other crew members. Knowing about conditions such as diabetes, allergies, and seizures can affect the actions taken by the crew leaders or crew members in the event of an emergency. For minor medical conditions, crew members should use the medical information form, presented in Appendix B of this SOP. This form should be filled out in private by seasonals during the first week of work, and kept in a sealed blue envelope within their clipboards. In the event of a serious emergency, the sealed envelope will be presented to medical providers.

3.6 Injury Reporting

All injuries and illnesses must be reported using the national online Safety Management Information System (www.smis.doi.gov). Once at this site, click on the "Accident Reporting" button. The type of claim filed will depend on the nature of the accident or injury. All crew members will be briefed on the use of this system within the first two days of employment.

3.7 Radio Use

When working in parks where communication is primarily via radio, seasonal employees will be trained in their use prior to the initiation of sampling. This training will ensure that the employees can navigate between channels (i.e., repeaters) within a park, and between the park frequencies and the weather stations. Seasonal employees will also be taught proper radio communication etiquette, including how to call another person, how to communicate with dispatch, and what to do when there is no contact. Details of this are spelled out below.

Use the radio number of the person **you are calling first, then your radio number**.

If you are call number 981, and you want to call 700 (dispatch at many parks):

To call, say: 700 981 (wait fifteen seconds for a reply.)
If there is no answer, repeat the call: 700 981
If there is still no answer, try moving to a better location or switching to the other repeater channel (if there is more than one at the park where you are).

If you do not get through, say 'No contact, 981 clear' so that other park staff know you are done with the radio call.

We DO NOT use codes, signals, etc. on the park radio system. Plain text is the standard.
Say what you need to say, keep it brief and concise. The radio will "time-out" after a period of time cutting off your message if you are long winded.

In remote areas, you may have trouble "hitting" the repeater. If you are in a marginal area for radio coverage, you can key the radio quickly to see if you hit the repeater. You will know if you did when the repeater stops because you will hear a click on the radio. This then, indicates that you are able to use the radio in this location.

In the event you need *emergency assistance*, you should state this right away.

For example: 700 981 Medical Emergency – State your location

Then stop and wait for a response. If none is heard, repeat the radio transmission. Make sure that you are hitting the repeater, and continue.

This radio call will get everyone's attention. Just keep in mind that an emergency is something life threatening that needs immediate medical assistance. The dispatcher replying to your radio call will ask for additional information. Answer *only the questions they ask* and do so as briefly as possible. Their name is not important, but you should include as much of the following as you can:

Chief Complaint:	What is the problem?
Age:	How old is the patient?
Location:	Where are you? Where is your vehicle/boat/canoe?
What happened?	Provide an answer, keep it concise!

You never know when another park staff member might be in your area and can help you with the emergency. Putting the information over the park-wide radio channel allows anyone close to hear the call and to respond. Keep in mind that dispatch may need to change radio channels in order to communicate with everyone.

Be specific and concise. Can you imagine the difference if you called without stating the emergency and the dispatcher has to ask multiple questions to determine the situation? The additional time required to get the basic facts would slow everyone down. Tell the dispatcher or responding ranger where you are and what is going on.

3.9 Communications

Park staff must be made aware of fieldwork conducted in their park. For front-country fieldwork this can be an informal email to the host park's primary contact. If it is being sent by the Ecologist, the Botanist should be copied on the email; similarly, if it is sent by the Botanist, the Ecologist should be copied. This communication can also be a radio message to dispatch following a park's procedures for boat operations. All trip plans should include who will be involved in the fieldwork, when the fieldwork will take place, what mode of transportation exists, where the work will be performed, and how the crew can be reached. For example an informal email: *To: Park Contact, cc: Joe Supervisor. I and Jane Doe will be at plot 3014 tomorrow, 6/15/2013, from approximately 8:00 AM until 4:30 PM. We will park our NPS vehicle at trailhead X and hike to the plot from there. I will have a cell phone (###-###-####) and a park radio, but the radio will be off unless I have an emergency.* Such an email is not only a good way of providing essential safety information, it is good policy for keeping the park informed of our activities.

When working in the front country, crews should communicate with the field crew leader (either the Botanist or Ecologist) for that hitch to make them aware that they have returned from the field. If crew members do not encounter the crew leader in the office at the completion of work, a text message will be sent to his/her cell phone.

Crews will check-in on a daily basis *per specific park protocol* while traveling by boat or going off trail (i.e. radio in to dispatch in the morning and evening, or on and off the water). When crews are camping in the backcountry, they are also required to check-in with GLKN using the Spot Satellite Personal Tracker (also called Spot Locators).

For all backcountry trips, or for fieldwork spread over several days, a more formal trip plan is filed with the park and with the Network office. The Botanist and Ecologist are responsible for ensuring the trip plan meets the host park's need for detail and flow of communication.

All trip plans should consider the following guidelines and standards:

- The Botanist or Ecologist must file a trip plan for each hitch with the host park contact, and any other designated individual, such as a law enforcement ranger. These designated individuals will be identified prior to the sampling season.
- A trip leader must be identified when more than one person is involved.
- The park's primary contact will typically be responsible for establishing the park's internal communications, ensuring GLKN trip plans are available to park staff, and if necessary, initiating an emergency response according to park policy. At some parks (e.g., SLBE), it may be more desirable to have the dispatcher or other individual be the day-to-day primary point of contact.
- For backcountry trips, the trip leader will post the trip plan on the GLKN SharePoint site under the Safety folder (http://imnetsharepoint/glkn/safety/default.aspx.) Depending on the complexity and inherent dangers of the fieldwork, supplemental information like GPS coordinates for sites, or maps of survey areas will also be posted to the SharePoint.
- If plans change to such a degree that someone would be unable to easily locate the crew, the trip leader should inform the park as soon as practical.

Each evening while in the backcountry, turn the Spot Locator on and press the OK ✓ button (Figure 2). A message will be sent to a pre-programmed cell phone number to someone at GLKN stating that all is well with the crew. Leave the Spot Locator on and in a relatively open area for a minimum of 30 minutes to ensure that the message has been sent. Each crew is required to send the OK message via the Spot Locator every evening while camping in the backcountry, even if two crews are camping together at one campsite.

There is no good way to determine if the Spot Locator has sent the OK message. When you turn the unit on, the green light above the ON/OFF button flashes every 3 seconds (Figure 2A). When you engage the OK message to send, the green lights above the ON/OFF button and above the OK button both flash at the same time every three seconds (Figure 2B). When the Spot Locator is engaging with satellites and sending the message, there is an alternate light flashing pattern between the ON/OFF and OK lights for a brief period, after which it goes back to the green lights above the ON/OFF button and above the OK button both flashing at the same time every three seconds. It is not in your best interest to stare at the Spot Locator to watch for this temporary change in light flashing pattern. We will assume that if the unit is left in an open area for approximately 30 minutes, the OK message will be sent out. Each time a message is sent using the Spot Locators, the UTM coordinates are also sent.

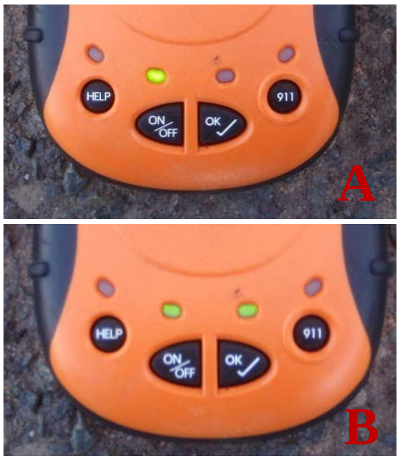

Figure 2. Light patterns on Spot Locator.

If the crew is in danger or a crew member has been injured, turn the Spot Locator on and press the HELP button. This will send a "please come help us" message to the pre-programmed cell phone number. If you are in circumstances dire enough to send out a help request, you should also be on the park radio requesting help from a ranger or other park staff. This would be an appropriate time to use the satellite phone to call the GLKN contact person and inform them of the specific circumstances, and to call headquarters at the park you are working in if you cannot reach anyone by radio.

If you have a life threatening emergency, turn the Spot Locator on and press the 911 button. This sends out an urgent message to the pre-programmed cell phone number, as well as to emergency responders in the vicinity of your location. Only use this feature in extreme emergencies, as a search and rescue team will be sent out to find you. For backcountry work in areas with poor radio contact (e.g., ISRO, VOYA), it is recommended that the crew carry the Spot Locator during the day in case of emergencies or debilitating injuries.

If the GLKN contact person does not receive a message from you on a given evening, they will contact park headquarters first thing in the morning (Table 1). Headquarters may have to transfer them to dispatch or the appropriate person to talk to. Park headquarters will then radio the crew to make sure you are OK. If park headquarters cannot get through to you by radio by mid-day, they will initiate a search and rescue. To avoid this, it is very important to use the Spot Locators according to protocol and keep your park radio turned on and with you at all times, or during GLKN vegetation monitoring crew designated radio hours. If park headquarters does successfully reach you, they will inform the GLKN contact person by phone. If you are pulled from the backcountry early, for example, bad weather is coming in so the boat operator picks you up a day before the scheduled pick-up in the trip plan, it is imperative that you still send the Spot Locator message. Your supervisor in Ashland will not necessarily be informed of the change in the trip plan and will initiate the search and rescue if your Spot Locator message is not received.

Table 1. Contact phone numbers for the Network parks.

Park	Headquarters	Emergency numbers
APIS	715-779-3397 x122 (dispatch)	Bayfield Co. Dispatch 715-373-6120
GRPO	218-475-0123	Chief Ranger 218-475-0123
INDU	219-395-1008 (dispatch)	Chief Ranger 219-395-1653
ISRO	906-482-0984	Mott HQ 906-337-4986, Chief Ranger 906-483-7148
MISS	651-290-4160	Dispatch 651-290-3030 x0
PIRO	906-387-2607	Alger Co. Dispatch 906-387-2607, Emergencies 906-387-4444
SACN	715-483-3284	
SLBE	231-326-5134 x700	
VOYA	218-283-6652 (dispatch)	Koochiching Co. Dispatch 218-283-4416

The NPS Ranger Emergency Service number through INDU is 800-727-5847. This is a 24-hour dispatch that serves INDU, as well as APIS during non-business hours. There is also a 24-hour dispatch at Cuyahoga Valley National Park (CUVA) which is used by ISRO and VOYA. This number is 440-546-5945.

SOP 3, Appendix A: Job Hazard Analysis Forms

The job hazard analyses for plot sampling vary by park. As a result, there are six versions used by the vegetation monitoring program. Here we present the most inclusive JHA. During training, the seasonal employees will actually be presented with the correct version for the park where they will be working. Here, we also present the JHA for canoe use.

JOB HAZARD ANALYSIS (JHA)

JOB HAZARD ANALYSIS (JHA)		Date: July 23, 2012	☐ New JHA ■ Revised JHA
Park Unit: GRPO, MISS, PIRO, SACN, VOYA	Division: Inventory and Monitoring	Branch: Great Lakes Network	Location:
TASK TITLE: Canoe Transport and Operation		JHA Number: Veg 7	Page ___1___of ___4___
Job Performed By: GLKN field crew, Botanist, Terrestrial Ecologist	Analysis By: Suzanne Sanders and Ted Gostomski	Supervisor: Bill Route	Approved By: Bill Route

Required Standards and General Notes:	
Required Training:	Canoe transportation training provided by the Botanist and Terrestrial Ecologist or outside contractor
Required Personal Protective Equipment:	Hiking boots, long pants
Tools and Equipment:	Cam-lock straps, canoe trailer

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Canoe transport.	Attaching canoe trailer to vehicle	Attach the trailer to the vehicle using the following steps: 1) Back up the vehicle so that the ball of the trailer hitch is approximately 30 cm from the hitch attachment point of the trailer. 2) Pull the trailer to the hitch and lower it firmly down over top of the ball of the hitch. 3) Fully retract the jack and rotate it 90°, securing it in its trailering (rather than unattached, storage) position. 4) Plug the electrical connection cord into the outlet on the vehicle. 5) Secure the safety chains to the vehicle by running each of them below the hitch and attaching them to the vehicle on the opposite side of their attachment point on the trailer. 6) With one person in the vehicle driver’s seat and one behind the trailer, check the brake lights and both turn signals of the trailer to ensure they are in working order.

JHA - CONTINUATION SHEET	JHA Number: Veg 7	Page __2__of __4__
Sequence of Job Steps	**Potential Hazards**	**Safe Action or Procedure**
See page 1.	Attaching canoe to trailer	Attach the canoe to the trailer using cam-lock straps via the following steps: 1) While the canoe rests on a pair of horizontal supports of the canoe rack, lay the first strap over the canoe so that the free (non-buckle) end extends over the top of the canoe and hangs freely over the far side, while the buckle end hangs freely over the near side. The buckle should be approximately six centimeters above the gunwale of the canoe. 2) Feed the free end of the strap underneath the horizontal support of the rack on the far side of the canoe, then back up and over the top, allowing the free end to now hang loose on the near side of the canoe. 3) Feed the free end of the strap underneath the horizontal support on the near side of the canoe, and through the buckle. 4) Tighten the buckle by pulling down on the strap. 5) Repeat this procedure on the second horizontal support. 6) Wrap extra strap around horizontal support bar securely so it will not come loose while the vehicle is underway. NEVER ATTACH A CANOE THAT REQUIRES PULLING UP ON A STRAP. If this occurs, remove the strap and re-secure the canoe correctly.
	Loading and attaching canoe into and on motor boat	This will vary depending on the motor boat used, whether or not a canoe rack is present, and on water conditions. If a rack is present, the canoe should be attached in the same manner as it is attached to the trailer. If not, defer to the discretion of the motor boat operator for direction.
	Logistical challenges of vehicle shuttle	Canoe shuttles should all start and end at official water access areas (put-ins). Secure the motor vehicle by making sure all doors are locked. Prior to beginning canoe trips, ensure that all appropriate parties have all needed keys for the vehicle they will be accessing at their designated takeout.

JHA - CONTINUATION SHEET	JHA Number: Veg 7	Page __3__of __4__

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
Canoe operation	Swift current	Crew members should strive to keep the canoe pointed downriver. Recognize the fact that the distance to get from the center of the river to the edge will be greater when the river is faster. Crew members should account for this, and allow plenty of time to exit. No crew members should operate a canoe when the park is under a high water caution advisory.
	Rapids	Canoeists should scout any major rapids that they hear, and portage around any rapids they are not comfortable paddling.
	Obstacles in the river	The canoeist in front must alert the person in the rear (who is steering) of any obstacles to be avoided.
	Fog, lightning, and extreme weather.	Do not canoe during an electrical storm. If a storm begins during the course of canoe use, exit the river immediately and seek the best shelter available in the area. This may include assuming the lightning position within a wooded area. Canoe operation during high winds, fog, and other extreme weather will be left to the discretion of the canoe operators, as the severity of these events vary tremendously, as do the river conditions, and paddler's ability. If both (or all three) canoeists do not agree on a course of action, crew members will make the most cautious choice for the situation (i.e., not getting on the water, or immediately exiting the river).
	Flipping a canoe	The conditions under which a canoe may flip are highly variable; as such, it is not possible to describe every ideal course of action under every possible scenario. In general, canoeists should undertake the following steps: 1) Ensure that you, personally, are all right, and ascertain the condition of the other canoeist(s). 2) Grab onto the canoe and paddles, so that they are not lost downriver; this will also lessen the likelihood of the canoe slamming into you uncontrollably. 3) Once the first two steps are accomplished, secure the cargo, right the canoe, and pull it to the shore. The order of these last three steps will vary depending on the river conditions, the nature of the flip, and the abilities and conditions of the canoeists.

JHA - CONTINUATION SHEET	JHA Number: Veg 7	Page __4__of ___4___

Text Description of Task When it is Done Safely

The field crews will canoe to the most practical access point, bushwhack to the plot, sample the plot, return to the canoe, and either to the take-out or the campsite for the evening. The canoe distances may be anywhere from <1 km to over 10 km. All canoe operators will wear appropriately fitting Type III personal flotation devices (PFDs) at all times when the canoe is on the water. PFDs will be provided by the Network.

Authorized Employee Information

Employee ID	Last Name	First Name	Qualifications/Remarks

JOB HAZARD ANALYSIS (JHA)

JOB HAZARD ANALYSIS (JHA)		Date: July 23, 2012	☐ New JHA ■ Revised JHA
Park Unit: APIS, ISRO, VOYA	Division: Inventory and Monitoring	Branch: Great Lakes Network	Location:
TASK TITLE: Plot sampling		JHA Number: Veg 1	Page 1 of 4
Job Performed By: GLKN field crew, Botanist, Terrestrial Ecologist	Analysis By: Suzanne Sanders, Jessica Grochowski, and Ted Gostomski	Supervisor: Bill Route	Approved By: Bill Route

Required Standards and General Notes:	
Required Training:	Standard early season plot sampling training
Required Personal Protective Equipment:	Hiking boots, long pants
Tools and Equipment:	Maps, compass, Garmin GPS, Trimble GPS, sonar distance measurers, diameter tapes, meter tapes, quadrat, ruler, calipers.

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
This job involves three tasks: 1) hiking to the plot, 2) establishing the plot, and 3) sampling the plot. Because the potential hazards for all three tasks are the same, we are only listing them once, here.	Deer ticks and wood ticks	Wear long pants and hiking boots at all times. Consider wearing a long-sleeved shirt, gloves, and gaiters. Perform tick checks nightly, being especially diligent about looking for deer ticks. Consider using a repellant containing permethrin.
	Stinging insects	Be conscientious about bee and wasp hives, especially on the ground. Be aware of your reaction to stings and, if needed carry an EpiPen®. If allergic, make your coworkers aware of your allergies and where you keep your EpiPen®. Benadryl® is available from the first aid kits and can be taken if there is a mild reaction.
	Poisonous plants	Know the appearance of all poisonous plants including both species of poison ivy, woodland nettle, stinging nettle, and wild parsnip. Be mindful of your personal reaction to these species and the level of contact you may tolerate. Wash with a mild soap and water as soon as possible following exposure. Tecnu® wash is provided and can be used as well.

JHA - CONTINUATION SHEET	JHA Number: Veg 1	Page __2__of __4__

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
See page 1.	Uneven ground (often hidden by leaves and twigs)	Be aware of the microtopography beneath the litter layer. If you are prone to ankle sprains, consider moving more slowly through the woods, and maintain awareness about foot placement and weight bearing as you walk.
	Snags	Be aware that many standing trees are dead and, as such, are not stable. When climbing uphill, check to make sure a tree has leaves before grabbing onto it for support. Similarly, check for leaves before leaning onto any tree at any time. If you lean on a tree and it starts to fall, yell out loudly and immediately to the crew that a tree is falling.
	Twigs and branches at eye level	Crew members and permanent staff should consider wearing eyewear, either in the form of standard prescription eyeglasses, sunglasses, disposable protective glasses, or customized safety eyeglasses. When bushwhacking, maintain enough distance from the person ahead of you so that the branches pushed aside from their movement will not strike you.
	Working a great distance from a water source	Crew members should be aware of the distance needed to travel by foot to plots, as well as the weather for the day. Typically, crew members should carry at least three liters of water on days when both the temperature and distance will be great. Crew members should also note the presence/location of natural water bodies in relation to the plot and carry a filter as a precaution against running out of water on especially challenging days.
	Working in extreme heat (while wearing multiple layers of clothing to protect from the elements)	Supervisors and crew members need to be aware of the absolute and apparent temperature, and be cognizant that physical work is being conducted wearing a large amount of clothing. The crew will take regular breaks to rest and re-hydrate. All field workers should monitor one another for early signs of heat exhaustion. These include failure to carry out or comprehend basic tasks as well as speaking in sentences which do not fully make sense. When especially high temperatures and/or humidity create dangerous working conditions, supervisors have the discretion to cancel field work and perform office work inside.

JHA - CONTINUATION SHEET	JHA Number: Veg 1	Page __3__of __4__

Sequence of Job Steps	Potential Hazards	Safe Action or Procedure
See page 1.	Accessing the shore when the motorboat cannot	Wear water-ready shoes (e.g. Tevas) and roll pants up when accessing shore. Slowly sink into the water from the boat, without the backpack. Have someone on the boat hand your pack to you. Be cognizant of a slick subsurface and the potential for submerged logs and other debris. Make sure feet and ankles are fully dried before putting socks and hiking boots back on to reduce the likelihood of blister formation.
	Cold weather	All crew members should be aware of the forecasted low temperatures. Hats, gloves/mittens, long underwear, and a coat or heavier-weight jacket are strongly recommended, especially when camping in the backcountry. Wearing multiple layers of clothing is also beneficial as layers can be removed when temperatures rise.
	Hiking for long periods and/or with heavy backpacks	Crew members should be aware of how to properly load and adjust backpacks. They should also be cognizant of what food and containers they choose to carry when in the backcountry. This is especially true when gear is carried to the campsite via a backpack. Cans and jars should be avoided, while dehydrated food is preferred.
	Lightning and extreme weather	Where there is cell phone service, all crews should carry cell phones, programmed to receive National Weather Service severe weather alerts. Where there is no cell service, crews should listen to the weather on the hand-held radios. If the situation and time permit, crews should return to vehicles and other shelter in the event of a tornado or severe thunderstorm warning. Otherwise, crews should seek the best shelter possible at the field site. This includes assuming the lightning position, in the event of an electrical storm. All crew members should carry full body raingear with them at all times. This raingear should be waterproof, yet breathable.

JHA - CONTINUATION SHEET	JHA Number: Veg 1	Page __4__of ___4___

Text Description of Task When it is Done Safely
The field crews will hike to the plot. This will require the use of maps, a compass, and both the Garmin recreational grade GPS and a Trimble mapping grade GPS. Hiking to the plot will likely involve a combination of trail hiking and bushwhacking and may be anywhere between <100 meters to over five miles. Crew members will then establish the plot. This will require the use of meter tapes, diameter tapes, sonar distance measurers, compasses, and GPSs. Once the plot is established, it may be sampled. This requires diameter tapes, 1 m quadrats, rulers, and calipers. Once sampled, the field equipment is collected and put away, and crews will hike back from the plot.

Authorized Employee Information

Employee ID	Last Name	First Name	Qualifications/Remarks

Appendix B: Medical information form

Name

Date of birth

Local mailing address

Local phone number

Cell phone number

Emergency contact information #1

Relationshp:

Emergency contact information #2

Relationship:

Allergies and medical issues of concern

Medications currently being taken

☐ Check here and provide additional information on the back or on attached sheets if there are other issues you feel emergency personnel need to know to properly care for you in an emergency.

☐ By checking this box and signing below, the employee indicates their preference to **not share** personal medical information with the National Park Service, Great Lakes Network Office. The employee understands that his/her refusal may delay or hinder necessary care if he/she has an undisclosed underlying medical condition or drug allergy. The employee is free to change their mind at any time and submit a completed form.

____

Employee

Completion of this form is voluntary and does not influence any hiring decision or performance evaluation. It is strictly to be used in case of an emergency when the person named above is unable to provide such information to emergency personnel. This form will be kept in a locked file at the Network office and will be destroyed by the employee at the end of their term of employment.

SOP 4: Using the Global Positioning System

Version 2.0 (6/1/12)

Mark Hart, Ulf Gafvert, David VanderMeulen, Jessica Grochowski and Suzanne Sanders
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Details on the use of the Trimble were added, as was detail about new software. A great deal of extraneous material was deleted.	The technology in this field changes quickly, and this needed to be spelled out.	1.1
1.1	8/15/13	Suzanne Sanders and Jessica Grochowski	Downloading instructions were revised to reflect use with the GeoExplorer 6000 units.	Necessary to stay current	2.0

4.0 Introduction

This Standard Operating Procedure (SOP) provides guidance on the common operations associated with global positioning system (GPS) units. The term GPS unit is used in this SOP in reference to units on the United States Global Positioning System (US GPS) satellite constellation, and to units on the Global Navigation Satellite System (GNSS) satellite constellation. This SOP includes guidance for loading predetermined site locations, data dictionaries, and maps. In addition, it also covers GPS standards to be met by GLKN. Appendix A contains instructions for GPS use in the field and for post-collection processing (downloading and differential correction) of data.

Two GPS systems are currently used by the Great Lakes vegetation monitoring program. Mapping-grade Trimble GeoXT units are used to record the location of all six transect endpoints. Recreation-grade Garmin 76CSx units are used, in conjunction with maps, for navigation.

As of 2013, software pertinent to the use of these GPS units includes:

- TerraSync (Trimble GeoXT) – single table forms software
- Windows Mobile Device Center – for connecting to Trimble GPS units
- GPS Pathfinder Office 5.x (Trimble GeoXT) – desktop GPS processing software
- ESRI ArcGIS 10.x (Trimble GeoXT or Garmin 76CSx) – desktop GIS software
- DNR GPS 6.x – for connecting the Garmin 76CSx units to the computer, and to perform uploads to and downloads from the Garmin units.

Due to the rapid development of commercial software and hardware capabilities, it is likely that other GPS units or software will be used in the future. Therefore, this SOP will be updated periodically as new hardware and software become available.

4.1 Using Mapping-Grade GPS Units

"Mapping-grade" refers to the GPS unit's sub-meter accuracy. All mapping-grade GPS users should become familiar with the general unit functions and collection procedures. Program supervisors should also go over the unit's supporting documentation with all users. This includes GeoExplorer CE Series: Getting Started Guide, GPS Mapping for GIS with TerraSync and GeoExplorer CE Series, Basic GPS Data Capture Using TerraSync: A Quick Start Guide.

Pre-season Use

The Botanist or GLKN Data Manager should prepare the Trimble GeoXT GPS units ("Trimbles") by loading park topographic maps, park plot waypoints, and data dictionaries onto the units. Site maps are 7.5 minute USGS topographic ("topo") quads available on the GLKN server. If possible, aerial photography is also loaded onto the units, although the availability of this imagery varies by park. Data dictionaries are used to store attribute information associated with the six transect endpoints. The data dictionary specific to each of the nine parks is developed using Pathfinder Office and is updated regularly by the Botanist or GLKN Data Manager. This file is then then uploaded onto the Trimble unit which contains TerraSync software.

Once the plot locations have been selected for a given season, these are loaded onto the Trimble GeoXT units. The plot location shapefile is added as a background file. This shapefile is also converted into a waypoint file using Pathfinder Office, which is then uploaded to the Trimble.

Field Use

The Trimbles are used to collect the six transect endpoints at each plot. Because endpoint data collection is nearly always under a canopy, acquiring satellite signals can be difficult. It is important to understand the Trimble settings, so that one can know how to best remedy the situation. Table 1 lists multiple settings and includes the definition and the standard setting. Step-by-step field instructions are presented in Appendix A of this SOP.

Once all six endpoints have been collected, view the map to look at their positions relative to one another. The six points should form a reasonably close approximation to a rectangle. Occasionally one or two endpoints will deviate significantly from their obvious expected location. When this occurs, return to locations of the questionable endpoints and recollect the GPS waypoints.

Positional accuracy of GPS data can be affected by several factors that can be monitored and recorded with mapping-grade GPS units. Table 1 lists these factors, their definitions, and the standard settings for GLKN field work. All spatial data collected shall be analyzed for spatial accuracy and shall meet or exceed the National Map Accuracy Standards (http://mapping.usgs.gov/standards).

Table 1. GPS receiver settings, definitions, and standards for use at GLKN parks.

Setting Name	Definition	GLKN Setting Standard
Almanac	File containing estimated position of satellites, time corrections, and atmospheric delay parameters	Acquired automatically by GPS unit or from online sources within 10 days prior to GPS field work
Altitude reference	Ellipsoid model	Height above Ellipsoid (HAE) (preferred) or Mean Sea Level: if MSL is used, indicate Geoid Model
Antenna height	GPS antenna height above the ground	Variable, usually 1.0 meters for handheld and 1.5 m for backpack
Datum	Geodetic model designed to fit a point on the earth's surface to an ellipsoid	NAD 83 (CONUS) [preferred] WGS 84 [GPS default, as fallback]
Elevation mask	The minimum angle above the horizon at which a GPS receiver will track a satellite	15 degrees
Feature types	Geometry of spatial data	GIS native formats; point, line and polygon are preferred
Logging interval	Time interval between the recording of individual GPS fixes	Points: 1 second
Minimum fixes for point positions	Number of GPS fixes that are used to calculate a single position for a point feature	60 fixes
Mode	2 dimensional for horizontal positions and 3 dimension with an elevation position	3-dimensional (4 satellite minimum)
PDOP mask	Positional Dilution of Precision, a GPS quality estimate based on satellite geometry	The target is 6.0 or less
Real-time settings	GPS unit may be capable of performing differential correction of data during collection	Select Integrated WAAS; setting will be 'auto' or 'on'
Satellite vehicles	Number of satellites used for position fixes	4 minimum
SNR mask	Signal-to-Noise ratio is a measure of the satellite signal relative to background noise	4.0 minimum, 6.0 or greater preferred
Unit of measure	Linear unit of measure	Meter (metric)

GPS units on the US GPS satellite constellation receive signals in the WGS84 datum. GPS units on the GNSS satellite constellation receive signals in NAD83 (CONUS). Processing and transformation of the positional information to other datums can take place internally in the GPS unit or in software—either the GPS data processing software (see below) or in GIS software. GPS data that will receive no post-processing differential correction can be collected in native WGS84 or NAD83 (CONUS), ensuring that the datum used is recorded in the metadata. Depending on the mapping grade receiver used, the GPS data may be differentially corrected after collection using data from one or more reference base stations. The majority of public base stations in the U.S. are part of the National Geodetic Survey's Continuously Operating Reference Station (CORS) network, and output information in the NAD83 datum. Setting the GPS unit on the GNSS satellite constellation to record data in NAD83 CONUS datum will result in the most accurate spatial information when differentially corrected against a CORS base station.

GPS units create files to store data during a field session using a prefix and date-time stamp as file names. Consider the following file name example:

RMMDDHHx

R – Unit Prefix
MM – Month
DD – Day
HH – Hour
X – a, b, c, etc., the order files are created within an hour

If multiple GPS units are used for a project, a unique prefix (letter) should be assigned to each unit, which will ensure that downloaded files for each unit contain a unique identifier within the filename. For example, with four GPS units for the GLKN vegetation monitoring, the unique letters for the units are Y, R, P, and G (representing the colored label on each respective unit of yellow, red, purple, and green). Those letters serve as a prefix for the file name (e.g., Y102715A, G102715A, and R102715A would indicate units Y, G, and R, October 27, 15 hour, A first in hour).

Each user should be familiar with the capabilities of the GPS hardware and field computers. Vegetation monitoring biological technicians should receive hands-on instruction from the Botanist or Ecologist. A Trimble user guide specific to the vegetation monitoring program will be updated regularly and provided to each biological technician.

It is extremely important that each user become familiar with the battery power and memory capabilities of the GPS units. All units have limited battery and memory resources; these features should be thoroughly tested to gain an understanding of the power and memory limitations of the GPS units before being deployed in the field. It is possible to power or recharge these units from a DC power source, such as a vehicle power outlet.

Data Processing

When data collection is complete for the day or sampling hitch, data are downloaded from the GPS unit to a computer. For Trimble GPS units, the proprietary software GPS Pathfinder Office (or the GPS Analyst extension) is used to download, differentially correct, and then export the data to a GIS format. [Note: Trimble Pathfinder Office and GPS Analyst are relatively expensive. However, Trimble also offers a free data transfer utility to download data from the GPS units to a Windows-based PC]. Detailed instructions are provided in Appendix A of this SOP. Differential correction is a post-processing procedure to improve upon raw GPS positions using base station data. Base stations consist of a GPS antenna and receiver positioned at a known location specifically to collect data from satellites. The distance between the base station(s) and the remote GPS receiver should be kept to a minimum.

Differential correction should be conducted on most GPS data collected, even if data were collected using the real-time collection feature. Once the data are differentially corrected, they can be verified and edited. Unintentional features can be deleted and attributes can be reviewed. Differential correction of the GNSS satellite constellation is becoming available in North America through state DOT CORS stations. The availability of these DOT CORS stations will be determined by the GIS manager, and the appropriate files will be downloaded for differential correction of units collecting on the GNSS constellation.

The last step in processing data is exporting the dataset to GIS (such as ArcMap). Depending on the software used for this process, newly created files generated when exporting data are often assigned generic names. For example, if Pathfinder Office is used to export a file named 'VOYA2007.cor' (.cor denotes that the file has already been differentially corrected) that only contains point features, the exported file will be named 'point_ge.shp'. Great care should be taken to not overwrite this file when exporting other data, as the software will continue to use this generic naming convention the next time it is used. In addition, during the export process, the coordinate system to which the data will be exported to should be verified (Table 2).

Managing the incoming GPS data can be a challenge, especially if there are multiple units per project. Common practices used by GLKN include:

- Download all data to a computer or network drive that is regularly backed up.
- Keep GPS data and GIS data separate through electronic file management.
- Directories and files names should not contain non-alpha-numeric characters and/or spaces (except underscores).
- Keep GPS data in well-organized directories (see Hart and Gafvert 2005 for more details).

Table 2. UTM zones for Great Lakes Network parks.

Park	UTM Zone
APIS	15
GRPO	16
INDU	16
ISRO	16
MISS	15
PIRO	16
SACN	15
SLBE	16
VOYA	15

Additional data attributes can be included in the data exports. Data attributes recommended by GLKN are listed in Table 3.

Table 3. Recommended fields to be exported in addition to GPS features.

All features	Point features	Line features	Area features
PDOP	Height	Length (2D)	Area (2D)
Correction status	Position	Length (3D)	Perimeter (2D)
Receiver type			Perimeter (3D)
Date recorded			
Data file name			
Total positions			
Data dictionary name			

At the end of a project, all data and background files should be removed from the GPS unit to free available memory. Data files should not be left on a unit if they have been properly downloaded and verified. In addition, some GPS units require their batteries to be re-charged periodically. Failure to do so can cause the GPS unit batteries to discharge completely, and may cause some files and software to be deleted. Additional information can be found at **http://www.nps.gov/gis/gps/gps4gis/**, which describes the steps outlined here in greater detail.

4.3 Using Recreational-Grade GPS Units

Recreational-grade GPS units are the primary tool for navigation. Recreational-grade GPS units can also be used to acquire location information when there are problems with the mapping grade GPS units. Recreational GPS units do not have data dictionaries for storing attribute information with the point location. However, using a recreational-grade unit to record transect endpoints at each site is a reliable alternative when mapping-grade units cannot be used.

As with mapping-grade GPS units, personnel that employ recreational-grade GPS units should become familiar with GLKN GPS collection procedures and relevant manufacturer's user guides and operating manuals before GPS operation. For example, prior to using a Garmin 76CSx (recreational-grade) GPS unit, the following documents should be reviewed:

- GPSMAP 76CSx Quick Start Guide
- GPSMAP 76CSx Owner's Manual and Reference Guide
- Garmin MapSource™ User's Manual and Reference Guide

Planning

The monitoring sites must be loaded onto the GPS unit before departure to the field. In addition, topographic maps and other GIS layers (e.g., roads, campsites, rivermiles, etc.) which can aid in navigation should also be loaded beforehand.

Data Collection

Location data are captured by recreational-grade GPS units as *waypoints*. When taking a waypoint, enter the site ID or site designation in the text field provided. This ID should be consistent with the naming convention used in the data dictionaries. For example, transect endpoint 5 of plot 7045 will be labeled as "7045-5".

Data Processing
Data should be downloaded from GPS units after a sampling trip, or after each field season. The DNR GPS freeware product: (http://www.dnr.state.mn.us/mis/gis/DNRGPS/DNRGPS.html) can be used to download data from Garmin GPS units. Data should be downloaded both as a text file and a shapefile. Each file name should include the download date. Points should be checked for reasonable spatial accuracy and errors. Subsequent downloads should be error-checked in the same manner. When data collection is finished, all files should be compiled into one spatial file, and along with the raw downloads, should be saved to the appropriate location on Great Lakes Network servers.

4.4 Metadata
Regardless of the type of GPS unit used to collect data, all resulting GIS datasets need to have information documenting how the GPS data were collected. NPS requires that FGDC (Federal Geographic Data Committee, www.fgdc.gov/index.html) compliant metadata be written for all geospatial layers created (Executive Order 12906). Until final FGDC metadata is written, the data collection and management process is incomplete. Tracking GPS projects depends on the complexity of the project, how many participants, length of project, etc. Documentation can be a simple ‘readme’ text file, or a detailed daily log.

The Great Lakes Network recommends formal metadata be written by the data collectors, as they are the ones familiar with the project and resulting data. However, Network data management and GIS staff are usually the ones documenting someone else’s work. Chapter 7 of the GLKN Data Management Plan (Hart and Gafvert 2005) includes a detailed discussion of metadata procedures. At a minimum, the following details should be documented to facilitate final FGDC metadata:

- Name of project
- Name(s) of data collectors
- EHE/EPE or maximum PDOP (using four satellites)
- Coordinate system (projection, datum, and zone)
- Type (or types) of GPS units used
- The range of field collection dates
- Name of base station(s) used for differential correction
- Name and version of software used for downloading
- Any major editing performed on the raw data (e.g., moving of points)
- All versions of data dictionaries used

4.5 QA/QC
Long-term monitoring is only useful if users have confidence in the data. Efforts to detect trends and patterns in ecosystem processes require high-quality, well-documented data that minimize error and bias. Data of inconsistent or poor quality can result in loss of sensitivity and lead to incorrect interpretations and conclusions.

NPS Director’s Order #11B: Ensuring Quality of Information Disseminated by the National Park Service (www.nps.gov/policy/DOrders/11B-final.htm) specifies that information produced by the NPS must be of the highest quality and based on reliable data sources that are accurate, timely, and representative of the most current information available. Therefore, GLKN will establish and document procedures for quality assurance (QA) and quality control (QC) to identify and reduce the frequency and significance of errors at all stages in the data life cycle. Under these procedures, the progression from raw data to verified data to validated data implies increasing confidence in the quality of those data. Quality assurance and quality control procedures will document internal and external review processes and include guidance for addressing problems with data quality.

Examples of QA/QC practices pertaining to use of GPS include:

- Ensure that GPS-related software is periodically updated as it becomes available and has been tested.
- Check to see if the accuracy of the GPS unit meets or exceeds the National Map Accuracy Standards.
- Ensure that the appropriate coordinate system is used when collecting and exporting data.
- Use mapping software (e.g., Pathfinder Office or ArcGIS 10.x) to view features (or waypoints) overlaid on a geo-referenced air photo or topographical map to check for accuracy.
- If applicable, check the accuracy of the attribute(s) recorded on a GPS unit by using mapping software and look-up tables or in spreadsheets generated after post-processing is complete.

4.6 Literature Cited

Hart, M., and U. Gafvert. Editors, 2005. Data management plan: Great Lakes Inventory and Monitoring Network. GLKN/2005/20. National Park Service, Great Lakes Network Office, Ashland, Wisconsin.

SOP 4, Appendix A: Download and Differential Correction of GPS Data

Overview

This document covers equipment and procedures specific to collecting location information with sub-meter accuracy. This SOP is specific to the Trimble GeoXT unit; subsequent upgrades or new versions will require updating this document.

The current GPS hardware for the GLKN vegetation monitoring program consists of a Trimble GeoXT GNSS or GPS Receiver (6000 series or 2008 series, respectively) and the Geo XT internal antenna.

Post-processing (differential correction) should be performed as soon as possible after data collection. The CORS (Continuously Operating Reference Stations) base station data is usually available within a 2 hour lag time, though occasionally there are periods of time when data is not available, either due to malfunction of equipment, inadequate satellite coverage, or high ionospheric disturbance. These factors are not within the control of the field personnel collecting the data, but post-processing will uncover these problems. Any affected locations should be revisited to obtain high accuracy information.

CORS stations on the US GPS constellation maintain complete records for only 30 days, after which the data collection interval is reduced from 1, 5, or 30 second, depending on the station, to 30 minute intervals. This is done in order to save hard drive space. Differential correction files that are downloaded should be archived with the data, so that high temporal resolution base station files are available, in the event that post-processing needs to be redone on a dataset at a later time.

The state DOT CORS stations on the GNSS constellation typically have records available from the previous 60 days at a 5 second interval. These files are downloaded, based on Julian date, directly by the Botanist or GIS Specialist as RINEX files, and stored on Network servers.

Field Operations

The steps for field data collection are specific to the hardware configuration currently used by GLKN. The following settings will provide the best accuracy with the GeoXT unit. The Network will provide a standard data dictionary (.ddf file), and TerraSync configuration file (.tcf file), to ensure those settings are programmed into the unit.

In TerraSync Setup, select Logging Settings

- Measure and input precise antenna height
- Allow Position Update: Confirm
- Confirm End Feature: Yes
- Filename Prefix Y, R, P, or G, depending on unit
- Between Feature Logging Style: Time
- Between Feature Logging Interval: 1s

In TerraSync Setup, select Coordinate System

System: UTM
Zone: 15 North (for APIS, MISS, SACN, VOYA)
16 North (for GRPO, INDU, ISRO, PIRO, SLBE)
Datum: NAD 1983 (Conus)
Altitude Reference: Height Above Ellipsoid
Altitude and Coordinate Units: Meters
Display USNG: Off

In TerraSync Setup, select Real-time Settings
Use Uncorrected GNSS

Post-Processing the Data

The Network is currently using Pathfinder Office (v.5.x) for completing differential correction on the field data files. Alternatively, ArcGIS GPS Analyst (available from Trimble) may be used; GPS Analyst is an extension to ArcGIS, available from Trimble. Both software packages effectively accomplish the same task using a nearly identical interface.

Data files should be downloaded from the Trimble shortly after returning from the field. This is done using the 'Data Transfer' option under Utilities within Pathfinder, and the files are downloaded as a bundled .ssf file. The Trimble must be connected to the computer, and Windows Mobile Device Center is used to establish the communication. In Pathfinder Office, select the file, and go through the differential correction utility (Figure 2).

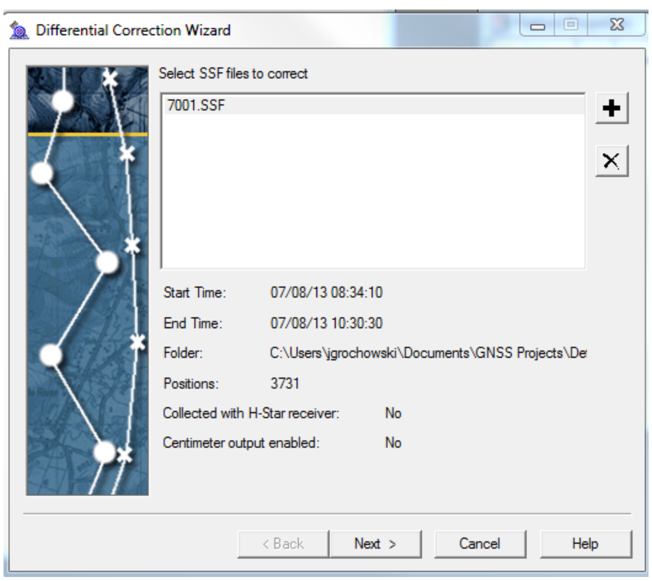

Figure 2. Differential correction wizard using Pathfinder Office.

Select the Automatic Standard Carrier and Code Processing radio button in the next dialog box.

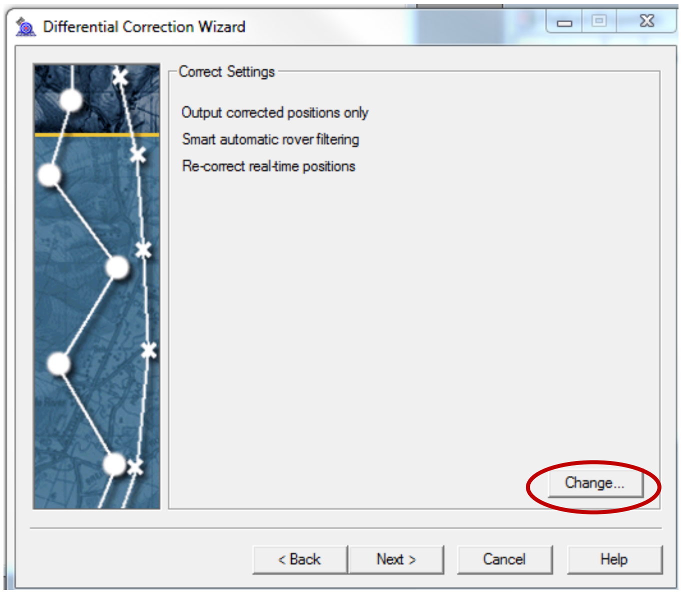

Figure 3. Correct settings in the differential correction wizard.

Be sure to select all the proper settings (Figure 3). We primarily use the default settings, but you may have to click the 'Change' button. For example, if a data file cannot be differentially corrected, you will have to change the settings to output corrected and uncorrected positions.

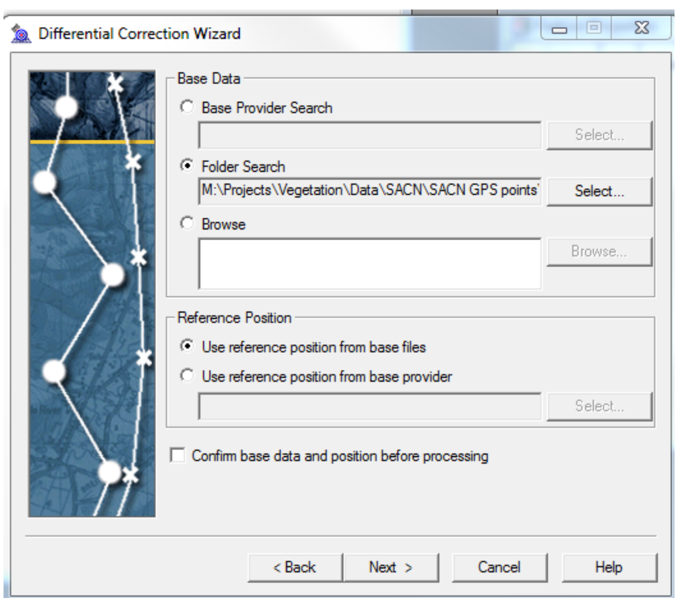

Figure 4. Select 'Use reference position from base providers' when using the US GPS satellite constellation, and select 'Use reference from base files' for the GNSS satellite constellation.

Using reference position from base providers for the US GPS satellite constellation (Trimble 2008 series) ensures that all data will be in WGS 84 datum. Trimble maintains a database in which all station locations are based on WGS84. Selecting the radio button to use reference position from base providers (Figure 4) accesses that database rather than using the data directly from base files. Also click on the 'Confirm data and position before processing' check box. This will check for any discrepancies between the base provider file in the Trimble software with the actual base station location information.

When collecting data using the GNSS satellite constellation (Trimble 6000 series), data from the state DOT CORS stations using GNSS must be downloaded to use for post-processing; save these data as zipped RINEX files. For the Reference Position, click the radio button to use reference position from base files (Figure 4). To differentially correct, you will have to select the folder location of these RINEX files in PathFinder. RINEX files downloaded from state DOT sites by the Botanist or GIS Specialist will be stored according to the following file path: M:\Projects\Vegetation\Data\PARK\PARK GPS points\PARK Downloaded and corrected points\YEAR\CORS Files

There are three files relevant to gathering information on each CORS station, and are accessible from the NGS website (http://www.ngs.noaa.gov/CORS/). These are the *data sheet*, *log file*, and *RINEX2* file. It is advisable to manually verify the location of the base station by downloading the *data sheet* from NGS.

The following example of a *data sheet file* is for Wisconsin Point 1 (WIS 1)

```
RN1701
***********************************************************************

  RN1701  DESIGNATION -  ENTRY
  RN1701  PID         -  RN1701
  RN1701  STATE/COUNTY-  WI/DOUGLAS
  RN1701  USGS QUAD   -  SUPERIOR (1994)
  RN1701
  RN1701                         *CURRENT SURVEY CONTROL
  RN1701  ___________________________________________________________________
  RN1701* NAD 83(1997)-  46 42 16.09557(N)    092 01 01.14242(W)     ADJUSTED
  RN1701* NAVD 88     -       184.850  (meters)     606.46   (feet)  ADJUSTED
  RN1701  ___________________________________________________________________
```

The *log file* provides additional information (e.g., the Point of Contact agency information).

The *RINEX2* file has information on observation frequency (1 sec, 5 sec, 30 sec), and whether single or dual frequency (L1 & L2) data are collected.

After viewing information on the stations, select the best available CORS station. Choose CORS based on closest distance to the GPS data collected, a high 'integrity index', and data collected a 1 second or 5 second frequency (rather than 30 second).

Once differential correction is complete, export the data using the Export utility in Pathfinder Office. Set the output coordinate system to UTM NAD83 CORS96, zone 15N or 16N, for the US GPS satellite constellation. If using the GNSS satellite constellation, set the output coordinate system to UTM NAD83 CONUS, zone 15N or 16N. Click on the Properties button to set the coordinate system (Figures 5 and 6, see Table 1 for UTM zones), making sure you select 'Use Export Coordinate System' and click the Change button to make any changes to system, zone, datum or units. In the Export Setup, make sure you have selected Sample ESRI Shapefile Setup.

If the user does not have Pathfinder office, there is a free data transfer utility from Trimble that will provide for bundling the raw export files from the Trimble into an ssf file, which can then be sent to the GLKN Data Manager or GIS Specialist to complete the post-processing. (Go to: http://www.trimble.com/datatransfer.shtml)

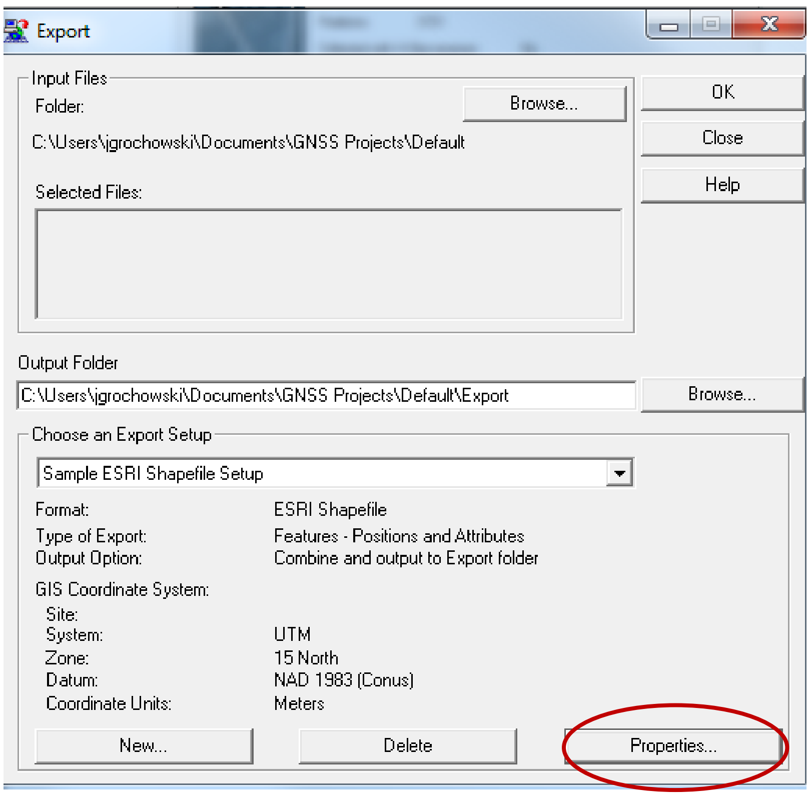

Figure 5. Export to shapefile utility in Pathfinder Office.

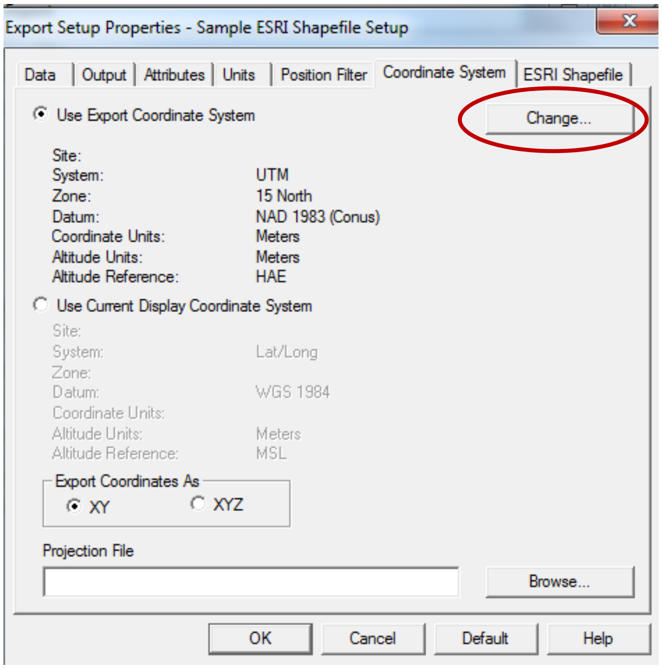

Figure 6. Changing the coordinate system.

Additionally, check that all pertinent data attributes are selected for export within the shapefile (Figure 7). This is done from the Properties tab on the Export page.

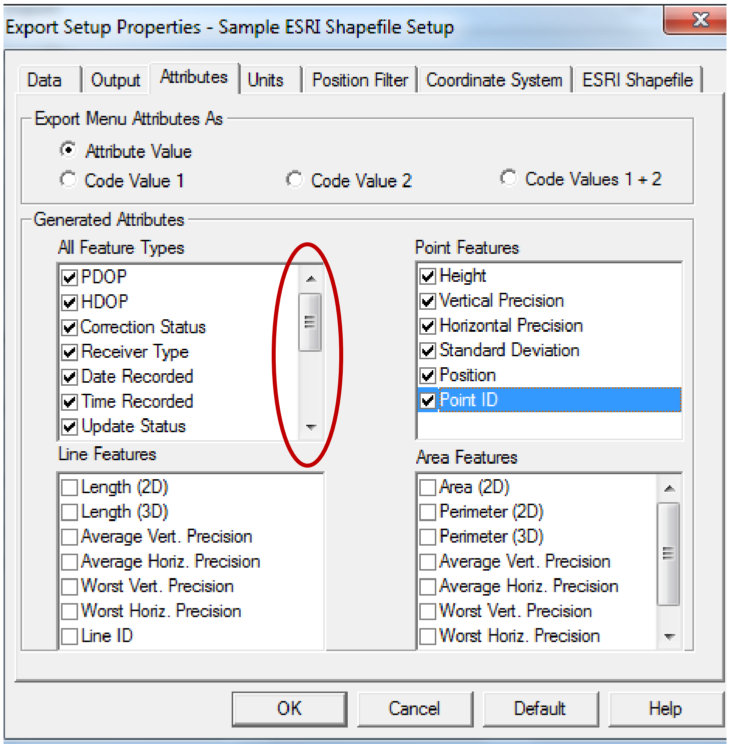

Figure 7. Ensure that all boxes above are checked when exporting corrected GPS files (note scroll bar in 'All Feature Types').

Table 1. UTM Zones for the nine GLKN parks.

Park	UTM Zone
APIS	15
GRPO	16
INDU	16
ISRO	16
MISS	15
PIRO	16
SACN	15
SLBE	16
VOYA	15

Output from Pathfinder Office is in shapefile format with a default name, but no projection information is created. The next step is to rename the file using standard naming conventions outlined in the GLKN Data Management Plan, open in ArcGIS, and use ArcToolbox to define the correct projection. In ArcToolbox, choose Data Management Tools, Projections and Transformations, then Define Projection. For the Input Dataset or Feature Class, select the file that was exported and renamed by clicking the folder icon. For Coordinate System, click on the icon, choose Projected Coordinate System, UTM, NAD83, Zone 15N or 16N (depending on the park), and then click OK. Finally, archive the output files from Pathfinder Office.

SOP 5: Plot Establishment

Version 2.0 (6/1/12)

Suzanne Sanders and Jessica Grochowski
NPS – Great Lakes Network

Sarah Johnson
University of Wisconsin-Madison

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Permanent marking details were added, and the criteria for applying declination was modified.	These changes provide greater precision for plot relocation.	1.1
1.1	5/1/13	Suzanne Sanders and Jessica Grochowski	Explanation of reestablishing an existing plot was added.	With a few exceptions, we are now only resampling existing plots, rather than adding new ones.	2.0

5.0 Introduction

Potential sampling sites were selected for all parks prior to the first round of sampling. These potential sites were generated by a computer algorithm following a generalized random-tessellation stratified design (GRTS, Stevens and Olsen 2004). This design ensures that the sampling areas are both spatially balanced throughout the sampling frame but also randomly placed. All existing, and potential sites, are limited to areas with at least 10% cover, or the potential for such. Additional plots will be established during the second sampling visit to APIS, MISS, and VOYA. Prior to beginning field work, all potential sites for new plots at these parks will be viewed using GIS by overlaying the potential plot location on aerial photography or satellite imagery. This will eliminate many sites that are not in appropriate habitat (e.g., those potential sites on beaver ponds, parking lots, or other non-forested habitats). The remaining sites will be presented to the park's natural resource manager for final comments.

All potential sites that are not eliminated by the process described above will be visited for plot establishment and data collection. While at the site, the sampling crew will perform a final check with additional criteria as outlined below.

5.1 Criteria for Accepting or Rejecting Sampling Sites in the Field

Once a potential site for a new plot is located in the field, it must be checked to ensure that the plot meets acceptable sampling criteria.

1) Within each transect, the ground must be at least 70% vegetated or potentially vegetated. For example, in many northern Network parks, there are large expanses of exposed bedrock. If any single transect is covered by >30% bedrock, the site must either be moved (see below) or abandoned, as this cover type will never be vegetated. In contrast, areas that have recently been burned or experienced a blowdown will become vegetated over time. These areas will be monitored. In addition, the plot must not have an obstacle (stream, trail) that runs the length of a transect. A transect may, however, cross one of these obstacles.

2) There must not be any obstacles that present a safety hazard to the crew. This includes, but is not limited to, steep cliffs within the transect or hornet/wasp nests directly where plot marking will be placed.

3) The plot must be fully located within National Park Service-administered lands. This is especially relevant at Saint Croix NSR, where a large number of irregularly shaped, private inholdings are interlaced with the federally-administered land on which monitoring will be conducted.

If the three criteria outlined above are not met, the plot may be moved. Movement of a plot must only be to the closest location meeting the criteria outlined above (Figure 1). No plot will be moved greater than 100 meters from the original location based on topographic maps and aerial photography. If the plot cannot be moved within 100 m and meet the desired criteria, the plot will not be established and the site will not be monitored.

While setting up the plot, if an obstacle such as a steep cliff, a pond with water more than waist-deep, or a safety hazard such as a wasp nest is encountered, a transect can be less than 50 meters long. A short transect is acceptable only if it affects a portion of the plot, and does not impede the ability of the crew to set up the remainder of the plot. If the crew has points 1, 2, 3 and 4 set up, and they encounter an obstacle or safety hazard while trying to establish point 5, the most time efficient manner of completing plot set-up is to return to point 1, and establish a point 50 meters to the north. This new point is designated as point 1, and a new point 2 can be established 50 meters east of it. What were previously points 1 and 2 will become points 3 and 4, and what were previously points 3 and 4 will become points 5 and 6.

If the field crew cannot establish the plot because of obstacles or safety hazards that were not detected before the field season using topographic maps and aerial photography, they can use their discretion to move to an area where they can establish the plot, keeping in mind to move the plot the smallest distance possible, and refraining from a biased placement of the plot.

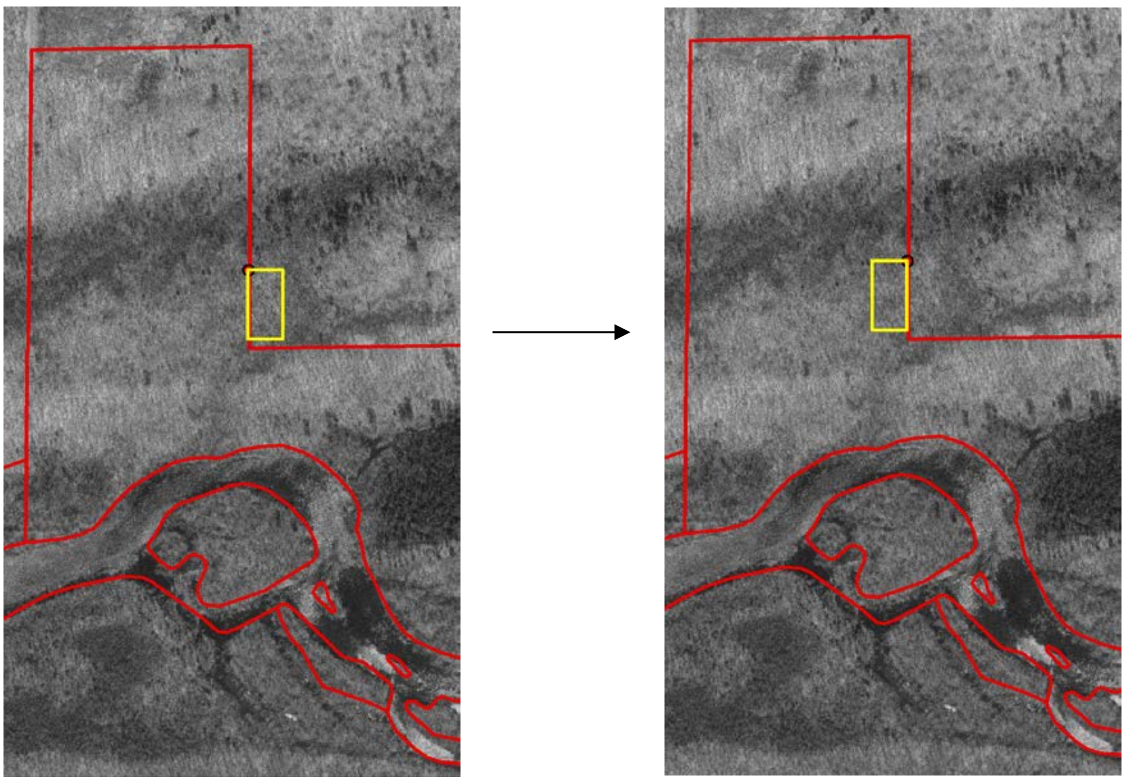

Figure 1. The red lines in the image on the left show the irregular shape of parcels of federally owned land at Saint Croix NSR. The original plot coordinates are denoted by the red dot; the yellow rectangle in the image on the left shows the original plot location. This plot will be moved 49 m due west to fit it entirely into the federally owned parcel.

5.2 Initial Plot Establishment

Sampling at Great Lakes Network parks will use the Hybrid plot (Johnson et al. 2006; see protocol narrative). Additionally, we will use true north as the reference from which all bearings are taken. We will account for declination at all parks and years where magnetic north differs from true north by 1° or more (Table 1).

Table 1. Declination for each park within the Great Lakes Network in 2013. (Source: http://www.magnetic-declination.com)

Park	Magnetic declination	Declination direction
APIS	1° 46' west	Negative
GRPO	2° 35' west	Negative
INDU	3° 60' west	Negative
ISRO	4° 2' west	Negative
MISS	0° 29' east	Positive
PIRO	5° 29' west	Negative
SACN	0° 53' west	Negative
SLBE	5° 39' west	Negative
VOYA	0° 5' east	Positive

Hybrid plots consist of three parallel 50 m transects, spaced 50 meters apart (Figure 2). The GPS coordinates of the site are the northwest corner of the plot, corresponding to endpoint 1 on transect 1.

Transect 1 is laid out using a compass along with both a tape measure and, in some instances, electronic sonar distance measurers. Sonar measurers allow one to easily delineate a straight path through shrubs and brush. Pin flags are placed along this path. A tape measure is then pulled out along the path of the pin flags. This tape measure is needed to accurately place the location of the herbaceous quadrats (Figure 2, and SOP 6). Specific instructions on this process are presented below.

Typically Person 1 will walk out a distance at a bearing of approximately 90°, while Person 2 (at transect endpoint 1) directs Person 1 exactly to the correct bearing (90°) using a compass. The distance that Person 1 walks will depend on the thickness of the brush. In more open plots, Person 1 may walk as far as about 25 meters, while in brushy plots, Person 1 may walk out less than 10 meters. A pin flag is placed in the ground at the correct bearing (90°) and the horizontal distance is recorded. Person 2 then pulls the measuring tape to the pin flag, ensuring that it is completely straight, and that it is as close to the ground as possible. Person 2 then walks out again, and this process is repeated until the entire 50 meter transect is laid out, and transect endpoint 2 is established. Transect endpoint 3 is established by following this same procedure from transect endpoint 1, with two exceptions. The bearing followed for establishing transect endpoint 3 is 180°, instead of 90°. In addition, there is no tape measure laid out. A sonar distance measurer is used to measure the distance between endpoints 1 and 3. Pin flags are still placed between transect endpoints 1 and 3 to aid in orientation when working in the plot. Following the establishment of transect endpoint 3, transect 2 and endpoint 4 are established in the same manner as transect 1 and endpoint 2. Transect endpoint 5 is established in the same manner as transect endpoint 3. Finally, transect 3 and endpoint 6 are established in the same manner as transect 1 and endpoint 2 (Figure 2). It is important to note that all transects are based on horizontal distances. GPS coordinates of all six transect endpoints are collected.

At the completion of sampling, all pin flags are pulled up.

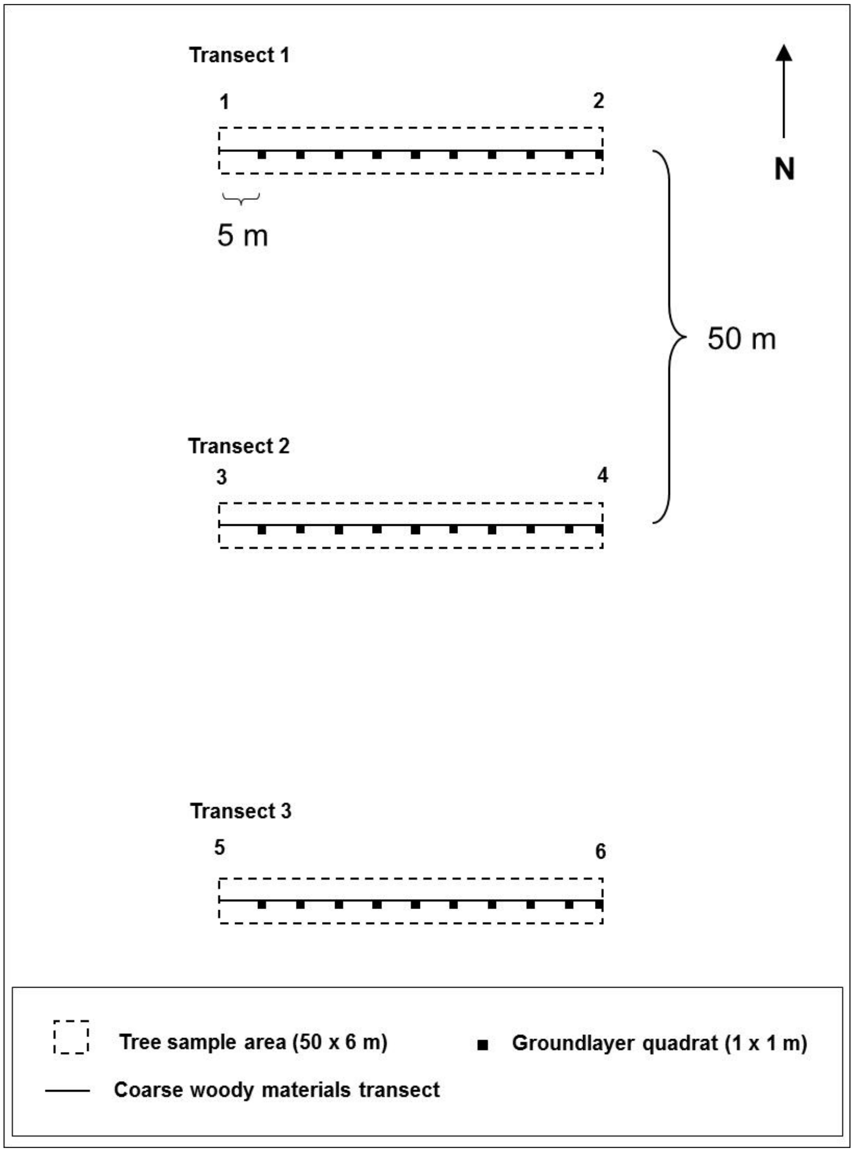

Figure 2. Diagram of the Hybrid sampling plot.

5.3 Permanently Marking Plots

Each of the six transect endpoints are permanently marked. The degree of permanent marking varies by park. Within parks with designated wilderness areas, marking is minimal, while permanent marking at other parks is slightly more visible. No plots are marked in such a manner as to be evident from roads, trails, or other heavily used public use areas.

At all transect endpoints, a 30 cm piece of rebar (3/8 inch diameter) is sunk nearly flush with the ground. Where there is bedrock or some other obstruction preventing the rebar from being placed adequately into the ground, first attempt to hammer the rebar in at an angle so that the top of the piece is in the correct place representing that transect endpoint. If that is not possible, the rebar is placed a short distance away from the actual transect endpoint, and the distance and bearing from the rebar to the transect endpoint are recorded. If possible, offset the rebar in a cardinal direction, preferably directly west or east of the actual transect endpoint (and thus in line with the meter tape that is run out for sampling).

The GPS locations of all transect endpoints as well as any offset rebar are recorded in the Trimble data dictionary. Each plot is stored as a unique file, and the locations of all transect endpoints for that plot are contained within that file. The name of the file is the four digit plot number. Within the data dictionary, each recorded endpoint has a SiteID (the four digit plot number, chosen from a drop-down list for the park) and an EndpointID (1-6, chosen from a drop-down list). The Offset field will default to 'No.' If rebar is offset, there are two waypoints recorded for a single endpoint. Both of them are given the same Site ID and Endpoint ID in the data dictionary, changing the Offset field to 'Yes' for the rebar, and leaving it as 'No' for the waypoint of the actual endpoint.

To help locate transect endpoints in the future, yellow plastic end caps are placed on the top of the rebar pieces, and three reference trees are tagged. The distances and azimuths from the trees to the rebar are recorded. The end caps are marked with the words 'NPS STUDY' on them, and the tree tags are 1.25 inch diameter, aluminum, and numbered 1 – 1,000. In the event of offset rebar, distances and azimuths are taken to the rebar and not the actual transect endpoint.

5.4 Plot Reestablishment During Subsequent Site Visits

Plots and points are relocated using a combination of GPS, a metal detector, and reference trees. Because sites are visited only once every nine years, permanent markers and the reference points are checked during each visit and reestablished as needed. Every attempt is made to sample plots approximately in the same order as they were sampled during previous monitoring visits. Ideally, the month and day that an individual plot is sampled is within two weeks of the month and day it was sampled in previous visits.

5.4.1 Reestablishing Points

When sampling established plots, we attempt to relocate the rebar designating transect endpoints using a combination of reference trees and a metal detector. Crews navigate directly to the transect endpoint using the mapping-grade GPS unit. Once at the correct coordinates, crews try to locate the reference objects. When at least one reference object is located, measure out from that object at the bearing and distance provided to locate the rebar. Begin sweeping with the metal detector to locate the rebar. Continue to identify the remaining reference object(s) to hone in on the location of the rebar. It may be helpful to leave plastic flagging on the ground at the precise point each reference tree leads you to, and then use the metal detector at and in between those points. Once the rebar representing the transect endpoint is located, the distance and bearing from each of the reference objects to the transect endpoint is rechecked. The values should be within 10 cm and 2˚ from the values recorded during the previous visit to the plot. For any reference tree where these criteria are not met, the new values are recorded. All tag numbers are checked to confirm that they are correct, and correspond to the respective tree measurements. A new DBH is taken for every reference tree, as this value will continue to change through time.

Replace transect endpoint reference objects that are dead, injured, or fallen. On the datasheet, write the appropriate letter to indicate the status of the tree. Status codes for reference objects include D for dead, I for injured or damaged, and F for fallen. It is unnecessary to update any DBH or distance measurements for this tree, as it will no longer be active. Remove the tag from the tree. Replace this now inactive reference object with a new reference object. Use a new tag number on the new reference object.

In addition, you may choose to eliminate a healthy, intact tree from the reference object list. Reasons for this include a reference tree that is in the *Fraxinus* genus, which will presumably be infected by the emerald ash borer in the future, as well as poor triangulation of reference objects, or poor species choices made for reference objects. If you encounter this, record the status as E for eliminated, remove the tag, and replace the tree with a new reference object, making sure to use a new tag number. Additional reference object status descriptions are M for missing, in which case you will not remove the tag from the tree since it cannot be located, and N for not applicable, which is used on non-living reference objects such as road signs or telephone poles.

Where rebar cannot be relocated, it is left to the discretion of the field crew to reposition the rebar based on reference tree data. It is up to the discretion of the field crew to position the rebar by any means possible. This could include reconstructing the likely locations of fallen reference trees, or extrapolating the transect endpoint position from an adjacent transect endpoint.

5.4.2 Recording Locational Data

Following reestablishment of permanent points, the GPS coordinates are again recorded during each site visit. Because of limitations on the locational accuracy of current GPS units, it is probable that these coordinates will differ from the coordinates recorded at the time of plot establishment. Nonetheless, it is hoped that both the continued improvement of GPS units and repeated visitation to sites will refine the actual site coordinates.

5.4.3 Reestablishing the Transect Line

Once the rebar at the transect endpoints is located, the transect lines are reestablished between transect endpoints 1 and 2, transect endpoints 3 and 4, and transect endpoints 5 and 6. The bearing and length of each transect is calculated in ArcMap using the GPS coordinates from previous visits. The transect line is laid out at the predefined bearing using flags. If the flagged line meets up with the known location of the rebar, the meter tape is pulled out along the flags. If the flagged line does not meet up with the known location of the rebar, adjust the flags accordingly to create a straight line between the two pieces of rebar representing the transect endpoints (Figure 3).

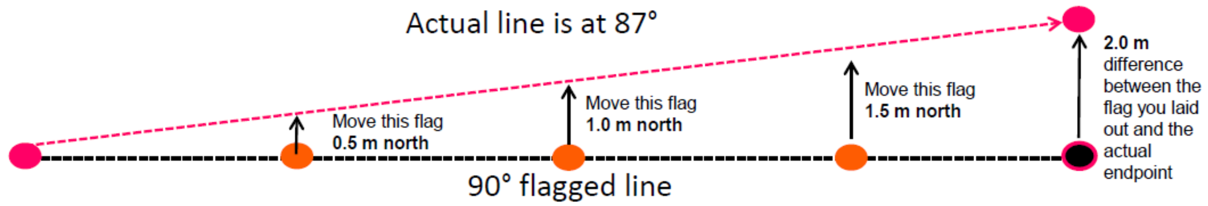

Figure 3. A representation of how the line is adjusted to create a straight line between the two pieces of rebar at the transect endpoints (pink circles).

5.5 Literature Cited

Johnson, S. E., E. L. Mudrak, and D. M. Waller. 2006. A comparison of sampling methodologies for long-term monitoring of forest vegetation in the Great Lakes Network National Parks. GLKN 2006/06. National Park Service, Great Lakes Network Office, Ashland, Wisconsin.

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

SOP 6: Field Methods and Data Collection

Version 2.0 (6/1/12)

Suzanne Sanders and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	We no longer monitor shrubs and seedlings in circles at transect endpoints; many browse methods have been modified.	The refined methods will improve our ability to detect long-term change, but also allow for effective time management at the plots.	2.0

6.0 Introduction

This standard operating procedure defines the criteria for data collection in the field. It is intended to ensure consistency between observers and sampling events. In addition, this SOP clarifies potentially ambiguous scenarios, eliminating uncertainty with measurements and data collection. It is intended to be a reference source, taken into the field and consulted as needed.

6.1 Whole Plot Data

Plot identification – Record the predetermined plot identifier and date.

- **GPS points –** Record the GPS locations of the six transect endpoints using UTM coordinates with the North American Datum of 1983 (NAD83) These values are not written down, but are stored electronically.

- **Kotar/NVCS forest type –** Record the forest type using the Kotar Classification system and/or the choices within the National Vegetation Classification System. This is typically done after all groundlayer data are collected for the day. This is used in post-stratification analyses.

- **Photopoints –** Three photos are taken at each of the six transect endpoints, facing directly into the plot. Therefore, at endpoints 1, 3, and 5, the photos are taken facing due east (90˚), while at endpoints 2, 4, and 6, the photos are taken facing due west (270˚). Photos are always taken at these bearings, even at active plots where the transect line may not be exactly 90°. Record the photo identification number from the camera for each of the endpoints. All photos are taken at a resolution of at least 3072 x 2304 pixels.

6.2 Tree Data

Trees ≥2.5 cm (1 in) in diameter are sampled within the belt transects. 'Tally trees' are defined as all live and standing dead trees in the transects the first time a plot is established, and all trees that grow into the transects thereafter. Details of measuring standing dead trees are presented below. Trees are considered 'live' if they have any living parts (leaves, buds, cambium) **at or above the point of diameter measurement.** Trees that have been temporarily defoliated are still live. Once tallied, dead trees at least 2.5 cm in diameter are tracked until they no longer qualify as standing dead. **Working around dead trees is a safety hazard - crews should exercise extreme caution! Trees that are deemed unsafe to measure should be estimated.**

Standing dead:

To qualify as a standing dead tally tree, dead trees must be at least 2.5 cm in diameter, have a bole with an unbroken height of at least 1.37 m (4.5 ft), and lean less than 45 degrees from vertical as measured from the base of the tree to 1.37 m. See Figures 1-3 for examples. (Note that dead trees equal to or greater than 45 degrees from vertical are counted as coarse woody material. See section 6.3 for details.)

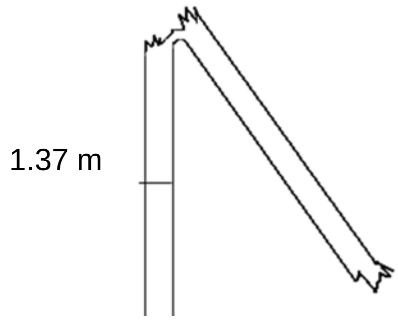

Figure 1. This tree would be tallied because it is at least 1.37 m in unbroken actual height and is at least 2.5 cm in diameter at the 1.37 m height.

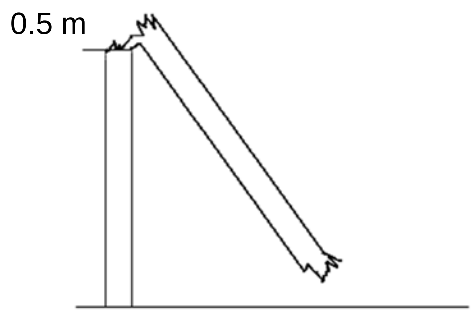

Figure 2. This tree would not be tallied because it does not have an unbroken height of 1.37 m.

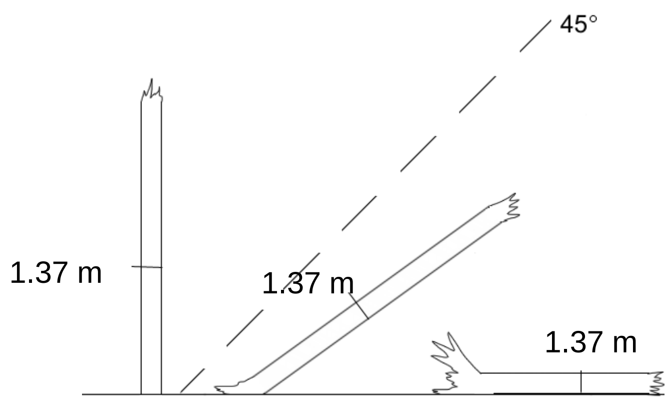

Figure 3. Other examples of dead trees. The tree on the left would be tallied since it is at least 2.5 cm in diameter at the 1.37 m height, and it has at least 1.37 m in unbroken actual height. The two trees on the right would not be tallied as standing dead trees since they are leaning at an angle ≥45˚ from vertical (although they would be counted in the CWM tally, provided they meet all of the qualifications in that assessment).

- **Species** – Record the six-digit code of each tree ≥2.5 cm diameter at breast height (DBH, 1.37 m) in each of the three 6 meter-wide belt transects.

- **Diameter –** Unless one of the following special situations is encountered, measure the diameter at 1.37 m above the ground line on the uphill side of the tree. Make sure that the diameter tape is horizontal to the ground, not slanting downward on the far side of the tree, and that it is pulled tight. Round each measurement down to the nearest tenth of a centimeter. For example, a reading of 12.78 cm is recorded as 12.7 cm. For trees with a DBH smaller than 5 cm, it is more efficient to use the calipers for measurement. When using the calipers, continue to record to the nearest tenth of a centimeter, rounding down when necessary. In many situations, irregularities in the bole (e.g., forking trees, bulges) will impede the circumference measurement. Refer to the special instructions below for taking measurements in these instances.

- **Live/dead –** Record whether the tree is living or dead.

- **Damage –** If any damage is evident, use the diagnostic key for tree pest detection to pinpoint the area and type of damage. Examine the bark as well as any branches, leaves/needles, and buds that are accessible and/or observable from the ground. Only list damage on dead trees if the causal agent is obvious (this will be rare). Table 1 lists the primary and secondary pest and pathogen signs, as well as the shortcut used for recording evidence of pests or pathogens on the datasheet. Consider the following information about locations affected by damage when collecting damage data:
    - Roots – Above ground up to 30 cm on bole.
    - Bole – Main stem(s) starting at 30 cm (12 in), including forks up to a 10 cm top. (A fork is at least 1/3 the diameter of the main stem, and occurs at an angle <45° in relation to the main stem.
    - Branch – All other woody material. Primary branch(es) extend at an angle >45° in relation to bole.
    - Foliage – All leaves, buds, and shoots.

Table 1. Primary and secondary pest and pathogen signs to look for using the diagnostic key.

1° Pest/Pathogen Sign	2° Pest/Pathogen Sign	Shortcut
Dieback	>10%, but not pervasive	Die - >10%
Dieback	pervasive, throughout the crown	Die - pervasive
Epicormic sprouts	on bole (**not root collar**)	Epi sprouts
Wilted foliage	partial crown	W – partial crown
Wilted foliage	whole crown	W – whole crown
Environmental	frost cracks	Env – frost cracks
Environmental	lightning strike	Env – lightning
Environmental	hail injury	Env – hail
Environmental	sunscald	Env - sunscald
Environmental	broken branches	Env – broken branches
Environmental	flooding	Env – flooding
Environmental	drought/poor soil	Env – drought
Environmental	cedar bark splitting	Env – cedar splitting
Environmental	fire	Env – fire
Environmental	other	Env – other
Human-caused Stress	topping/poor pruning	Stress – topping
Human-caused Stress	poor or restricted planting/mulching	Stress – restricted planting
Human-caused Stress	wounding of woody tissues	Stress – wounding
Human-caused Stress	salt/chemicals	Stress – salt
Human-caused Stress	other	Stress – other
Defoliation	defoliation > 10% foliage, but not pervasive	Def - > 10%
Defoliation	defoliation pervasive throughout crown	Def - pervasive
Defoliation	leaf mining, > 10% of foliage, but not pervasive	Def – leaf mining >10%
Defoliation	leaf mining, pervasive throughout crown	Def – leaf mining, pervasive
Defoliation	chewing of the mid-rib only (any level)	Def – midrib only
Discolored Foliage	mottling, spots, or blotches	DF – mottling/spots
Discolored Foliage	marginal scorching of leaves	DF – marginal scorching
Discolored Foliage	interveinal scorching of leaves	DF – interveinal scorching
Discolored Foliage	white coating	DF – white coating
Discolored Foliage	black coating (often sticky)	DF – black coating
Discolored Foliage	complete browning/bronzing of needles	DF – browning/bronzing
Discolored Foliage	complete yellowing of leaves or needles	DF – yellowing
Discolored Foliage	stippling	DF – stippling
Discolored Foliage	yellow/orange/white pustules	DF – pustules
Abnormal Foliage	foliage/twigs distorted or galls	AF - distorted/galls
Abnormal Foliage	witches' brooms	AF – witches' brooms
Insect Signs - foliage & twigs	caterpillars/sawflies feeding throughout crown	ISFT – caterpillars feeding
Insect Signs - foliage & twigs	beetles feeding throughout the crown	ISFT – beetles feeding
Insect Signs - foliage & twigs	aphids/white cotton pervasive throughout crown	ISFT – aphids/white cotton
Insect Signs - foliage & twigs	bags pervasive throughout the crown	ISFT – bags
Insect Signs - foliage & twigs	scales pervasive throughout the crown	ISFT – scales
Insect Signs - foliage & twigs	tents/webbing on more than one branch	ISFT – tents/webbing
Foliage Affected	> 10% but less than 30%	Fol - > 10%
Foliage Affected	>30% but not the whole crown	Fol - > 30%
Foliage Affected	whole crown	Fol – whole crown

Table 1. Primary and secondary pest and pathogen signs to look for using the diagnostic key (continued).

1° Pest/Pathogen Sign	2° Pest/Pathogen Sign	Shortcut
Insect Signs - branches & bole	frass only	ISBB – frass
Insect Signs - branches & bole	sawdust	ISBB – sawdust
Insect Signs - branches & bole	pitch/resin exudation	ISBB – pitch/resin
Insect Signs - branches & bole	D-shaped exit holes	ISBB – D-shaped exit
Insect Signs - branches & bole	pencil round or oval exit holes (≥2mm)	ISBB – round/oval exit
Insect Signs - branches & bole	shot holes (< 2mm)	ISBB – shot holes
Insect Signs - branches & bole	other holes	ISBB – other holes
Insect Presence	caterpillars	IP – caterpillars
Insect Presence	beetles	IP – beetles
Insect Presence	aphids	IP – aphids
Insect Presence	scale	IP – scale
Insect Presence	carpenter ants	IP – carpenter ants
Disease Signs	decay	DS – decay
Disease Signs	conks	DS – conks
Disease Signs	fleshy mushrooms	DS – fleshy mushrooms
Disease Signs	cankers	DS – cankers
Disease Signs	bleeding/slime flux	DS – bleeding
Disease Signs	resinosis/gummosis	DS – resinosis
Disease Signs	woody galls or burls	DS – woody galls
Problem Location	branches	PL - branches
Problem Location	bole and/or root collar	PL – bole
Problem Location	both branches and bole	PL – branches & bole
Loose Bark	loose bark only	LB – loose bark only
Loose Bark	rhizomorphs present	LB – rhizomorphs
Loose Bark	mycelial fans or pads present	LB – mycelial fans/pads
Loose Bark	insect boring or galleries causing loose bark	LB – insect boring

Special DBH situations:

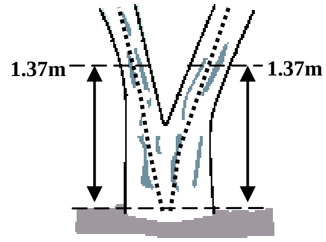

Figure 4. Forked below 30 cm.

1. Forked tree: In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45 degrees or less. Forks originate at the point on the bole where the piths intersect. Forked trees are handled differently depending on whether the fork originates below 30 cm, between 30 cm and 1.37 m (inclusively), or above 1.37 m. **Note: Fork does not have to be live to be considered a fork.**

- Trees forked below 30 cm. Trees forked in this region are treated as distinctly separate trees (Figure 4). Distances are measured individually to the center of each stem where it splits from the stump (Figures 4 - 6). DBH is measured for each stem at 1.37 m above the ground. When stems originate from pith intersections below 30 cm, it is possible for some stems to be within the limiting distance of the belt transect, and others to be beyond the limiting distance. If stems originating from forks that occur below 30 cm fork again between 30 cm and 1.37 m (Figure 7-E), the rules in the next paragraph apply.

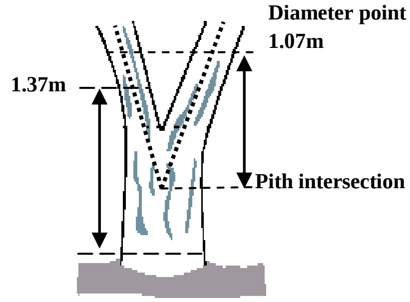

Figure 5. Forked between 30cm – 1.37m.

- Trees forked between 30 cm and 1.37 m. Trees forked in this region are also counted as separate trees (Figures 5, 7 D-F). The DBH of each fork is measured at a point 1.07 m (3.5 feet) above the pith intersection. When forks originate from pith intersections between 30 cm and 1.37 m, the limiting distance is the same for all forks--they are either all in or all out --and it is determined by the central stump.

  Multiple forks are possible if they all originate from approximately the same point on the main stem. In such cases, measure DBH on all stems at 1.07 m above the common pith intersection (Figure 7-F).

  Once a stem is tallied as a fork that originated from a pith intersection between 30 cm and 1.37 m, do not recognize any additional forks that may occur on that stem. Measure the diameter of such stems just below the base of stem separation as shown in Figure 7-E (i.e., do not move the point of diameter the entire 1.07 m above the first fork).

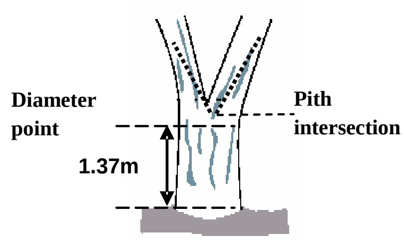

Figure 6. One tree.

- Trees forked at or above 1.37 m. Trees forked in this region are considered to be a single tree (Figure 6). If a fork occurs at or immediately above 1.37 m, measure diameter below the fork just beneath any swelling that would inflate DBH.

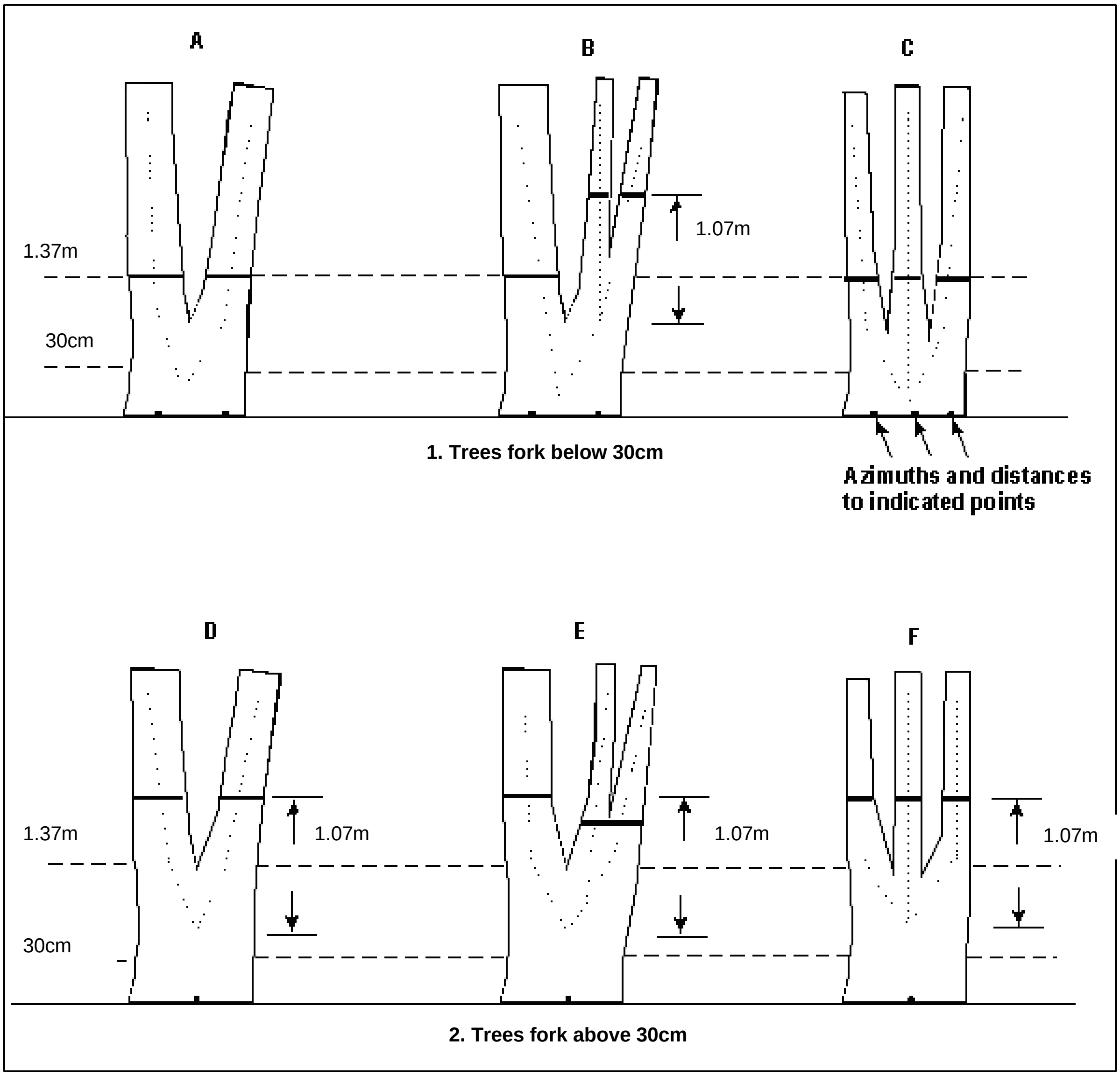

Figure 7. Summary of where to measure DBH, distance, and azimuth on forked trees.

2. Stump Sprouts: Stump sprouts originate between ground level and 1.37 m on the boles of trees that have died or been cut. Stump sprouts are handled the same as forked trees, with the exception that stump sprouts are not required to be 1/3 the diameter of the dead bole. Stump sprouts originating below 30 cm are measured at 1.37 m from ground line. Stump sprouts originating between 30 cm and 1.37 m are measured at 1.07 m above their point of occurrence. As with forks, rules for measuring distance depend on whether the sprouts originate above or below 30 cm. For multi-stemmed woodland species, treat all new sprouts as part of the same new tree.

Tree with butt-swell or bottleneck: Measure these trees 46 cm above the end of the swell or bottleneck if the swell or bottleneck extends 91 cm or more above the ground (Figure 8).

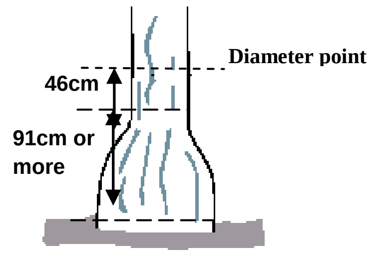

Figure 8. Bottleneck tree.

3. Tree with irregularities at DBH: On trees with swellings (Figure 9), bumps, depressions, or branches (Figure 10) at DBH, measure the diameter immediately above the irregularity at the place it ceases to affect normal stem form.

Note: If a normal diameter cannot be obtained at or above 1.37 m, it is valid to measure the diameter below 1.37 cm.

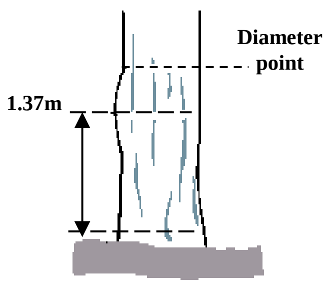

Figure 9. Tree with swelling.

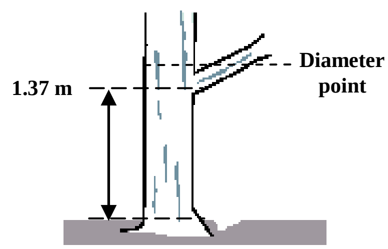

Figure 10. Tree with branch.

4. Tree on slope: Measure diameter at 1.37 m from the ground along the bole on the uphill side of the tree (Figure 11).

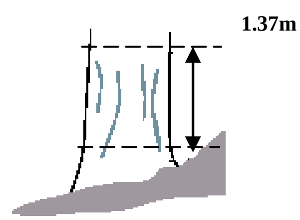

Figure 11. Tree on a slope.

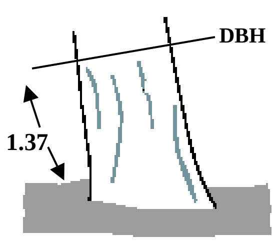

Figure 12. Leaning tree.

5. Leaning tree: Measure diameter at 1.37 m from the ground along the bole. The 1.37 m distance is measured along the underside face of the bole (Figure 12).

6. Independent trees that grow together: If two or more independent stems have grown together at or above the point of DBH, continue to treat them as separate trees. Estimate the diameter of each.

7. Missing wood or bark: Do not reconstruct the DBH of a tree that is missing wood or bark at the point of measurement. Record the diameter (to the nearest 0.1 cm) of the wood and bark that is still attached to the tree (Figure 13). If a tree has a localized abnormality (gouge, depression, etc.) at the point of DBH, apply the procedure described for trees with
irregularities at DBH (Figure 9 and 10).

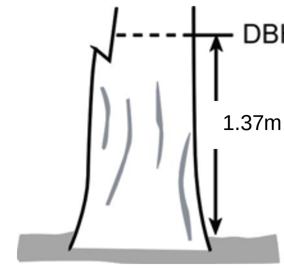

Figure 13. Tree with part of stem missing.

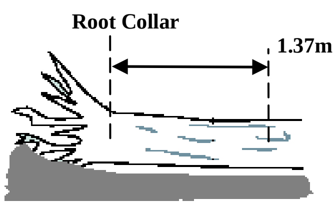

Figure 14 Tree on the ground.

Live windthrown tree: Measure from the top of the root collar along the length to 1.37 m (Figure 14). Note that this only applies to **live, rooted trees**. The angle of the tree from the vertical does not matter as long as the tree is **live**.

8. Down live tree with tree-form branches growing vertical from main bole. When a down live tree that is touching the ground has vertical (less than 45 degrees from vertical) tree-like branches coming off the main bole, first determine whether or not the pith of the main (downed) bole is above or below the duff layer.

- If the pith of the main bole is above the duff layer, use the same forking rules specified for a forked tree, and take all measurements accordingly (Figure 15).
- If the pith intersection of the main down bole and vertical tree-like branch occurs below 1.37 m from the stump along the main bole, treat that branch as a separate tree, and measure DBH 1.07 cm above the pith

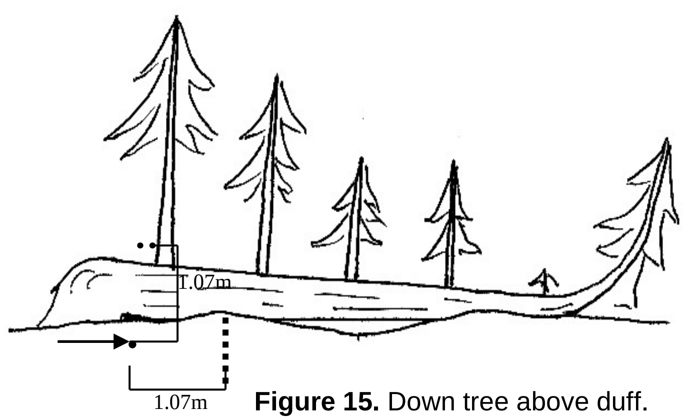

Figure 15. Down tree above duff.

intersection for both the main bole and the tree-like branch (Figure 15).

If the intersection between the main down bole and the tree-like branch occurs beyond the 1.37 m point from the stump along the main bole, treat that branch as part of the main down bole (i.e., do not tally it) (Figure 15).

- If the pith of main tree bole is below the duff layer, ignore the main bole, and treat each tree-like branch as a separate tree; take DBH from the ground, not necessarily from the top of the down bole (Figure 16). However, if the top of the main tree bole curves out of the ground towards a vertical angle, treat that portion of that top as an individual tree originating where the pith leaves the duff layer.

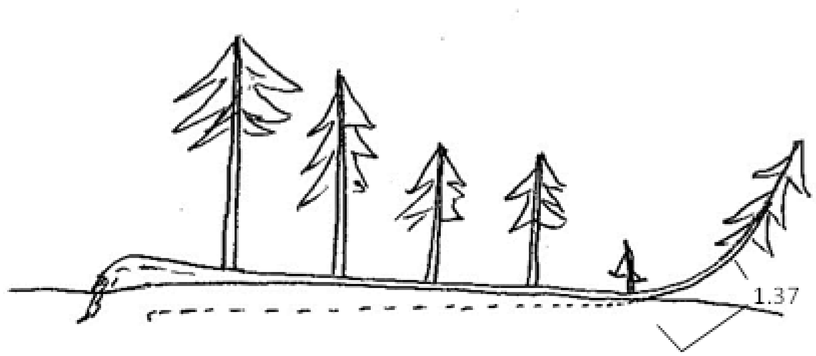

Figure 16. Down tree below duff.

12. Tree with curved bole (pistol butt tree): Measure along the bole on the uphill side (upper surface) of the tree (Figure 17).

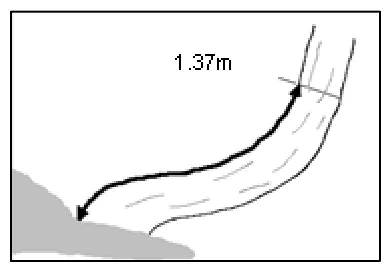

Figure 17. Tree with curved bole (pistol butt tree).

Any transect that has no trees is clearly marked as such on the datasheet, using the phrasing **sampled, no data**. If a transect is not sampled due to time constraints or safety, this is clearly marked on the datasheet using the phrasing **not sampled**.

6.3 Coarse Woody Materials

Data on coarse woody material will be collected along each of the three parallel 50 m horizontal distances using the planer intercept method. Tally rules follow below. For all pieces of coarse woody material tallied, the parameters recorded are: species, diameter at plane intercept, small end diameter, large end diameter, length, and decay class.

- **Species –** Record the six-digit code of each piece of coarse woody material (≥0.90 m [3 ft] long and ≥7.5 cm [3 in] diameter) that crosses the plane of the transect. Because this is a planar transect, the tree is counted whether it is on the ground, or at any height above it.

- **Diameter at plane intercept –** Record the diameter (in centimeters) at the point of intercept. This diameter is measured perpendicular to the length of the log, regardless of the orientation of the piece to the transect plane. Record the measurement to the tenth of a centimeter, rounding down, rather than to the nearest tenth. For example, a reading of 12.78 cm is recorded as 12.7 cm.

- **Small end diameter –** Record the diameter (in centimeters) at the piece's small end. This diameter will occur either (1) at the actual end of the piece, if the end has a small end diameter of ≥7.5 cm, or (2) at the point where the piece tapers down to 7.5 cm in diameter. If the end is splintered or decomposing (sloughing off), measure the diameter at the point where it best represents the overall log volume. Record the measurement to the tenth of a centimeter, rounding down, rather than to the nearest tenth.

- **Large end diameter –** Record the diameter (in centimeters) at the piece's large end. The large end will occur either at a broken end, a fracture, or at the root collar. If the end is splintered or decomposing (sloughing off), measure the diameter at the point where it best represents the overall log volume. Record the measurement to the tenth of a centimeter, rounding down, rather than to the nearest tenth.

- **Length –** Record the length of the piece from the piece's recorded diameter at small end to the recorded diameter at large end. For curved logs, measure along the curve. Record the measurement to the tenth of a centimeter, rounding down, rather than to the nearest tenth. For example, a log that is 3.57 meters would be recorded as 3.5 m.

- **Decay class –** Record the decay class of the piece using the rules outlined in Table 2. Because decay conditions may vary along a piece, record the decay class that predominates.

Table 2. Distinguishing characteristics of the five decay classes (From Woodall and Williams, 2005).

Decay class	Structural integrity	Texture of rotten portions	Color of wood	Invading roots	Branches and twigs
1	sound, freshly fallen, intact logs; all bark intact; hard when kicked	intact, no rot; conks of stem decay absent	original color	absent	if branches are present, fine twigs are still attached and have tight bark
2	sound; some bark missing; hard when kicked	mostly intact; sapwood partly soft (starting to decay) but can't be pulled apart by hand	original color	absent	if branches are present, many fine twigs are gone and remaining fine twigs have peeling bark
3	heartwood sound; most of the bark is missing; piece supports its own weight; still hard when kicked	hard, large pieces; sapwood can be pulled apart by hand or sapwood absent	reddish brown or original color	sapwood only	branch stubs will not pull out, and most of the branches < 1" missing
4	heartwood rotten; piece does not support its own weight, but maintains its shape; sounds hollow when kicked and you can remove wood from outside with boot	soft, small blocky pieces; a metal pin can be pushed into heartwood	reddish or light brown	throughout	branch stubs pull out
5	none, piece no longer maintains its shape, it spreads out on the ground; easy to kick apart	soft; powdery when dry	red-brown to dark brown	throughout	branch stubs and pitch pockets have usually rotted down

Tally Rules for Coarse Woody Material Sampling:

1. Tally dead and down trees whose central longitudinal axes intersect the transect plane (Figure 18). This includes all *unrooted* dead trees and their branches regardless of the angle at which they are leaning away from vertical. Some parameters may have to be estimated, depending whether part or all of the piece is elevated.

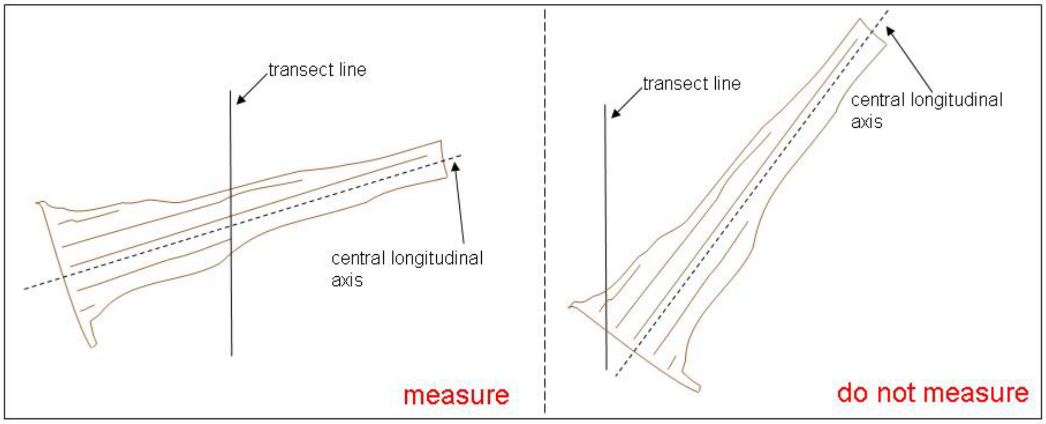

Figure 18. Do not tally any CWM piece whose central longitudinal axis does not cross the transect plane.

2. Tally dead trees and stumps that are leaning ≥45˚ from vertical. (Do not tally live trees or standing dead trees and stumps that are still upright and leaning <45˚ from vertical. See section "Tree Data" above.)

3. The minimum length of any tally piece is 0.90 m (3 ft) for decay classes 1 through 4.

4. The decay class of the piece determines whether or not the piece is tallied.

<u>For decay classes 1 to 4:</u> tally a piece if it is ≥7.5 cm in diameter at the point of intersection with the transect plane. The piece must also be ≥0.90 m (3 ft) in length and ≥7.5 cm (3 in) in diameter along that length.

<u>For decay class 5:</u> tally a piece if it is ≥12.7 cm in diameter at the point of intersection with the transect. The piece must also be ≥1.52 m (5 ft) in length and ≥12.7 cm in diameter along that length. Only pieces that still have some shape and log form are tallied – humps of decomposed wood that are becoming part of the duff layer are not tallied.

5. Tally pieces created by natural causes or by human activities such as cutting only if not systematically machine-piled.

6. Tally a piece only if the point of intersection occurs above the ground. If one end of a piece is buried in the litter, duff, or mineral soil, the piece ends at the point where it is no longer visible. Measure the diameter and length at this point.

7. If the central longitudinal axis of a piece is intersected more than once on a transect plane, tally the piece each time it is intersected. This is an uncommon situation. (Figure 19).

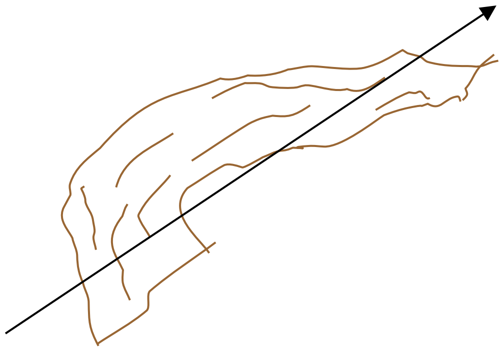

Figure 19. If the central longitudinal axis crosses a transect twice, then tally the piece twice.

8. If a piece is fractured across its diameter or length, and would pull apart at the fracture if pulled from either end or sides, treat it as two separate pieces. Tally only the piece intersected by the transect plane. If judged that it would not pull apart, tally as one piece.

9. Do not tally a piece if it intersects the transect plane on the root side of the root collar (see right side of Figure 18). Do not tally roots.

10. When the transect crosses a down tree bole that is forked, or a large branch connected to a down tree, tally each qualifying piece separately (Figure 20). To be tallied, each individual piece must meet the minimum diameter and length requirements.

11. In the case of forked trees, consider the ‘main bole’ to be the piece with the largest diameter at the fork. Variables for this fork, such as ‘decay class’ and ‘total length” should pertain to the entire main bole. For smaller forks or branches connected to the main bole (even if the main bole is not a tally piece), variables pertain only to that portion of the piece up to the point where it attaches to the main bole (see Figure 20).

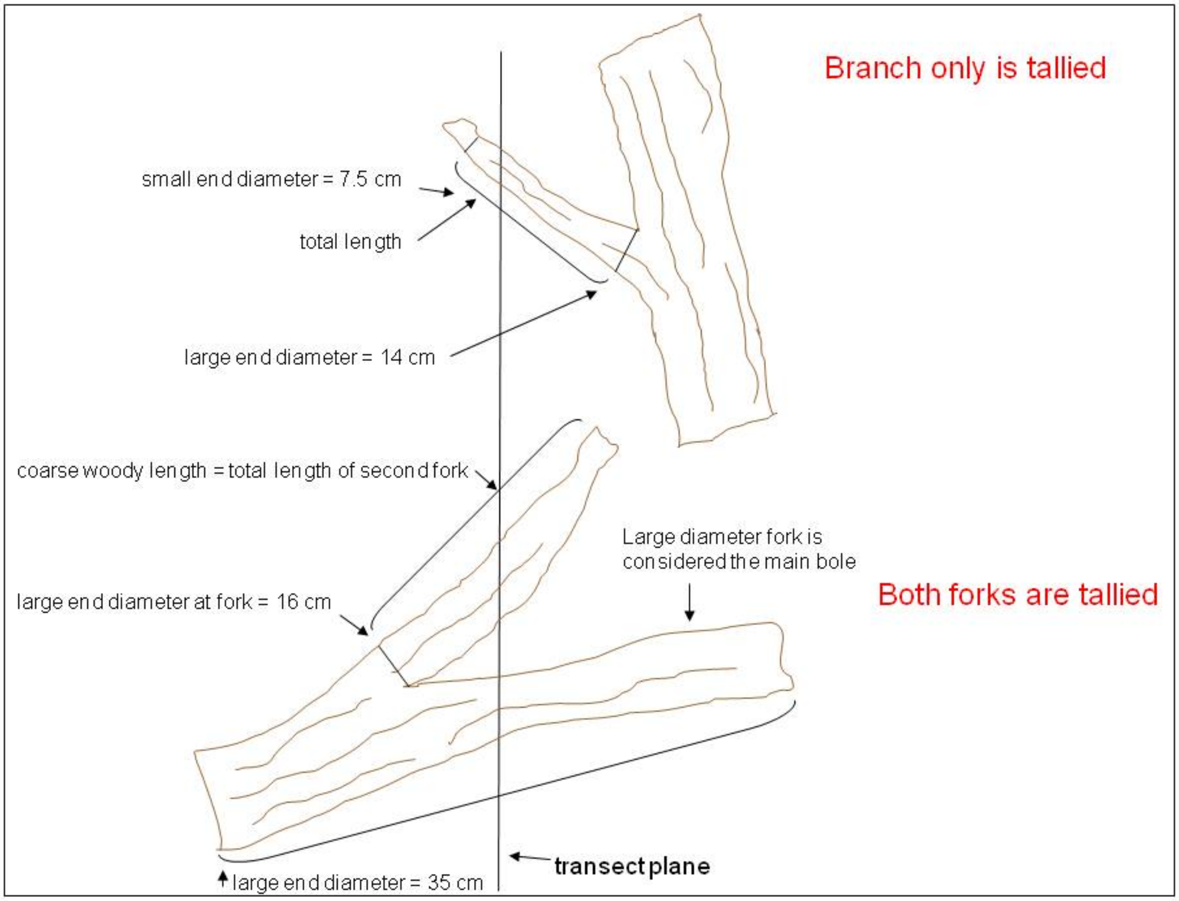

Figure 20. CWM tally rules for forked trees.

Any transect that has no CWM is clearly marked as such on the datasheet, using the phrasing **sampled, no data**. If a transect was not sampled due to time constraints or safety, this is clearly marked on the datasheet using the phrasing **not sampled**.

6.4 Canopy Cover

The canopy cover is assessed for each plot sampled. This is an estimate of how much area is covered by all the woody species present throughout the entire plot. The canopy of a plot will be divided into two vegetation layers:

Top canopy layer - this is the layer of trees that is tallest in the plot, the dominant overstory layer. Gap in the canopy is recorded for this top canopy layer only.

Sub-canopy layer - this is the layer of trees below the top canopy, which can still be quite tall, or could be much shorter or even not present, depending on the plot.

For each layer, a cover/abundance code for the layer overall will be recorded using the Braun-Blanquet scale (Table 3) (DNR 2007). A listing of all the tree species present in that layer and their **absolute** cover/abundance code is also recorded. **The cover code for a given species must be less**

than or equal to the cover code for the layer overall. An individual species can be present in multiple vegetation layers.

Table 3. Braun-Blanquet cover/abundance scale.

Code	Percent Cover
5	76%-100%
4	51%-75%
3	26%-50%
2	5%-25%
1	<5%; Used when there are numerous individuals of the species, but they collectively cover less than 5% of the plot (abundance code)
T	<5% ; Used when there are only a few individuals of the species, which collectively cover less than 5% of the plot (abundance code)

6.5 Groundlayer

Herbs, tree seedlings, shrubs, and indirect browse are all assessed in the thirty 1 m × 1 m groundlayer quadrats. For herbaceous plants and shrubs, record each species that is rooted in each groundlayer quadrat. Do not count these or estimate coverage.

Record the species of qualifying tree seedlings in each 1 m × 1 m groundlayer quadrat. Qualifying tree seedlings must be at least 15 cm tall and exhibit signs of second-year growth, such as bud scars. Seedlings must also be <2.5 cm diameter at breast height. In addition, record the count of each species present. For stem sprouts, if you can clearly see that the sprouts are growing from the trunk of a tree, do not count them. If there are numerous seedlings at the base of a tree, but they are growing from the ground, they are counted. In the case of *Thuja occidentalis*, which roots and produces ramets from downed trees, count the number of ramets rooted within the groundlayer quad only if the pith of the downed tree bole from which they are growing lies below the duff layer. Make sure that only those shoots that meet the qualifying tree seedling criteria (above) are tallied.

If there are no plants in a quadrat, the quadrat is considered sampled, but with no data. To simplify the data collection and data entry, write that transect and quadrat number at the top of the datasheet and write ND for Sampled, No Data. If there are numerous quadrats in a transect that are sampled with no data, write ND down as a species and check the boxes corresponding to the quadrats where there are no data. A quadrat landing on a dirt trail with no living plants is considered sampled with no data because there is potential for vegetation to grow there. A quadrat comprised of mud, a pile of coarse woody debris, or a large tree trunk with no visible vegetation growing should also be marked as sampled, no data.

If a quadrat is not sampled, for example if the transect is cut short due to a cliff or if one quadrat is skipped due to a ground hive, clearly write in the transect/quadrat notes section at the top of the datasheet which transect and quadrat(s) were not sampled, using NS to represent not sampled. A quadrat landing completely on a mowed or paved area should be marked as NS for not sampled, as the vegetation is continually altered or is unable to grow, respectively. Any quadrat with water deep enough that you cannot tell if vegetation is growing or not should be marked as not sampled.

6.6 All Species Walkthrough

Prior to completing the plot, perform a 30 minute time-delimited walkthrough of the entire plot (50 meters × 100 meters) to determine the complete list of species that are present in each plot. Any species that have already been accounted for in the groundlayer or tree sampling are not recorded again. Record each species only once.

6.7 Browse

Indirect browse

Indirect browse measures are made in each of the 30 groundlayer quadrats. For each park, three pre-identified herbaceous species are examined in each quadrat. For each of the three target species, record the maximum height to the nearest whole or half centimeter, and note whether or not any individuals of the given species are reproductive or show evidence of browse. It is not uncommon for a plant to be browsed early in the season so that only a few centimeters of the stem remain, but then produce another fully developed stem. Where this occurs, if the connection is at or above ground level and is clearly discernible, the individual is considered to be browsed. When measuring the maximum height, do not lift or extend any part of the plant. Instead, measure the maximum height of the natural stature of the plant (Figure 21a). If the plant is growing on unlevel ground, measure the distance to the ground immediately below the highest part of the plant (Figure 21b). If the plant is growing on a structure that is off the ground, like a tip-up mound, measure the height from the highest part of the plant to where it is rooted.

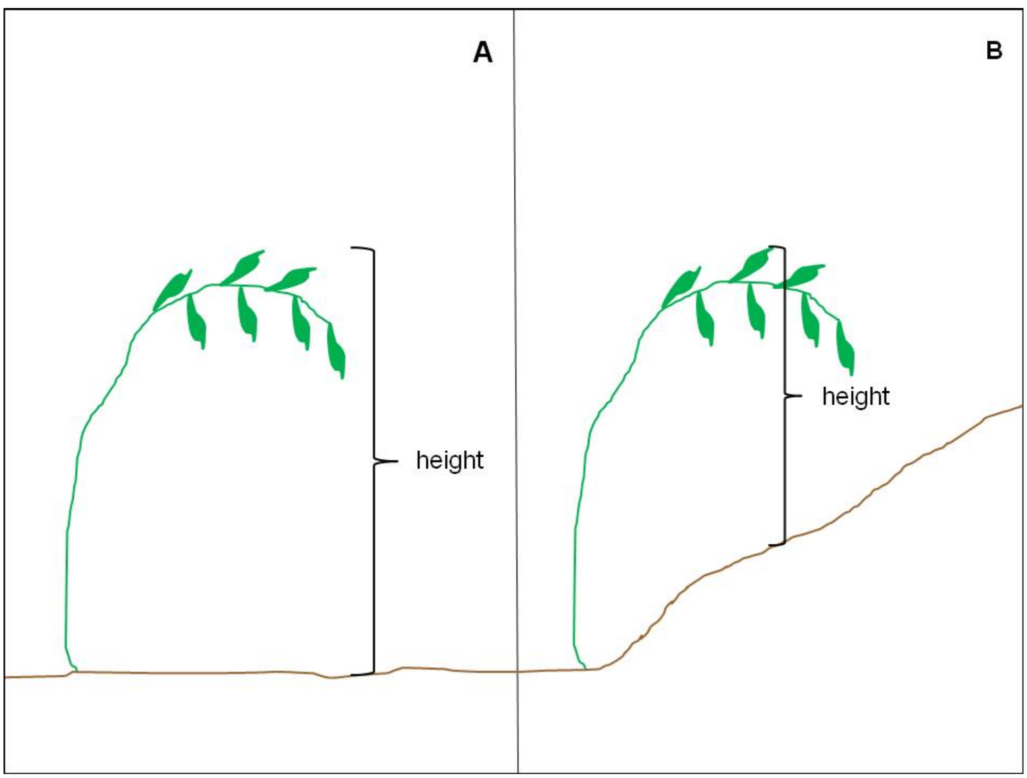

Figure 21. Locations for measuring height of indirect browse herbs.

The predetermined species are chosen based on a number of criteria including abundance of each potential species at a given park, known browse species preferences at the park, and height of potential species (white-tailed deer in the region generally exhibit a lower preference for smaller species, such as *Maianthemum canadense* (Grochowski and Sanders, personal observation)). Potential species include, but are not limited to, *Streptopus* spp., *Actaea* spp., and *Aralia nudicaulis*. Note that all of these species are above-ground throughout the growing season. At Isle Royale, where moose are present, but not deer, indirect browse species are *Aralia nudicaulis*, *Streptopus* spp., and *Trillium grandiflorum*.

Direct browse

Direct browse is measured along each of the three 50-meter transects and along four additional transects flanking the east and west sides of the plot (Figure 22). Note that transects 6 and 7 do not have direct browse data for quadrat 10 (at the 50 meter mark) because this area is sampled along transects 2 and 3, respectively, resulting in a total of 68 direct browse sampling circles. In addition, a meter tape is not be run along the east and west edges of the plot (corresponding to Transects 4-7); here, the locations of direct browse sampling, conducted every 5 meters along these transects, is paced out by the field crew member conducting the sampling.

Direct browse measurements are done in a 3.14 m^2 circular sampling area (with a radius of 1.0 m) (Figure 22). These browse sampling circles are centered every 5 meters along each transect, starting at the 5 meter mark, for a total of 10 circles along the transect. On transects 1, 2, and 3, each direct browse circle is centered on the transect line at the appropriate position (i.e. 5 m, 10 m, etc.). The 3.14 m^2 sampling area has a radius of 1.0 meters. For each direct browse sampling circle, all woody species present from ground level (shrub species only) up to the top of the browse zone (defined as 1.8 m in height [3.0 m at ISRO]) is recorded. For tree species in the browse circles, seedlings need to be at least 15 cm high and show signs of second-year growth to be counted as present in the circle. The upper limit of the browse zone remains the same. In addition to species presence, evidence of any ungulate browse on that species in the sampling circle is recorded. Only evidence of the current year's browse is recorded. Note that for both presence and browse, it does not matter whether a tree or shrub is rooted within the cylinder; presence and browse are recorded if any part of a tree or shrub is within the cylinder and if any part within the cylinder is browsed. For example, browse is noted on a tree rooted outside of the cylinder that has branches extending into the cylinder, where it is browsed. In contrast, a tree that is rooted within the cylinder but that is browsed outside of the cylinder is not be marked as being browsed.

It is possible there will be no shrubs or saplings within the sampling circle; in these instances, no direct browse is assessed for those sampling circles. These browse circles are considered sampled, but with no data. Clearly mark in the notes section of the datasheet the transect and quadrat number, followed by ND to represent sampled, no data. If there are numerous quadrats with no data, write 'sampled, no data' in as a species, and mark the appropriate boxes to represent which quadrats have no data. If an entire transect has no woody species present, be sure to write this on the datasheet so there is no confusion post-season.

If a browse circle is not sampled, for example if the transect is cut short due to a cliff or if one quadrat is skipped due to a ground hive or deep standing water, clearly write in the transect/circle notes section at the top of the datasheet which transect and which circle(s) were not sampled, using NS to represent not sampled.

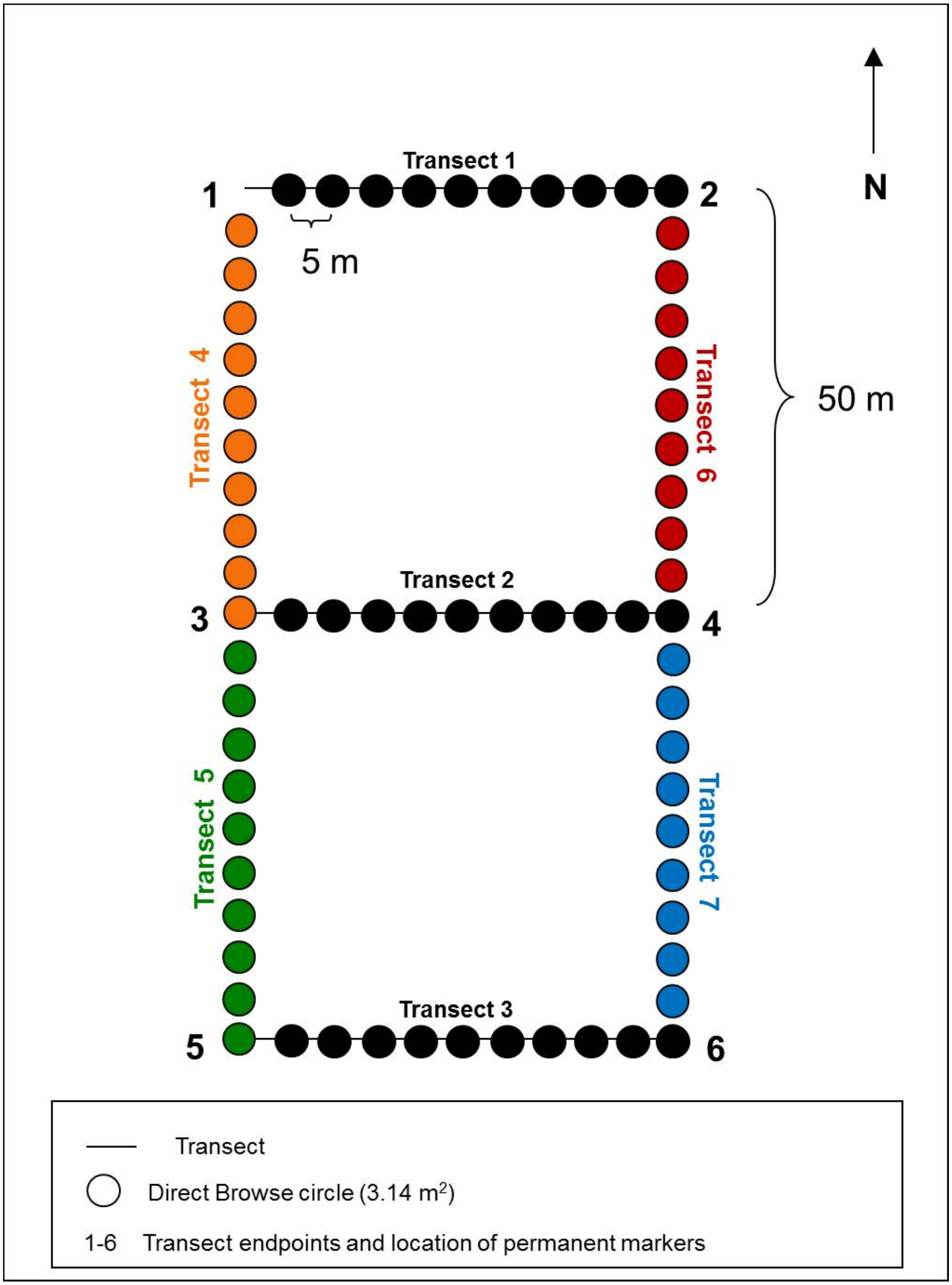

Figure 22. Direct browse sampling circles in plot.

6.8 Herbarium

Plants are collected, pressed, and added to the herbarium at the GLKN office. Ideally, plants that are collected are good specimens with intact leaves and bearing flower or fruit. Collections are made at a given park only if the park has granted permission, and notes should include the date, collector, genus and species, specific location information, and associated plants.

Mounting herbarium specimens

The pressed and dried specimens are mounted on 11.5” x 16.5” heavy weight, unbuffered hemp paper, procured through University Products, The Archival Company (# 170-1116HU-A). To attach plants to the mounting paper, use neutral pH adhesive glue, archival quality, through Lineco Inc. (Item 901-1008), or Elmer’s glue that has been diluted with water (1 part glue to 1 part water). Apply glue to plants using small paint brushes over scrap paper or newspaper, then attach to the mounting paper. For woody plants and non-cooperative root masses, use ½” acid-free, linen tape from Pacific Papers (PO#4299-INV861437). This tape needs to be moistened to stick to the mounting paper. Once mounted, fill out a GLKN herbarium label, and organize the plants by family to be stored in labeled folders in the herbarium cabinet (folders are called Plain Genus Cover, and are acquired from University Products, The Archival Company, # 170-1012). GLKN herbarium labels are printed on 3⅓” x 4” white, laser printer labels. Herbarium specimens will be used as educational tools during training for new seasonal employees, and as a reference for confusing species encountered during sampling. Our contact for herbarium supplies is Carolyn Wallingford, Program Manager at National Park Service, Midwest Regional Office, (402) 661-1950, Carolyn_Wallingford@nps.gov.

6.9 Acknowledgments

We are indebted to the U.S. Forest Service, North Central Region both for providing text files of the FIA field guide and allowing us to incorporate it into the GLKN field guide.

6.10 Literature Cited

DNR (Minnesota DNR). 2007. A Handbook for Collecting Vegetation Plot Data in Minnesota: The Relevé Method. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Woodall, C. and Williams, M. 2005. Sampling protocol, estimation, and analysis procedures for the down woody materials indicator of the FIA program. General Technical Report NC-256. St. Paul, Minnesota: U.S. Department of Agriculture, Forest Service, North Central Research Station. 47 p.

SOP 7: Procedures for Handling Unknown Species

Version 2.0 (6/1/12)

Sarah Johnson
University of Wisconsin – Madison

Suzanne Sanders and Suzanne Sanders
NPS – Great Lakes Network

Revision History Log:

Previous Version #	**Revision Date**	**Author(s)**	**Location in Document and Concise Description of Revision**	**Reason for Change**	**New Version #**
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Details of plant collection slips and pictures were added.	This will improve our ability to identify unknown specimens.	2.0

7.0 Introduction

Occasions will arise when the field crew is unable to identify species on-site. Before collecting any plants or insects from the field, attempts should first be made to identify it on-site using reference books. When this is not possible, follow the guidelines in this standard operating procedure for collecting and preserving specimens.

7.1. Collection of Herbaceous Plants

To collect groundlayer plants, an attempt must first be made to locate individuals of the questioned species outside of the outer boundary of the plot. There must be at least five individuals (hereafter, this also refers to ramets if the unknown species is, or appears to be, clonal) present for one to be removed. If ten individuals are present, two may be collected. No more than two individuals of a given species should be collected at any given plot. If no individuals can be located outside of the outer plot boundary, one or two may be collected from within the boundary, provided they are not within the quadrats.

Photograph the plant to show characteristics that will facilitate identification at a later time. This includes taking multiple close-up photographs of the flowers, fruits, and leaves, as well as whole plant pictures in which the plant size is placed in context with that of other plants. Always get a picture of the plant. It is *incredibly* useful to have pictures of all the unknown plants post-season, so please take the time to do this. If a camera is not available on-site, collect the plant, but then take pictures of it at the end of the day.

Exercise caution when selecting which plant(s) to collect. While it may be tempting to collect the largest plant(s) meeting the criteria above, this practice should be avoided. Larger plants may be making proportionately greater contributions to species recruitment than smaller plants. Collection of plants should tend toward smaller individuals, provided there is sufficient material present for identification.

Try to remove the root as well as the aboveground portion of the plant. All field crews will carry a trowel with them for this purpose. Soil should be knocked free from the roots to the extent possible without damaging them. Name the unknown with the plot number and a dash, followed by sequentially increasing integers. For example, the first unknown species collected at plot 7012 would be labeled 7012-1 while the second would be 7012-2. Fill out the unknown plant slip with the correct unknown plant ID (e.g. 7012-1), associated species, and habitat. Fill out the unknown plant datasheet with this same information. Once the datasheet and the slips are filled out, take at least one picture with the completed unknown plant slip next to the plant. The specimen is then placed in a plastic bag with the unknown plant slip. Keep the specimen in as cool and dark of a place as possible, and do not allow it to be crushed.

Filling out the unknown plants datasheet

Be sure to leave plenty of white space on your unknown plants datasheet, and draw lines between your records for each unknown, as notes will later be written on this sheet by the Botanist. If you reference an unknown from a plot you previously sampled, still give it an unknown number for the plot you are currently on. Then, in the description section of the unknown plant datasheet, write the unknown identifier that you are referring to. For example, if you are on plot 6008 and you have an unknown that you documented the previous day at a different plot, call your current unknown 6008-1, and in the description section of the unknown plant datasheet for 6008-1, write “same as 6012-3, Carex sp., additional sample not collected.” Include the picture numbers taken while at plot 6008. Only do this if you know the **exact unknown ID** of the plant you are referring to. If you cannot remember the exact unknown ID, **collect the plant again**. In addition, take good photos of the plant, even if you don’t re-collect a specimen, to confirm that it is indeed the same plant as a previous unknown. If you don’t actually *collect* an unknown plant because you are referring to another plot’s unknown, write “additional sample not collected” on the Unknown datasheet. Make sure all your notes are complete ***while you are still at the plot***, and collect a plant specimen if you have any doubt on the identification.

When more than one person is collecting data on herbs, both people will have an unknown sheet. To avoid overlapping unknown ID numbers, add an initial after the plot number on each unknown. For example, if Suzy and Jess are both collecting herb data on plot 6015, Suzy’s first unknown will be 6015-S1 and Jess’s will be 6015-J1.

If there are no plants of the given species outside of groundlayer quadrats, or if there are less than five individuals present, do not remove voucher specimens from the area. In these instances, later identification will be based entirely on the photographs and notes collected at the site. Good quality photographs are very important in these instances. Take detailed photographs of the entire plant, the leaves, and the stems, some with a ruler in the background for reference. Take close-up photographs of all leaves (upper and lower surfaces) and reproductive structures; take these close-ups from more than one angle for good perspective. You should have at least 10–15 photographs of an unknown plant if you cannot collect a specimen.

7.2 Collection of Woody Plants

In the event that woody plant species cannot be identified in the field after consulting reference manuals, portions of these plants may be cut and removed from the field for later identification. All crews carry pruning shears for this purpose. When collecting plants, an attempt must first be made to locate individuals of the same species outside of the outer boundary of the plot. To collect a stem containing reproductive structures, assure that at least five reproductive stems are present in total. This can include one plant with five reproductive stems; five plants, each with one reproductive stem; or some combination of the two. If at least 10 reproductive stems are present, then two may be collected for later identification. If leaves are not present on the reproductive stem, or if the judgment is made that additional stems with leaves may aid identification, up to two stems containing leaves may be collected, provided there are at least 10 present near the plot.

If there are no individuals present outside of the outer plot area, an attempt should be made to sample within the plot area but from trees rooted outside of the six-meter-wide belt transects and from shrubs located outside of the browse circles. The same rules about the number of stems required for collection apply here. As a last resort, collection of woody tree material may be made within the belt transects. Follow the directions for photographing and documenting as described for herbaceous plants. As detailed in the herbaceous section above, collection of smaller specimens, rather than larger ones, is the priority. Keep the specimen in as cool and dark of a place as possible, and do not allow it to be crushed.

Reproductive material (i.e., viable seeds, non-viable seed husks, decaying acorns) may be collected at the discretion of the field crew. However, caution must be exercised so that only a small portion is collected.

7.3 Collection of Insects and Insect Sign

An attempt will be made to identify any species of insect (native or exotic) that is adversely affecting tree health. If the insect species (or the ensuing disease) cannot be readily identified in the field, specimens may be collected for later identification. This can include individuals in either the adult or larval stages, or eggs. All samples will be collected in vials but will not be preserved.

In addition to direct collection of insects, pieces of insect sign may also be collected. This includes leaves or stems fed on by the insects, as well as other identifying material (pieces of tent, silk, cocoons, chrysalides, etc.).

Take photographs as needed to aid in identification and to show the extent of an infestation.

7.4 Collection of Fungal and Lichen Material

An attempt will be made to identify any species of fungus or lichen that is adversely affecting tree health. If the fungus (or the ensuing disease) cannot be readily identified in the field, specimens may be collected in vials for later identification. Photographs may also be taken to detail the disease.

7.5. Identification

In many years, we will contract with a botanist who is familiar with the park in which we are working. This contract will be based on the number of hours spent identifying plants and will not exceed $2,500. In addition, voucher specimens, collected material, and photographs may be taken to other subject matter experts for the park in which we are working.

SOP 8: Pests and Pathogens

Version 2.0 (6/1/12)

Suzanne Sanders and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Documentation was changed from visual confirmation of the problem to a symptom-based approach.	It was not realistic to expect monitoring crews to identify all diseases and insect pests impacting trees.	2.0

8.0 Introduction

Pests and pathogens can have tremendous impacts on trees, shrubs, and herbaceous plants (Johnson and Lyon 1991, Sinclair and Lyon 2005). It is important to document and quantify outbreaks and invasions of key taxa of insects, fungi, nematodes, and other pests so that associations may be drawn between pest presence and/or abundance and long-term vegetation dynamics. This standard operating procedure (SOP) outlines the process for doing this.

This Terrestrial Pest and Pathogen indicator of forest health will be monitored within the context of the Forest Vegetation Monitoring Protocol, Version 2.0 (Sanders and Grochowski 2014). Instructions for both field methods and analysis techniques are contained or referenced within this SOP.

Because the Network will be monitoring terrestrial vegetation at each park only once every nine years, pests and pathogens will also be documented at this interval. We concede that it is ideal to monitor annually and to quantify pest and pathogen abundance directly. However, because time demands and personnel costs are prohibitive, we will monitor for pests and pathogens while at terrestrial vegetation plots. Further, we will qualify and quantify pest and pathogen activity by the signs and symptoms evident on the vegetation, and the degree of damage to vegetation, rather than by assessing abundance of the disease agents directly (USDA Forest Service–Northeastern Area 2010). This is detailed below.

The NPS-GLKN pest and pathogen sampling and analyses are designed to answer the following specific questions:

- Which pests and pathogens are present on trees in forest vegetation monitoring plots? We will attempt to identify the major causal agents of tree damage.
- What is the extent of pest and pathogen damage on trees? We will calculate the percentage of trees impacted, and note the severity of these impacts.

The answers to these questions provide direct information about the health of forests in Great Lakes Network parks. Further, this information can be combined with information on community structure, succession, and other indices of forest growth and will allow us to draw inferences on overall forest health.

8.1 Field Methods

As part of the Forest Vegetation Monitoring Protocol, all trees tallied are assessed for damage. This is accomplished by examining the bark and any branches, leaves/needles, and buds that are accessible and/or observable from the ground. The key used for identifying signs and symptoms of pests and pathogens, as well as their severity, is shown in Box 1. The red text represents the three broad categories for identifying pests or pathogens, tree stress, signs and symptoms for foliage and twigs, and signs and symptoms for branches and bole. The text in blue are the primary pest/pathogens affecting the tree, and the text in green represents the secondary pest/pathogen, which can either be a severity indicator of the primary pest/pathogen identified, or detail on the primary pest/pathogen identified.

Box 1. Signs and symptoms key for pest and pathogen detection.

A simple diagnostic protocol for tree pest detection

All text in **blue** is listed as the primary pest/pathogen on your datasheet. The most relevant choice from the list of options in **green** below the blue text is listed as the secondary pest/pathogen on your datasheet. If none of these conditions are observed, then this item should not be included in your data.

1. **Describe symptoms of tree stress (Look in field guide under: Tree Stress)**
   (Dieback, Epicormic branches, Wilt, Abiotic factors)

Dieback of twigs or whole branches is often a symptom of either biotic or abiotic stress, including drought, chemical injury, root injury or disease.

• Is Dieback present? **(Display as: Dieback)**

-None noted
-**Twig dieback in upper/outer crown (>10%), but not pervasive**
-**Pervasive twig dieback throughout the crown**

Epicormic sprouts at the base of the tree or along the bole are often a symptom of either biotic or abiotic stress. **(Display as: Epicormic Sprouts)**

• Are epicormic sprouts present on the bole? Do not include sprouting at the root collar.

-**Yes**
-No

• Wilt caused by biotic or abiotic factors. **(Display as: Wilted Foliage)**

If you know that drought or other stress factors are responsible for the wilt observed, record it here. Otherwise record it under foliage symptoms.

-No wilt
-**Wilt, partial crown**
-**Wilt, whole crown**

• Environmental stress or injury **(Display as: Environmental)**

-None noted
-**Frost cracks**
-**Lightning strike**
-**Hail injury**
-**Sunscald**
-**Broken branches**
-**Flooding**
-**Drought/poor soil**
-**Cedar bark splitting**
-**Other**

• Human-caused stress or injury **(Display as: Human-caused Stress)**

-None noted
-**Topping/Poor pruning**
-**Poor or restricted planting/mulching**
-**Wounding of woody tissues**
-**Salt/Chemicals**
-**Other**

Box 1. Signs and symptoms key for pest and pathogen detection (continued).

2. **Inspect the foliage and twigs for signs & symptoms of insects or disease.**
(Defoliation, Discolored, Abnormalities)
(Look in field guide under: Signs and Symptoms of Foliage & Twigs)

• Is defoliation present? **(Display as: Defoliation)**
Subject to a 10% threshold
- None noted
- **Defoliation, >10% of foliage, but not pervasive**
- **Defoliation, pervasive throughout the crown**
- **Leaf mining, >10% of foliage, but not pervasive**
- **Leaf mining, pervasive throughout the crown**
- **Chewing of the mid-rib only (any level)**

• Is the foliage discolored but not defoliated? **(Display as: Discolored Foliage)**
Subject to a 10% threshold
- None noted
- **Mottling, spots, or blotches (any color)**
- **Marginal scorching (browning) of leaves**
- **Interveinal scorching (browning) of leaves**
- **White coating**
- **Black coating (often sticky)**
- **Complete browning/bronzing of leaves or needles**
- **Complete yellowing of leaves or needles**
- **Stippling**
- **Yellow/orange/white pustules**

•Do the foliage or twigs appear abnormal? **(Display as: Abnormal Foliage)**
- None noted
- **Foliage/twigs distorted (including galls on foliage)**
- **Witches' brooms present**

• Are any insects or signs of insects present on the twigs or foliage? **(Display as: Insect Signs Foliage/Twigs)**
- None noted
- **Caterpillars/sawflies feeding throughout the crown**
- **Beetles feeding throughout the crown**
- **Aphids/white cotton pervasive throughout the crown**
- **Bags pervasive throughout the crown**
- **Scales pervasive throughout the crown**
- **Tents/webbing on more than one branch**

• How much of the foliage/twigs is affected? **(Display as: % Foliage Affected)**
- None
- **>10%; <30%**
- **>30% but not the whole crown**
- **Whole crown affected**

Name of the causal agent, if known (enter as notes)

Box 1. Signs and symptoms key for pest and pathogen detection (continued).

3. Inspect the branches and bole for signs & symptoms of insect and disease.
(**Insect activity, Disease presence, Abnormalities**)
(Look in field guide under: Signs and Symptoms of Branches & Bole)

• Are there signs or symptoms of insect activity on the woody branches, on the bole, or at the base of the tree? **(Display as: Insect Signs Branches & Bole)**

-None noted
-**Frass only**
-**Sawdust**
-**Pitch/resin exudation**
-**D-shaped exit holes**
-**Pencil round or oval exit holes (>=2mm)**
-**Shot holes (<2mm)**
-**Other holes**

• Are insects present on the woody branches, on the bole or at the base? **(Display as: Insect Presence)**

-None noted
-**Caterpillars**
-**Beetles**
-**Aphids**
-**Scale**
-**Carpenter Ants**

• Are there signs or symptoms of disease on the woody branches, bole or at the base of the tree? **(Display as: Disease Signs)**

-None noted
-**Decay**
-**Conks**
-**Fleshy mushrooms**
-**Cankers**
-**Bleeding/slime flux**
-**Resinosis/gummosis**
-**Woody galls or burls**
(Rhizomorphs or mycelial fans, if present, are recorded under Loose Bark)

• The signs of insect or disease activity are located on: **(Display as: Problem Location)**

-**Branches**
-**Bole and/or root collar**
Both branches and bole

• Are there signs of loose bark on the bole or branches? **(Display as: Loose Bark)**

-None noted
-**Loose bark only**
-**Rhizomorphs present**
-**Mycelial fans or pads present**
-**Insect boring or galleries causing loose bark**

Name of the causal agent, if known (enter as notes)

Box 1. Signs and symptoms key for pest and pathogen detection (continued).

3. Inspect the branches and bole for signs & symptoms of insect and disease.
(**Insect activity, Disease presence, Abnormalities)**
(Look in field guide under: Signs and Symptoms of Branches & Bole)

• Are there signs or symptoms of insect activity on the woody branches, on the bole, or at the base of the tree? **(Display as: Insect Signs Branches & Bole)**

- -None noted
- -**Frass only**
- -**Sawdust**
- -**Pitch/resin exudation**
- -**D-shaped exit holes**
- -**Pencil round or oval exit holes (>=2mm)**
- -**Shot holes (<2mm)**
- -**Other holes**

• Are insects present on the woody branches, on the bole or at the base? **(Display as: Insect Presence)**

- -None noted
- -**Caterpillars**
- -**Beetles**
- -**Aphids**
- -**Scale**
- -**Carpenter Ants**

• Are there signs or symptoms of disease on the woody branches, bole or at the base of the tree? **(Display as: Disease Signs)**

- -None noted
- -**Decay**
- -**Conks**
- -**Fleshy mushrooms**
- -**Cankers**
- -**Bleeding/slime flux**
- -**Resinosis/gummosis**
- -**Woody galls or burls**

(Rhizomorphs or mycelial fans, if present, are recorded under Loose Bark)

• The signs of insect or disease activity are located on: **(Display as: Problem Location)**

- -**Branches**
- -**Bole and/or root collar**
- **Both branches and bole**

• Are there signs of loose bark on the bole or branches? **(Display as: Loose Bark)**

- -None noted
- -**Loose bark only**
- -**Rhizomorphs present**
- -**Mycelial fans or pads present**
- -**Insect boring or galleries causing loose bark**

Name of the causal agent, if known (enter as notes)

A reasonable threshold level should be exceeded for all signs and symptoms noted. For example, the presence of a single caterpillar should not be reported if there is no evidence of defoliation or other injury to the tree. Symptoms on leaves, twigs, or branches not affecting >10% of the crown should not be reported. Minor mechanical injury on the stem and branches should not be reported.

8.2 Analyses

Pest and pathogen data will be summarized and presented in tables and figures to show the current status after each year that a park is sampled. Analyses testing for either a change or trend may be performed after two or three visits to a park, respectively. These analyses, if performed, must be done so and interpreted with caution. Insect and disease outbreaks are frequently cyclic, often occurring in <5-year intervals. Results indicating differences after five or 10 years will not necessarily be a consequence of linear change during that period. Thus, rather than test for change in tree damage over a given time interval, we will likely use pest and pathogen damage as a covariate in other analyses. For example, we may be interested in determining whether pest/pathogen damage explains differences in species diversity between the two time periods.

8.3 Acknowledgements

We are grateful to Joe O’Brien, Steven Katovich, and Manfred Mielke of the U.S. Forest Service for providing reviews of earlier drafts of this SOP. We are also grateful to the U.S. Forest Service FIA program for providing us with information on the Damage Indicator and allowing us to incorporate portions of those guidelines into this SOP.

8.4 Literature Cited

Johnson, W. T., and H. H. Lyon. 1991. Insects That Feed on Trees and Shrubs. Cornell University Press, Ithaca, New York.

Sanders, S. M. and J. Grochowski. 2014. Vegetation monitoring protocol version 2.0: Great Lakes Inventory and Monitoring Network. Natural Resource Report NPS/XXXX/NRR—2014/XXX. National Park Service, Fort Collins, Colorado.

Sinclair, W. A., and H. H. Lyon. 2005. Diseases of Trees and Shrubs. Cornell University Press, Ithaca, New York.

USDA Forest Service–Northeastern Area (U.S. Department of Agriculture, Forest Service, Northeastern Area). 2010. IPED field guide, pest evaluation and detection. U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry, Newtown Square, Pennsylvania.

SOP 9: Succession

Version 2.0 (6/1/12)

Suzanne Sanders and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Figures 1 and 2 and Table 1 were modified.	The new version reflects what we are actually using, rather than what we foresaw we would be using.	2.0

9.0 Introduction

The successional states present in Great Lakes Network national parks range from newly fallow fields (SLBE) to old growth (parts of APIS and VOYA). Most, however, are in various stages of primary or secondary succession, following historical logging events prior to park designation.

The successional trajectories followed by individual stands depend not only on site conditions such as soils and hydrography (Leak 1986), but also on past land use (Dale et al. 1990). Some historical practices (e.g., logging) can affect succession by accelerating the successional pathway (Abrams and Scott 1989) as well as by altering the trajectory (Bourgeois at al. 2004). However, more subtle current and future events may also influence the course of succession. For example, longer fire intervals are allowing more shade-tolerant species such as balsam fir (*Abies balsamea*) and paper birch (*Betula papyrifera*) to become important forest components (Frelich and Reich 1995), while early and mid-successional species such as red pine (*Pinus resinosa*) can become less common (Scheller et al. 2005). Other current impacts on forest succession include competition from invasive tree species (Titus and Tsuyuzaki 2003), injury from insects and pathogens (Malmström and Raffa 2000), and differential species response to elevated CO_2 (Catovsky and Bazzaz 1999).

This standard operating procedure (SOP) is linked to the Great Lakes Network Forest Vegetation Monitoring Protocol (Sanders and Grochowski 2014), which specifies a nine-year sampling rotation for each of nine Network parks. This SOP provides guidance on analyzing and interpreting tree and sapling data from the Forest Vegetation Monitoring Protocol so that successional trajectories in Great Lakes Network national parks may be understood. Specifically, we hope to answer two key questions about succession in Network parks:

- What are the apparent successional trajectories for habitats and forest types within Great Lakes Network parks? We will use density-diameter graphs and seedling densities to project mid-term change in GLKN forests. We will also incorporate known information on species responses to climate change and current and projected pests and pathogens to infer long-term change in GLKN forests.

- Is forest structure changing? We will measure basal area and density of all tree species ≥2.5 cm (1 in) in monitoring plots and test for shifts in forest structure.

9.1 Field Methods

As part of the vegetation monitoring protocol (Sanders and Grochowski 2014), we will record the species and diameter at breast height (DBH) of all trees (minimum DBH ≥2.5 cm) that are growing along each of three 6 m × 50 m belt transects (Figure 1) that comprise each plot. We will also record DBH and species (when possible) of standing dead trees.

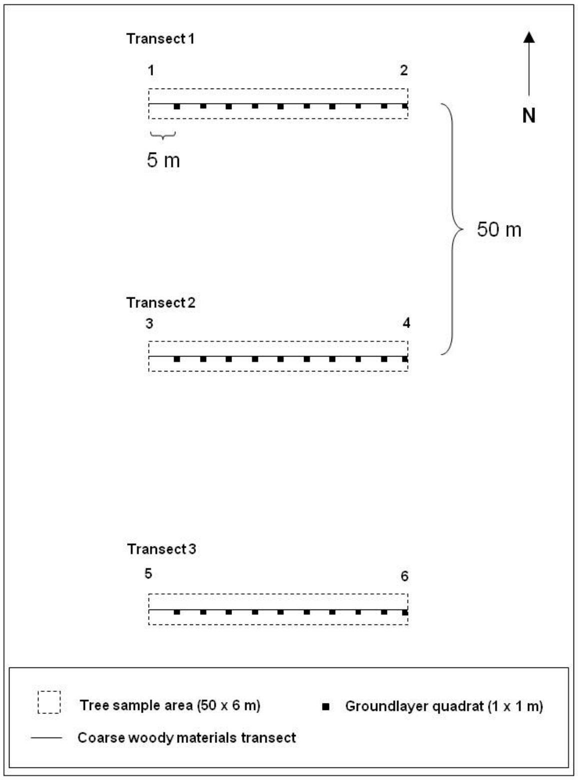

Figure 1. Hybrid plot, with 6 m × 50 m belt transects demarcated by the dashed lines.

9.2. Analysis Methods

Summary Analyses

Following the initial visit to each park, we will summarize the characteristics (density, basal area) at both the stand and individual species levels (Table 1). Summary graphs will include density–diameter graphs for different habitats or forest types (Figure 2).

Using the diameter distributions recorded during the first park visit, we will calculate the baseline (initial) surviving fraction between DBH size classes. This is the ratio of stems in a larger size class to that in the next smaller class. Where initial size structure is being maintained, a constant ratio in the number of trees present in successive size classes will emerge (Meyer and Stevenson 1943) and the resulting graphs will exhibit the characteristic reverse-J shape (Figure 3). This is typically the case in uneven-aged, and old growth forests where recruitment is balanced by mortality (Leak 1996). In younger forests—more common throughout GLKN parks—the diameter distribution shapes vary. Characteristic shapes can include a flattened bell shape (Ward and Smith 2000), indicating an even-aged forest resulting from either massive disturbance or a previous timber harvest. Severe browse can be evidenced by markedly smaller surviving fractions in the lowest size classes.

In addition to summary tables and graphs and diameter distribution graphs, additional summary information will be presented, as warranted, to display key traits about the initial forest structure.

Table 1. Example of the table layout showing basal area and density of individual species and all trees collectively during the year of plot establishment.

Latin name	Common name	Basal area (m^2/ha)	Density (trees/ha)
Hardwoods			
Acer rubrum	red maple	4.99	146.91
Acer saccharum	sugar maple	6.30	495.06
Acer spicatum	mountain maple	0.14	101.23
Betula alleghaniensis	yellow birch	11.62	303.70
Betula papyrifera	paper birch	2.65	38.27
Betula sp.	birch	0.02	0.62
Ostrya virginiana	ironwood	0.03	4.94
Populus tremuloides	trembling aspen	0.34	3.09
Quercus rubra	red oak	2.55	37.65
Sorbus decora	mountain ash	0.10	3.09
Tilia americana	basswood	0.23	3.09
Conifers			
Abies balsamea	balsam fir	0.37	95.06
Thuja occidentalis	eastern white cedar	3.67	84.57
Tsuga canadensis	hemlock	4.30	94.44
Total		37.31	1,411.72

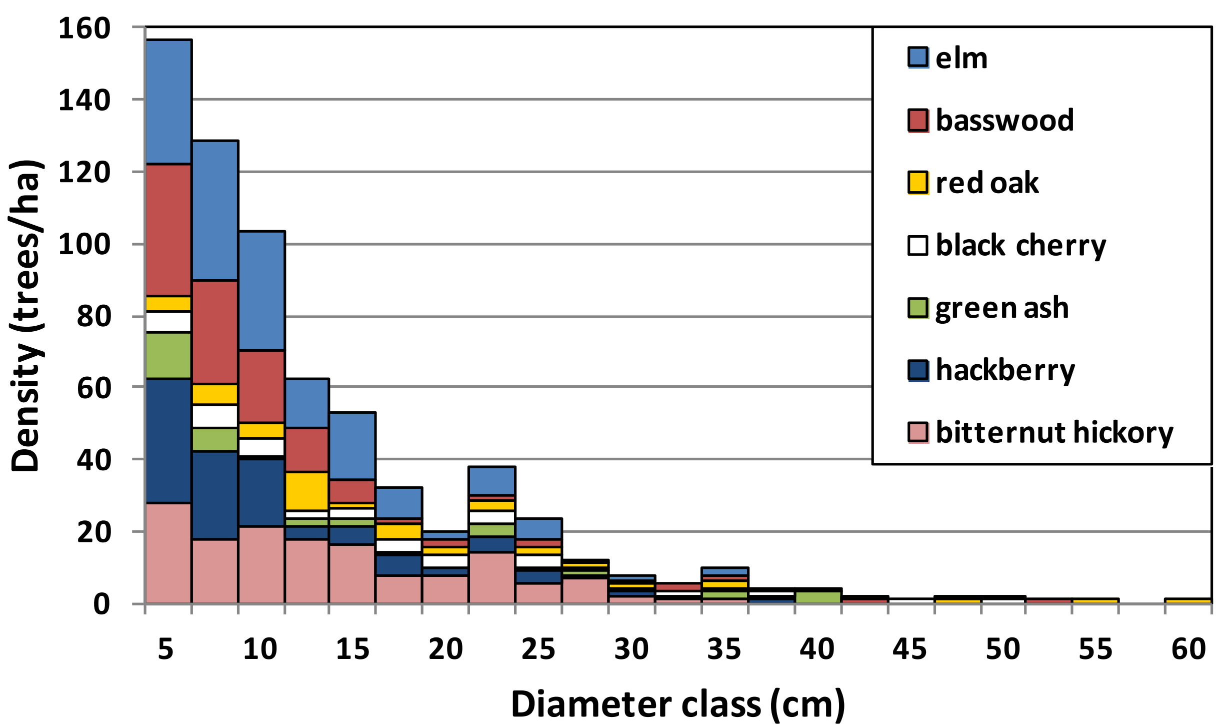

Figure 2. Example of a density-diameter graph showing upland habitats at MISS.

Trend Analyses

After the second and each subsequent visit to a park, we will again present density-diameter distributions, calculate the surviving fraction between size classes, and draw inferences about whether the site characteristics are moving toward those of stable, uneven-aged forests. We will also look at overall change in stand (plot) basal area and stem count between visits (or over time).

In addition to calculating data on surviving fractions of all species collectively, we will also present graphs and tables showing changes in size and frequency of individual species. For example, for a given habitat, we may present density–diameter distribution graphs of a given species during multiple sampling years (Figure 3). This can be used to detect and/or highlight density changes in a particular size class. Depending on the shape of these graphs, they can be used to infer the drivers of this change. For example, in Figure 3, changes in the density of the two lowest size classes may indicate high intensity browsing on saplings.

Finally, additional graphs, tables, and analyses will be presented, as warranted, to convey the successional states of Great Lakes Network forests.

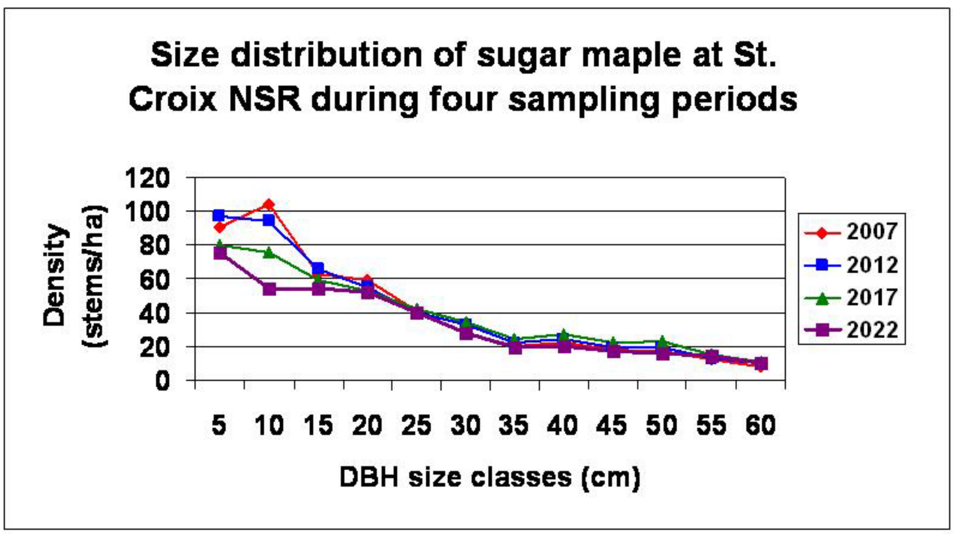

Figure 3. Hypothetical graphs showing the distribution of sugar maple size classes over four sampling periods.

9.3. Literature Cited

Abrams, M. D., and M. L. Scott. 1989. Disturbance-mediated accelerated succession in two Michigan forest types. Forest Science 35:42-49.

Bourgeois, L., C. Messier, and S. Brais. 2004. Mountain maple and balsam fir early response to partial and clear-cut harvesting under aspen stands of northern Quebec. Canadian Journal of Forest Research 34:2049-2059.

Catovsky, S., and F. A Bazzaz. 1999. Elevated CO_2 influences the responses of two birch species to soil moisture: Implications for forest community structure. Global Change Biology 5:205-518.

Dale, V. H., L. K. Mann, R. J. Olson, D. W. Johnson, and K. C. Dearstone. 1990. The long-term influence of past land use on the Walker Branch forest. Landscape Ecology 4:211-224.

Frelich, L. E., and P. B. Reich. 1995. Spatial patterns and succession in a Minnesota southern-boreal forest. Ecological Monographs 65:325-346.

Leak, W. H. 1986. Fifty years of compositional change in deciduous and coniferous forest types in New Hampshire. Canadian Journal of Forest Research 17:388-393.

Leak, W. H. 1996. Long-term structural change in northern hardwoods. Forest Science 42:160-165.

Malmström, C. M., and K. F. Raffa. 2000. Biotic disturbance agents in the boreal forest: Considerations for vegetation change models. Global Change Biology 6:35-48.

Meyer, A. H., and D. D. Stevenson. 1943. The structure and growth of virgin beech-birch-maple-hemlock forests in northern Pennsylvania. Journal of Agricultural Research 67:465-484.

Sanders, S. M., and J. Grochowski. 2014. Vegetation monitoring protocol version 2.0: Great Lakes Inventory and Monitoring Network. Natural Resource Report NPS/GLKN/NRR—2014/XXX. National Park Service, Fort Collins, Colorado.

Scheller, R. M., D. J. Mladenoff, T. R. Crow, and T. A. Sickley. 2005. Fire absence on forest composition and landscape structure in the Boundary Waters Canoe Area, northern Minnesota, USA. Ecosystems 8:396-411.

Titus, J. H., and S. Tsuyuzaki. 2003. Influence of a non-native invasive tree on primary succession at Mt. Koma, Hokkaido, Japan. Plant Ecology 169:307-315.

Ward, J. S., and D. M. Smith. 2000. Dynamics of Connecticut hemlock stands. Pages 50–54 *in* K. A. McManus, K. S. Shields, and D. R. Souto, editors. Proceedings: Symposium on Sustainable Management of Hemlock Ecosystems in Eastern North America. USDA Forest Service, General Technical Report GTR-NE-267. USDA Forest Service, Newtown Square, Pennsylvania.

SOP 10: Coarse Woody Materials

Version 2.0 (6/1/12)

Suzanne Sanders and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	References to other SOPs were changed to reflect new numbering.	Needed for accuracy.	2.0

10.0 Introduction

This standard operating procedure (SOP) provides guidance for monitoring coarse woody materials (CWM) within the nine Great Lakes Network national parks. This indicator of forest health will be monitored within the context of the Forest Vegetation Monitoring program (Sanders and Grochowski 2014). Field methods and analysis techniques are contained in this SOP, while specific details of field data collection are provided in SOP 6: Field Methods and Data Collection.

The NPS-GLKN coarse woody materials sampling is designed to answer the following specific questions:

- What is the CWM volume (m^3/ha) and biomass (kg/ha) in specific habitat types?
- What is the density (pieces/ha) of CWM in specific habitat types? We will calculate this for key size and decay classes.
- What is the magnitude and direction of change in CWM volume, biomass, and density in each habitat between two or more sampling events?

In addition to the questions above, we will use data collected on standing dead trees to determine densities of snags in key size classes.

Data from CWM sampling can be combined with that of community structure, succession, and other indices of forest growth and allow us to develop holistic forest health inferences.

10.1 Field Methods

As part of the Forest Vegetation Monitoring Protocol, the Great Lakes Network uses the Hybrid plot design (Johnson et al. 2006). This plot design was developed to meet the needs of the Great Lakes Network by combining assets of other long-term monitoring protocols used in the region. Our measurement methods and criteria mirror that of the U.S. Forest Service Forest Inventory and Analysis (FIA) program. For example, criteria for discerning between CWM decay classes will be identical between the two programs. This will enable comparisons of CWM data collected within the Network parks with that from forested areas surrounding the parks.

The Hybrid plot is composed of three parallel, 50-meter-long, horizontal distance transects, each oriented east-west (Figure 1). Data on CWM (minimum size is ≥0.90 m [3 ft] long and ≥7.5 cm [3 in] diameter) will be collected along each of these transects using the line intercept method (Brown 1974, de Vries 1986, Woodall and Williams 2005). For most CWM pieces, the parameters recorded are transect intercept diameter, small end diameter, large end diameter, length, species, and decay class (Table 1). For pieces in decay class 5, the small- and large-end diameters are not recorded, and volume and biomass calculations are based on the intercept diameter. In addition, the length must be ≥1.52 m (5 ft) and the diameter at the line intercept must be ≥12.7 cm (only pieces that still have some shape and log form are tallied; humps of decomposed wood that are becoming part of the duff layer are not tallied). Refer to SOP 6: Field Methods and Data Collection, for specific tally rules on data collection.

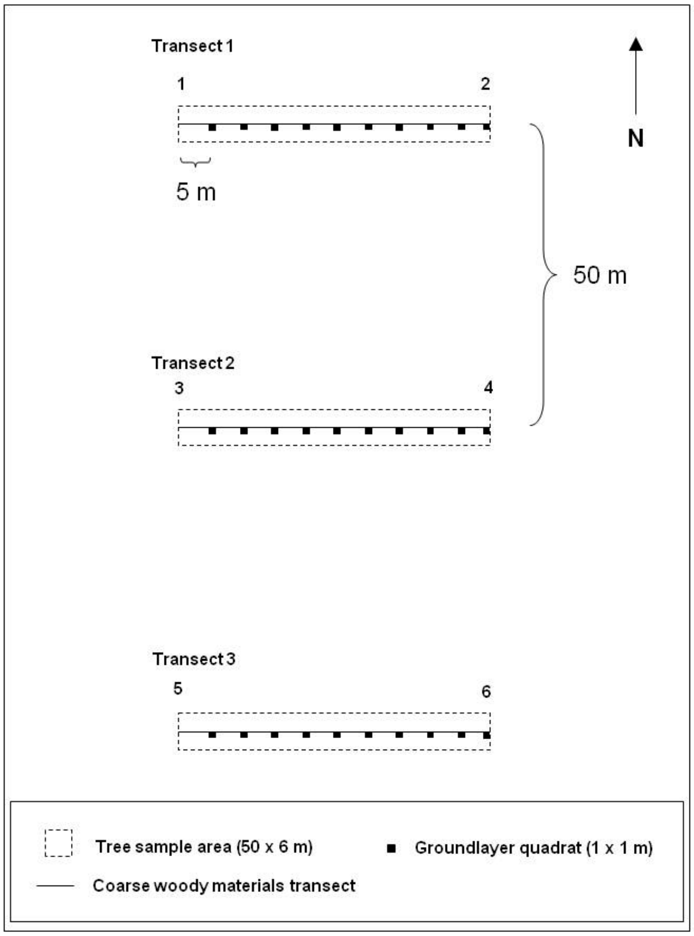

Figure 1. The Hybrid plot, showing the three parallel transects along which data on coarse woody materials will be collected.

Table 1. Distinguishing characteristics of the five decay classes. From (Woodall and Williams, 2005).

Decay class	Structural integrity	Texture of rotten portions	Color of wood	Invading roots	Branches and twigs
1	sound, freshly fallen, intact logs; all bark intact; hard when kicked	intact, no rot; conks of stem decay absent	original color	absent	if branches are present, fine twigs are still attached and have tight bark
2	sound; some bark missing; hard when kicked	mostly intact; sapwood partly soft (starting to decay) but can't be pulled apart by hand	original color	absent	if branches are present, many fine twigs are gone and remaining fine twigs have peeling bark
3	heartwood sound; most of the bark is missing; piece supports its own weight; still hard when kicked	hard, large pieces; sapwood can be pulled apart by hand or sapwood absent	reddish brown or original color	sapwood only	branch stubs will not pull out, and most of the branches < 1" missing
4	heartwood rotten; piece does not support its own weight, but maintains its shape; sounds hollow when kicked and you can remove wood from outside with boot	soft, small blocky pieces; a metal pin can be pushed into heartwood	reddish or light brown	throughout	branch stubs pull out
5	none, piece no longer maintains its shape, it spreads out on the ground; easy to kick apart	soft; powdery when dry	red-brown to dark brown	throughout	branch stubs and pitch pockets have usually rotted down

10.2 Estimation Methods

Volume estimation for CWM based on a single transect of horizontal distance length L (in meters) is calculated by:

$$\bar{y} = \frac{f\pi}{2L}\sum_{i=1}^{n}(y_i / l_i) \qquad (10.1)$$

where $\bar{y}$ is the volume in m^3/ha, f = 10,000 m^2/ha, y_i is the volume of piece i (m^3), and l_i is the length of piece i (m) (Woodall and Williams 2005).

The volume of individual pieces of CWM (V) is calculated following Smalian's formula (Husch et al. 1972):

$$V_m = \frac{(\pi/8)(D_S^2 + D_L^2)l}{10,000} \qquad (10.2)$$

where D_S is the small end diameter (cm), D_L is the large-end diameter (cm), l is the length of the piece (m), and subscripted m denotes that the units are cubic meters.

Where the small- and large-end diameters are not recorded and the only diameter is at the line intercept location, the volume of the individual piece (V) is estimated using Huber's formula (Husch et al. 1972):

$$V_m = \frac{(\pi/4)(D_T^2)l}{10{,}000} \qquad (10.3)$$

where D_T is the transect diameter (cm) and subscripted m denotes that the units are cubic meters. Refer to Appendix A for an example of the CWM volume calculation.

While volume of CWM per unit area is important for many applications, estimates of CWM biomass are critical to carbon and fuel monitoring efforts. Because the biomass of any individual CWM piece is partially dependent on its species and stage of decay, CWM biomass estimates of individual pieces must incorporate these values. Hence, biomass of individual pieces are calculated by:

$$\text{kg/ha} = (\text{cubic meters per hectare}) \times 1000\ \text{kg/m}^3 \times \text{AD} \qquad (10.4)$$

where AD is the absolute density for a given species-decay class combination (Table 2) (Harmon et al. 2008).

Biomass estimation for CWM based on a single transect of horizontal distance length L (m) is calculated by:

$$\bar{y} = \frac{f\pi}{2L}\sum_{i=1}^{n}(y_i / l_i) \qquad (10.5)$$

where $\bar{y}$ is the biomass in kg/ha, f = 10,000 m^2/ha, y_i is the biomass piece i (kg), and l_i is the length of piece i (m) (Woodall and Williams 2005).

In addition to volume and biomass, we are also interested in the density of CWM pieces. Estimation of the number of CWM pieces per hectare based on a single transect of length L is also calculated by:

$$\bar{y} = \frac{f\pi}{2L}\sum_{i=1}^{n}(1/l_i) \qquad (10.6)$$

where $\bar{y}$ is the number of pieces per hectare, f = 10,000 m^2/ha, and l_i is the length of piece i (m). An example of this calculation is shown in Appendix A.

Table 2. Species and absolute density values for trees in Great Lakes Network parks. Values are from Harmon et al. (2008).

	Decay class				
Species	**1**	**2**	**3**	**4**	**5**
Abies balsamea	0.360	0.360	0.290	0.170	0.100
Acer spp.	0.536	0.377	0.281	0.177	0.135
Acer negundo	0.536	0.377	0.281	0.177	0.135
Acer nigrum	0.536	0.377	0.281	0.177	0.135
Acer pensylvanicum	0.536	0.377	0.281	0.177	0.135
Acer rubrum	0.436	0.260	0.198	0.177	0.135
Acer saccharinum	0.536	0.377	0.281	0.177	0.135
Acer saccharum	0.679	0.452	0.324	0.182	0.150
Acer spicatum	0.536	0.377	0.281	0.177	0.135
Aesculus spp.	0.533	0.422	0.325	0.212	0.158
Aesculus flava	0.533	0.422	0.325	0.212	0.158
Aesculus glabra	0.533	0.422	0.325	0.212	0.158
Ailanthus altissima	0.533	0.422	0.325	0.212	0.158
Amelanchier spp.	0.533	0.422	0.325	0.212	0.158
Amelanchier arborea	0.533	0.422	0.325	0.212	0.158
Amelanchier humilis	0.533	0.422	0.325	0.212	0.158
Amelanchier interior	0.533	0.422	0.325	0.212	0.158
Amelanchier laevis	0.533	0.422	0.325	0.212	0.158
Asimina triloba	0.533	0.422	0.325	0.212	0.158
Betula spp.	0.580	0.403	0.265	0.170	0.110
Betula alleghaniensis	0.580	0.403	0.190	0.170	0.110
Betula lenta	0.635	0.420	0.283	0.170	0.110
Betula nigra	0.580	0.403	0.265	0.170	0.110
Betula papyrifera	0.469	0.403	0.352	0.170	0.110
Carpinus caroliniana	0.533	0.422	0.325	0.212	0.158
Carya spp.	0.633	0.417	0.195	0.173	0.151
Carya cordiformis	0.610	0.367	0.249	0.173	0.151
Carya glabra	0.599	0.409	0.238	0.173	0.151
Carya lacinosa	0.599	0.409	0.238	0.173	0.151
Carya ovata	0.551	0.479	0.308	0.173	0.151
Carya tomentosa	0.601	0.372	0.238	0.173	0.151
Castanea dentata	0.360	0.348	0.255	0.212	0.158
Celtis occidentalis	0.533	0.422	0.325	0.212	0.158
Cercis canadensis	0.533	0.422	0.325	0.212	0.158
Cornus spp.	0.533	0.422	0.325	0.212	0.158
Cornus florida	0.533	0.422	0.325	0.212	0.158
Crataegus spp.	0.533	0.422	0.325	0.212	0.158
Fagus grandifolia	0.570	0.300	0.167	0.240	0.160
Fraxinus spp.	0.475	0.317	0.298	0.212	0.100
Fraxinus americana	0.475	0.317	0.298	0.212	0.100
Fraxinus nigra	0.475	0.317	0.298	0.212	0.100
Fraxinus pennsylvanica	0.475	0.317	0.298	0.212	0.100
Fraxinus quadrangulata	0.475	0.317	0.298	0.212	0.100
Gleditsia triacanthos	0.533	0.422	0.325	0.212	0.158
Ilex opaca	0.533	0.422	0.325	0.212	0.158
Juglans spp.	0.533	0.422	0.325	0.212	0.158
Juglans cinerea	0.533	0.422	0.325	0.212	0.158

Table 2. Species and absolute density values for trees in Great Lakes Network parks. (2008) (continued).

	Decay class				
Species	**1**	**2**	**3**	**4**	**5**
Juglans nigra	0.533	0.422	0.325	0.212	0.158
Larix laricina	0.381	0.318	0.257	0.162	0.143
Liriodendron tulipifera	0.352	0.275	0.203	0.141	0.158
Maclura pomifera	0.533	0.422	0.325	0.212	0.158
Malus spp.	0.533	0.422	0.325	0.212	0.158
Morus alba	0.533	0.422	0.325	0.212	0.158
Morus rubra	0.533	0.422	0.325	0.212	0.158
Nyssa sylvatica	0.533	0.422	0.325	0.212	0.158
Ostrya virginiana	0.533	0.422	0.325	0.212	0.158
Picea spp.	0.393	0.312	0.280	0.155	0.129
Picea glauca	0.393	0.312	0.280	0.155	0.129
Picea mariana	0.393	0.312	0.280	0.155	0.129
Pinus banksiana	0.368	0.324	0.273	0.169	0.171
Pinus resinosa	0.340	0.324	0.270	0.150	0.110
Pinus strobus	0.368	0.324	0.273	0.169	0.171
Pinus sp.	0.368	0.324	0.273	0.169	0.171
Pinus sylvestris	0.368	0.324	0.273	0.169	0.171
Platanus occidentalis	0.533	0.422	0.325	0.212	0.158
Populus spp.	0.370	0.422	0.300	0.160	0.110
Populus balsamifera	0.353	0.422	0.299	0.160	0.110
Populus deltoides	0.353	0.422	0.299	0.160	0.110
Populus grandidentata	0.336	0.422	0.298	0.160	0.110
Populus tremuloides	0.353	0.422	0.299	0.160	0.110
Prunus spp.	0.489	0.418	0.281	0.212	0.158
Prunus pensylvanica	0.401	0.337	0.216	0.212	0.158
Prunus serotina	0.577	0.499	0.346	0.212	0.158
Prunus virginiana	0.577	0.499	0.346	0.212	0.158
Quercus sp.	0.565	0.462	0.318	0.196	0.248
Quercus alba	0.567	0.383	0.335	0.168	0.248
Quercus bicolor	0.611	0.450	0.382	0.241	0.248
Quercus macrocarpa	0.611	0.450	0.382	0.241	0.248
Quercus rubra	0.545	0.303	0.387	0.234	0.248
Quercus velutina	0.611	0.363	0.453	0.241	0.248
Robinia pseudoacacia	0.725	0.560	0.325	0.212	0.158
Salix sp.	0.533	0.422	0.325	0.212	0.158
Sassafras albidum	0.432	0.388	0.338	0.212	0.158
Sorbus americana	0.533	0.422	0.325	0.212	0.158
Sorbus decora	0.533	0.422	0.325	0.212	0.158
Thuja occidentalis	0.329	0.259	0.315	0.143	0.143
Tilia americana	0.406	0.333	0.256	0.212	0.158
Tsuga canadensis	0.398	0.322	0.325	0.178	0.140
Ulmus sp.	0.533	0.422	0.325	0.212	0.158
Ulmus americana	0.533	0.422	0.325	0.212	0.158
Ulmus pumila	0.533	0.422	0.325	0.212	0.158
Ulmus rubra	0.533	0.422	0.325	0.212	0.158
unknown hardwood	0.533	0.422	0.325	0.212	0.158
unknown softwood	0.375	0.323	0.279	0.164	0.142
unknown	0.454	0.372	0.302	0.188	0.150

10.3 Data Summaries and Analyses

Summarized data will be presented in figures and tables annually for each park (e.g., biomass of coarse woody material in different habitats and regions, as well as proportion of plots in different biomass categories).

To test for change between successive sampling events and among multiple sampling events, we will use repeated measures analysis of variance (ANOVA) (see SOP 13: Data Summary and Analysis). Prior to all analyses, assumptions (e.g., normality and sphericity) will be tested and modifications made if needed. Time and either habitat or region will be the main effects and CWM biomass will be the dependent variable.

Results of the CWM inventory will be compared qualitatively with those describing plant community structure. This will allow inferences to be drawn relating fuel loads, community structure, successional states, and forest health.

10.4 Acknowledgements

The Great Lakes Network is grateful to Christopher Woodall of the U.S. Forest Service for providing reviews and comments on this SOP.

10.5 Literature Cited

Brown, J. K. 1974. Handbook for inventorying downed woody material. General Technical Report INT-16. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

de Vries, P. G. 1986. Line-intercept sampling. Pages 242-279 *in* Sampling Theory for Forest Inventory: A Teach-Yourself Course. Springer-Verlag, Berlin, Germany.

Harmon, M. E., C. W. Woodall, B. Fasth, and J. Sexton. 2008. Woody detritus density and density reduction factors for tree species in the United States: A synthesis. General Technical Report NRS-29. U.S. Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, Pennsylvania.

Husch, B., C. I. Miller, and T. W. Beers. 1972. Forest Mensuration. Ronald Press, New York, New York.

Johnson, S. E., E. L. Mudrak, and D. M. Waller. 2006. A comparison of sampling methodologies for long-term monitoring of forest vegetation in the Great Lakes Network national parks. GLKN 2006/06. National Park Service, Great Lakes Network Office, Ashland, Wisconsin.

Sanders, S. M. and J. Grochowski. 2014. Vegetation monitoring protocol version 2.0: Great Lakes Inventory and Monitoring Network. Natural Resource Report NPS/GLKN/NRR—2014/XXX. National Park Service, Fort Collins, Colorado.

USDA Forest Service (U.S. Department of Agriculture, Forest Service). 2005. Forest inventory and analysis national core field guide, volume 1: Field data collection procedures for phase 2 plots, version 3.0. U.S. Department of Agriculture, Forest Service, Washington Office. Internal report. On file with: U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis, Arlington, Virginia.

Woodall, C., and M. S. Williams. 2005. Sampling protocol, estimation, and analysis procedures for the down woody materials indicator of the FIA program. USDA Forest Service General Technical Report NC-256. U.S. Department of Agriculture, Forest Service, North Central Research Station, St. Paul, Minnesota.

SOP 10, Appendix A: Example Calculations

We present here sample calculations for estimating both CWM volume per hectare and pieces per hectare. The table below shows measurements for three pieces of CWM located along a 50 m transect:

Piece ID	Species	Length (m)	Diameter (cm)	Decay class
1	*Acer saccharum*	6	8	4
2	*Quercus rubra*	14	20	3
3	*Pinus strobus*	8	12	1

Coarse woody material volume per hectare

Volume estimation for coarse woody material based on a single transect of length *L* is calculated by:

$$\bar{y} = \frac{f\pi}{2L}\sum_{i=1}^{n}(y_i / l_i) \qquad (11.1)$$

where $\bar{y}$ is the volume in m^3/ha, f = 10,000 m^2/ha, y_i is the volume of piece *i* (in $meters^3$), and l_i is the length of piece *i* (in meters) (Woodall and Williams 2005).

Where only transect diameter is measured at the line intercept location, the volume (*V*) of the individual piece will be estimated using Huber's formula (Husch et al. 1972):

$$V_m = \frac{(\pi / 4)(D^2)l}{10{,}000} \qquad (11.3)$$

where D^2 is the diameter (in cm) at the intercept point.

Thus, volume for each of the three pieces is calculated as:

Piece 1: V_m = (3.14/4) (8 cm)^2 (6m) / 10,000 = (0.785)(64 cm^2)(6m)/10,000 = 0.030144 m^3

Piece 2: V_m = (3.14/4) (20 cm)^2 (14m) / 10,000 = (0.785)(400 cm^2)(14m)/10,000 = 0.4396 m^3

Piece 3: V_m = (3.14/4) (12 cm)^2 (8m) / 10,000 = (0.785)(144 cm^2)(8m)/10,000 = 0.090432 m^3

Volume for the transect is calculated as:

$$\bar{y} = \frac{(10{,}000m^2 / ha)(3.14)}{2(50m)}\sum_{i=1}^{n}\frac{0.0301m^3}{6m} + \frac{0.4396m^3}{14m} + \frac{0.0904m^3}{8m}$$

$$\bar{y} = \frac{31400m^2 / ha}{100m} \times [0.0050m^2 + .0314m^2 + 0.0113m^2] = 314m / ha \times 0.3301m^2 = 103.71m^3 / ha$$

Coarse woody material biomass per hectare

Biomass estimation for coarse woody material based on a single transect of length L is calculated by:

$$\text{kg/ha} = (\text{cubic meters per hectare}) \times 1000\ \text{kg/m}^3 \times \text{SpG} \times \text{DCR} \qquad (11.4)$$

where SpG is the specific gravity for a species, and DCR is the decay reduction factor (Woodall and Williams 2005).

Because SpG and DCR vary, this calculation should be used for each tree:

Piece 1: $kg/ha = \dfrac{(10{,}000m^2/ha)(3.14)}{2(50m)} \times \dfrac{0.030144m^2}{50m} \times 1000kg/m^3 \times 0.44 \times 0.45 = 37.48kg/ha$

Piece 2: $kg/ha = \dfrac{(10{,}000m^2/ha)(3.14)}{2(50m)} \times \dfrac{0.4396m^2}{50m} \times 1000kg/m^3 \times 0.56 \times 0.71 = 1097.65kg/ha$

Piece 3: $kg/ha = \dfrac{(10{,}000m^2/ha)(3.14)}{2(50m)} \times \dfrac{0.0904m^2}{50m} \times 1000kg/m^3 \times 0.34 \times 1.00 = 193.02kg/ha$

then summed over all trees in the transect:

total kg/ha = 37.48 kg/ha + 1097.65 kg/ha + 193.02 kg/ha = 1328.15 kg/ha

Coarse woody material pieces per hectare

Estimation of the number of coarse woody material pieces per hectare based on a single transect of length L is calculated by:

$$\bar{y} = \frac{f\pi}{2L}\sum_{i=1}^{n}(1/l_i) \qquad (11.5)$$

where $\bar{y}$ is the number of pieces per hectare, f = 10,000 m^2/ha, and l_i is the length of piece i (in meters) (Woodall and Williams 2005).

Thus, the number of pieces per hectare is calculated as:

$$\bar{y} = \frac{(10{,}000m^2/ha)\pi}{2(50m)} \times [(1/6m) + (1/14m) + (1/8m)]$$

$$\bar{y} = 314m/ha \times [(0.16/m) + (0.071/m) + (0.125/m)]$$

$$\bar{y} = 314m/ha \times 0.356/m = 111.78/ha$$

SOP 11: Earthworm Assessments

Version 2.0 (6/1/12)

Jessica Grochowski, Ulf Gafvert, and Suzanne Sanders
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Invasion categories were revised; less emphasis on soils; better explanaitons of middens and castings.	Improves accuracy of monitoring.	2.0

11.0 Introduction

The standard operating procedure (SOP) for earthworm assessments is not intended to be a comprehensive guide for earthworm or soils monitoring. Rather, the intent is to provide information that is complementary to the vegetation protocol narrative (Sanders and Grochowski 2014) and to other SOPs assessing overall forest health.

Great Lakes Network soil monitoring will be limited to two goals: determine whether or not there is evidence of earthworms present, and determine whether or not soil horizon depths are changing between sampling events. Although more thorough analyses of soils, including tests of organic carbon and nutrients, would provide valuable information relating to plant growth and ecosystem carbon storage, these tests are cost-prohibitive.

Earthworm assessments will occur at all vegetation monitoring sites, with four samples taken at each plot (Figure 1). We have designed the earthworm assessments to address two key questions:

- Are the depths of soil horizons changing at sites through time? We will measure horizon thickness of the organic layer, and the A horizon, and note the presence or absence of the E horizon. Because earthworms can change soil horizon properties that may drive consequent changes in plant growth (e.g., richness, diversity), we will also likely test for associations between soil horizon depth and vegetative indices.

- Is there evidence of earthworms at vegetation monitoring plots? We will use visual cues on the forest floor as indicators of earthworm presence.

11.1 Definitions

We present some basic definitions below in order to clarify certain points and facilitate carrying out the methods of this SOP.

A horizon – Sometimes referred to as topsoil, this is the layer of soil located below the O horizon and above the E horizon. This layer is primarily mineral soil, with accumulation of organic matter, and typically has a dark color.

B horizon – Typically the layer of mineral soil immediately below the E horizon; this layer is generally darker than the E horizon, formed by translocation and accumulation of material from overlying horizons. We will not core to a depth representing the B horizon.

castings – Excretions left behind by worms after they finish digesting organic matter (Figures 2 and 3).

duff – Includes partially decomposed litter and woody debris. The parent material is not necessarily recognizable.

E horizon – Typically the layer of mineral soil immediately below the A horizon; this layer is generally lighter in color than both the A horizon and the underlying B horizon due to leaching (eluviation) of minerals and fine materials by rainwater and organic acids from litter.

humus – Organic matter that has decomposed to the point where it becomes stable and further decomposition will likely not occur. Humus can be present in all soil layers, but is primarily found in the organic layer (O horizon), and, to a lesser degree, in the A horizon.

litter – Non-woody organic material composed of plant parts. This includes fallen leaves, needles, cones, and seeds. The parent material of litter pieces is typically recognizable.

midden – Middens are distinctive piles of cast material around the openings to the deep vertical burrows of nightcrawlers (*Lumbricus terrestris*). These middens are usually about 1-5 cm in diameter and 1-3 cm in height, with a burrow hole (2-4 mm in diameter) near the center. The burrow entrances of middens also often have large numbers of leaf petioles or fragments of leaves sticking out of them. These become stuck there as the nightcrawler inhabitants attempt to pull leaves down into their burrows (Figure 4).

O (organic) horizon – This is the collective name for the litter and duff layer and is also sometimes referred to as the 'forest floor.'

soil horizon – A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. An upper case letter represents the defined horizons. See pages 122-123 in U.S. Department of Agriculture (1993) for more details on soil horizons.

11.2 Field Methods

Sampling locations

Sampling for both the visual cues of earthworm presence and assessment of the O, A, and E horizons is done within the plot, but outside the transects where vegetation sampling occurs. A 10- meter buffer from any outer edge of the plot perimeter is not sampled for earthworms or soils, leaving a 30 m x 30 m area (900 m^2) in each half of the plot where earthworms and soils are assessed (white area of Figure 1). In each of the two 900-m^2 soil sampling areas, two earthworm assessment sites are selected by the field crew that are representative of the plot as a whole, for a total of four earthworm assessment sample sites in the plot.

The earthworm assessments are not performed on trails or old roads, as the soil horizons in these areas were altered at one point in time. Also, low-lying wet depressions should be avoided, unless the majority of the plot is a wet depression.

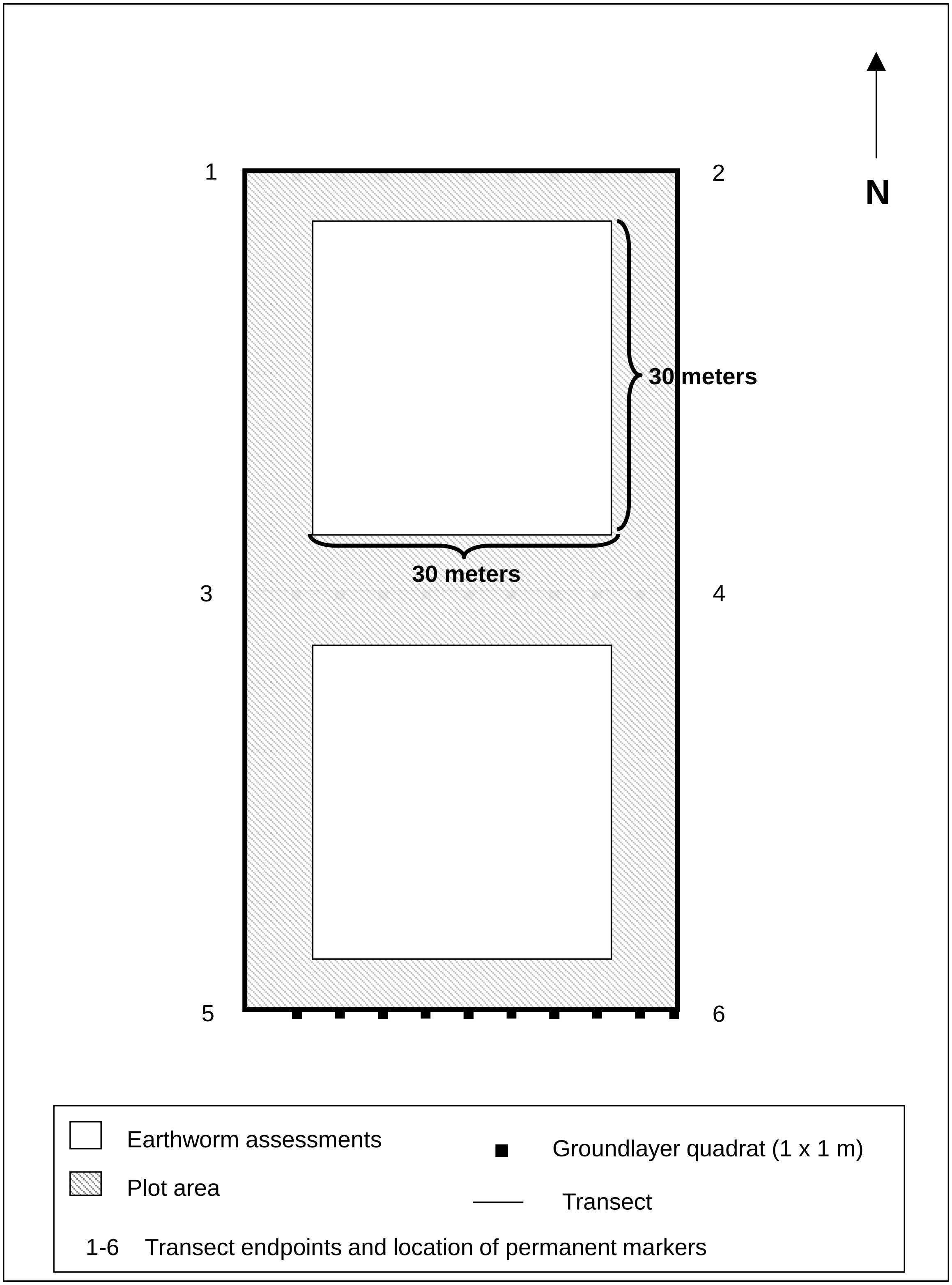

Figure 1. Forest vegetation monitoring plot layout, showing the three transects. The white squares represent the earthworm assessment sampling area. Two soil sample sites are chosen in each half of the plot, in places representative of the site as a whole.

Earthworm assessment

A visual assessment is done at each sample site to look for evidence of earthworms. Before each soil core is done, assess the forest floor in a 1 m^2 area around or adjacent to where the core will be taken. Assess the litter layer and record one of the following: 1) intact, layered forest floor in which fresh litter, fragmented litter, and humus are present (O_i, O_e, and O_a horizons); 2) litter layer partially fragmented, but containing litter from more than one year (O_i and O_e horizons); or 3) no intact litter, only freshly fallen leaves from the previous year (O_i horizon only).

1. Using a ruler, measure the depth of the litter layer (O_i) in a number of places in the 1 m^2 assessment area. If the fresh litter on the forest floor has a lot of air space, compress it to get an estimate of the thickness.

2. Using the measured values, calculate an average litter layer depth.

3. Calculate the average depth of the duff, or fragmented litter, layer (O_e).

4. Calculate the average depth of the humus layer (O_a). Note that measuring the depth of the humus layer is sometimes more easily accomplished using the soil core.

5. Record the average depth of the O horizon overall on the datasheet ($O_i + O_e + O_a$).

6. Brush away the litter layer, and look for castings and middens, classifying both as absent, present, or abundant.

    a. For the castings, absent means you did not find any, present means there are some casts but you really need to look for them, and abundant means that the castings are very obvious to see as you move the leaf litter away.

    b. For the middens, absent means you did not find any, present means there are some middens present (typically less than four), and abundant means there is a high density of middens.

7. Determine the forest floor ranking on the scale of 1-to-5, as described below (Loss et al. 2013).

Figure 2. Earthworm castings.

Figure 3. Earthworm cast material, with yellow arrows showing entrances to earthworm burrows. Note that this is *not* an earthworm midden.

Figure 4. Nightcrawler midden. Middens are about 1-5 cm in diameter and 1-3 cm in height with a burrow hole (2-4 mm in diameter) near the center. The burrow entrances of middens also often have large numbers of leaf petioles or fragments of leaves sticking out of them. Photo by Bob Bugg.

Rank 1, Earthworm free (Figure 5)

1) Forest floor and humus fully intact and layered (**O_i, O_e, and O_a horizons present**)
2) Roots and leaf fragments present in humus (O_e and O_a horizons)
3) Forest floor coherent when picked up, with intact recognizable layers
4) **No earthworms or earthworm sign present**
5) Distinct and rapid transition from forest floor to mineral soil horizon (E horizon, A horizon largely absent)

Result: Plant community remains very diverse, dominated by native species, no expansion of *Carex* spp.

Figure 5. Forest floor ranking of 1.

Rank 2, Minimally invaded

1) Humus present in patches (O_a horizon), may be slightly mixed with mineral soil; the rest of the forest floor is intact and layered (large and small fragmented leaves)
2) Some roots in the forest floor, but not thick
3) Small earthworms or cast material found in the forest floor
4) In mineral soil, earthworm **castings <u>present</u> or <u>absent</u>**, but not abundant
5) *Lumbricus terrestris* **middens <u>absent</u>**

Result: Plant community remains somewhat diverse, dominated by native species, minimal expansion of *Carex* spp.

Rank 3, Moderately invaded

1) Minimal forest floor present; larger, mostly intact leaves from the previous litter-fall present (O_i horizon)
2) Also, includes mostly intact, partially decayed leaves from more than one year (O_e horizon)
3) Plant roots <u>absent or sparse</u> in the thin forest floor
4) **No humus** present (O_a horizon)
5) Mineral soil and earthworm **castings <u>present</u>**, but not abundant
6) Small leaf fragments present under intact leaves
7) *Lumbricus terrestris* **middens absent or rare**

Result: Plant community may be somewhat diverse, with native species and/or with broken patches of *Carex* spp.

Rank 4, Substantially invaded (Figure 6)

1) **No forest floor**; larger, mostly intact leaves from the previous litter-fall present (O_i horizon)
2) Also, includes mostly intact, partially decayed leaves from more than one year (O_e horizon)
2) **No humus** present (O_a horizon)
3) Mineral soil and earthworm **castings <u>abundant</u>**
4) *Lumbricus terrestris* **middens <u>present</u>**
5) Plant roots absent in forest floor.

Result: Plant community may be sparse OR be dominated by exotic species such as garlic mustard and European buckthorn OR have a broken-to-unbroken carpet of *Carex* spp.

Figure 6. Forest floor ranking of 4.

Rank 5, Heavily invaded (Figure 7)

1) **No forest floor**; only larger, mostly intact leaves from the previous fall present (O_i horizon)
2) No small leaf fragments from more than one year present (O_e horizon)
3) No humus present (O_a horizon)
4) Mineral soil and **earthworm castings <u>abundant</u>**
5) *Lumbricus terrestris* **middens <u>abundant</u>**
6) Plant roots absent in forest floor.

Result: Plant community may be spare OR be dominated by exotic species such as garlic mustard and European buckthorn OR have a broken-to-unbroken carpet of *Carex* spp.

Figure 7. Forest floor ranking of 5.

Also look for exposed root crowns of trees and note this on the datasheet, regardless of the forest floor ranking. We will only determine the presence of earthworm signs; no attempt will be made to quantify, collect, or identify earthworms during this sampling.

Sampling at each soil sample site

In each of the four sample sites, a soil core will be taken. If you hit a rock and cannot get a complete soil core, take additional cores in the area as needed. Be careful to maintain the integrity of the core as you pull it up. You will be able to view the soil horizons in the open portion of the soil core (Figure 8).

Figure 8. Soil core used during earthworm assessments.

Using the core you removed from the ground, measure the total soil core depth. Then, measure the thickness of the A horizon, obtaining an average value if it variable in the core. If the entire soil core is comprised of the A horizon, simply record the total depth of the core and put a plus sign after it to indicate that it is deeper than you were able to get with the core. Then, note if E horizon was present or absent in the core. All measurements are to be done to the nearest 0.5 cm. If the E horizon is noted as absent, it is understood that it is absent based on the depth you were able to get to with the sole core.

Prior to leaving the site, any soil dug up will be placed back into the hole and packed down. If fine roots were present in any of the horizons, please note this on the datasheet.

The following descriptions provide more detail on the different soil horizons, and may help you differentiate between then when you are in the field. Examples of soil horizons are shown in Figures 9 and 10. Note that the soil cores used in the vegetation monitoring earthworm assessments will not go as deep as the examples provided in these figures.

O HORIZON: organic layer of fresh and decaying residue at the surface. May be separated into three layers (but all three are not always present).

O_i = fresh litter, often complete or nearly complete leaves readily distinguishable and even identifiable to species. Often layered or matted. If this layer is dry and fluffy and yielding an unreliable measure of thickness, compress the leaves to simulate what it would be if "layered" and then measure the thickness.

O_e = relatively undecomposed organic material that is fragmented so that it is difficult to identify as to its specific type or species. Peat-like and generally not blackened in color.

O_a = humified or decomposed organic material with less than 50% mineral soil component (as estimated by visual inspection). May be very black and mixed with worm cast material, but still maintains network of roots (dead or alive) and recognizable organic material.

Some O horizons are saturated with water for long periods or were once saturated but are now artificially drained; others have never been saturated. Some O horizons consist of undecomposed or partially decomposed litter (leaves, needles, twigs, moss, and lichens) that has been deposited on the surface; they may be on top of either mineral or organic soils. Other O layers, called peat, muck, or mucky peat, are organic material that was deposited underwater and has decomposed to varying stages. The mineral fraction of such material is only a small percentage of the volume of the material and generally is much less than half the weight. Some soils consist entirely of material designated as O horizons.

A HORIZON: The mineral horizon below an O horizon, or at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. If a surface horizon has properties of both A and E horizons but the dominant feature is an accumulation of humified organic matter, it is designated an A horizon.

This layer may or may not be present in any given core. It is distinguished from the O_a horizon by being composed of more than 50% mineral soil relative to organic matter. Sometimes the organic component is difficult to see, but is indicated by a black or dark brown color due to the accumulation of soluble organic molecules. Where earthworms are abundant this layer may be completely composed of worm cast material.

NOTE: *in worm free conditions this layer may not be present and the E horizon begins immediately below the O horizon.*

E HORIZON: An E horizon is most commonly differentiated from an overlying A horizon by lighter color and generally has measurably less organic matter than the A horizon. The color of this horizon generally grades quickly (2-10cm) from the black or darker colors of the overlying O or A horizon. This is a mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these, leaving a concentration of sand and silt particles of quartz or other resistant materials. An E horizon is usually, but not necessarily, lighter in color than an underlying B horizon. In some soils the color is that of the sand and silt particles, but in many soils coats of iron or other compounds mask the color of the primary particles. An E horizon is most commonly differentiated from an underlying B horizon by color of higher value or lower chroma, by coarser texture, or by a combination of these properties. An E horizon is commonly near the surface below an O or A horizon and above a B horizon, but the symbol E may be used without regard to position in the profile for any horizon that meets the requirements and that has resulted from soil genesis.

B HORIZON: The mineral horizon below an A, E or O horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon.

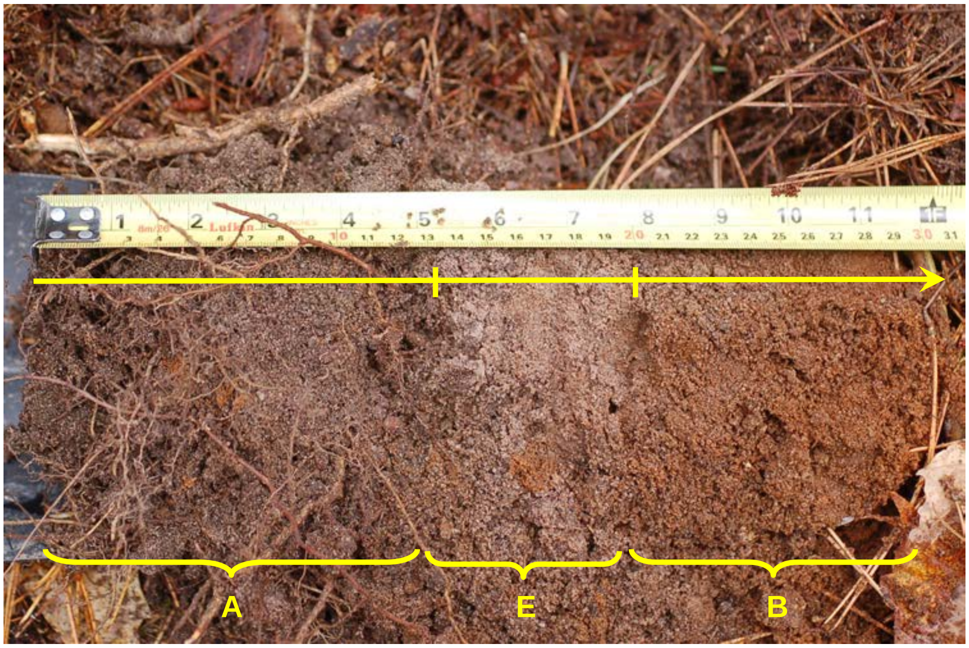

Figure 9. A horizon thickness 13 cm, E horizon thickness 7 cm, B horizon thickness 10+ cm; horizon boundary thickness is abrupt.

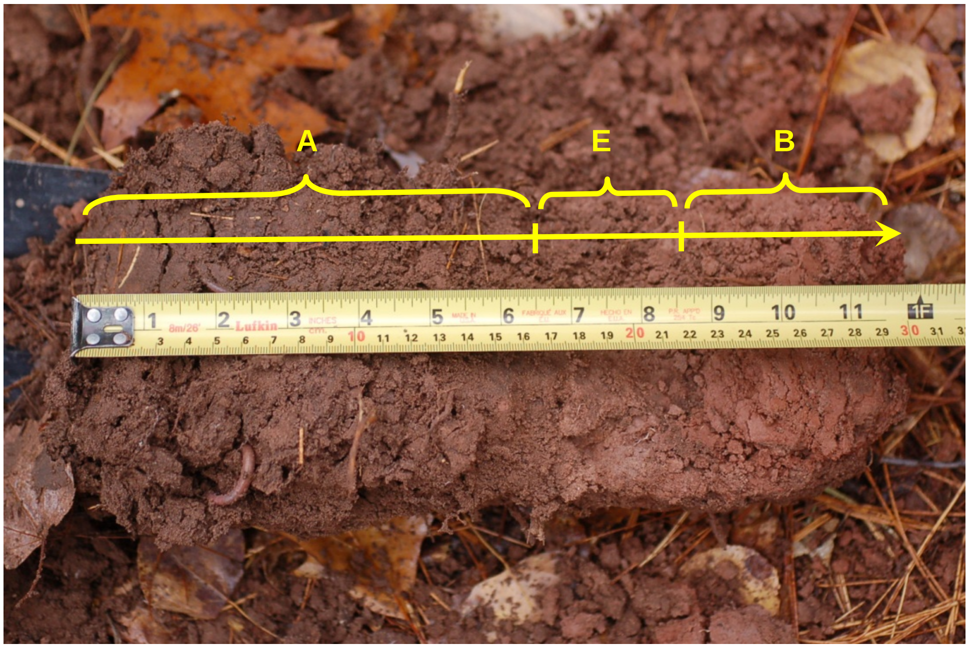

Figure 10. A horizon thickness 16 cm, E horizon thickness 6 cm, B horizon thickness 8+ cm; horizon boundary thickness is clear.

There will likely be instances where a cohesive core cannot be collected. In forested systems at Network parks, this will most likely occur where the site conditions are dry and sandy or very stony. If this is the case, deviations from the methods outlined above may be needed to determine soil horizon depths. This could include piecing together the sliced piece to simulate its original shape or any other reasonable and practical means. If there is no practical way to obtain horizon depths, then they will not be recorded and the reason why shall be noted.

11.4. Literature Cited

Loss, S. R., R. M. Hueffmeier, C. M. Hale, L. E. Frelich, G. E. Host, G. Sjerven, and L.E. Frelich. 2013. Earthworm invasions in northern hardwood forests: A rapid assessment method. Natural Areas Journal 33:21-30.

Sanders, S. M. and J. Grochowski. 2014. Vegetation monitoring protocol version 2.0: Great Lakes Inventory and Monitoring Network. Natural Resource Report NPS/GLKN/NRR—2014/XXX. National Park Service, Fort Collins, Colorado.

U.S. Department of Agriculture. 1993. Soil Survey Manual. United States Department of Agruculture Handbook No. 18.

SOP 12: Data Management

Version 2.0 (6/1/12)

Joan Elias, Mark Hart, Suzanne Sanders, and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	**Revision Date**	**Author(s)**	**Location in Document and Concise Description of Revision**	**Reason for Change**	**New Version #**
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Figure 1 was replaced; misc. wording not relevant to vegetation was removed.	This improves accuracy and conciseness.	2.0

12.0 Introduction

Data collected under the vegetation monitoring protocol (Sanders and Grochowski 2014) must be entered, quality-checked, documented, managed, and made available to others for a variety of purposes, such as management decision-making, research, and education. This standard operating procedure outlines data stewardship responsibilities and provides specific instructions and references for entering, quality-checking, and managing vegetation data.

12.1 Data Stewardship Roles and Responsibilities

The purpose of data stewardship is to share the responsibility for managing data and information resources that are organized, useful, compliant, available, and safe. The demand for detailed, high quality data and information about vegetation requires a group of people working together to ensure that data are collected using appropriate methods, and that resulting datasets, reports, maps, and other derived products are well managed.

The Great Lakes Network (GLKN) Terrestrial Ecologist serves as project manager for vegetation monitoring. The Ecologist, along with the Botanist, will supervise data collection, provide project oversight, direct on-the-ground data collections, and provide cohesive links among data collection, synthesis, interpretation, and reporting.

While the Ecologist and Botanist act as the stewards for the Network’s vegetation monitoring data, other project and GLKN personnel are also accountable for specific data management tasks. Table 1 lists stewardship responsibilities of personnel involved in the management of vegetation data. To ensure that all project data are managed properly, individuals must understand their responsibilities, communicate with one another, and assist one another as needed.

Table 1. Data stewardship responsibilities of vegetation monitoring personnel.

Personnel Role	Data management responsibilities related to vegetation monitoring
Project crew member	Crew members collect and manage data with direction and guidance from the Botanist (project crew leader) and Ecologist (project manager). Data collection includes obtaining GPS coordinates, taking digital photographs, and recording measurements and observations. Crew members are responsible for quality control by following data collection and recording instructions. Crew members will also perform data entry and verification.
Project manager (Network Terrestrial Ecologist)	The project manager is responsible for all project operations and results, and may also participate in field operations. The project manager ensures that data management activities are conducted according to established procedures and is responsible for data validation: approving the data content, quality, and documentation, as well as making decisions about data sensitivity and distribution. The project manager is responsible for evaluating project data at specified intervals, analyzing data for trends, and following reporting requirements.
Project crew leader (Network Botanist)	The crew leader normally performs many of the same duties as the project manager and ensures adherence to data collection and processing protocols, including data verification and documentation. The crew leader also works with the project manager on vegetation data management in the office.
Network Data Manager	The Network data manager ensures that vegetation monitoring data are organized, useful, compliant, available, and safe. The Network data manager oversees activities related to training, user support, quality assurance, documentation, backups, archiving, and data maintenance and distribution.
Network Data Specialist	The Network data specialist is the project manager's primary contact for database assistance, including development of tables and queries and reporting needs. The Network data specialist is also the initial contact for backups, archiving, and data maintenance and distribution.

12.2. Database Design

The vegetation monitoring database is a complex MS Access database made of two components, a front-end database and the back-end database. The front-end contains a user interface portion along with various queries, forms, reports, and visual basic code for underlying function of the database as a whole and use with the user interface. The user interface consists of various forms to help the user enter and validate data, along with the ability to query, through forms, the data for various QA/QC and final reports. The back-end database consists of numerous lookup and data storage tables, which are linked to the front-end database.

The Great Lakes Network will maintain one master copy of the vegetation database at the Ashland office on a central server. This is the only copy that can be used to export data to other locations. Additional copies of the database will be used by GLKN personnel stationed at parks, but those copies can only be used as a conduit for data entry. For analysis, the data from the master copy at the Network, that has passed all QA/QC procedures, must be used.

12.3 Data Management Procedures

Data Collection

Data values are measured and obtained according the GLKN Forest Vegetation Monitoring Protocol and recorded on field forms (see SOP 6: Field Methods and Data Collection). Crew members are responsible for legible, accurate entries on field forms. As a first step to verify data, crew members will check and double-check the recorded values prior to leaving a plot; these checks will ensure both legibility and that data were collected on all desired parameters.

Digital images of sample sites are acquired during site establishment (SOP 6: Field Methods and Data Collection) and at every visit thereafter. Crew members are responsible for proper settings and use of digital camera equipment and should refer to the user manual and SOP #6 for details specific to the camera. The photo identification number is recorded on the paper datasheets, as well as the date and time stamp on the camera. Once the photos are downloaded, the name of each photo file is changed to reflect the plot and transect endpoint at which it was taken. Original photo file names are maintained for a period of time to allow program managers to verify that the photo file names were accurately changed. Photos are stored on Network servers, which are backed up regularly.

GPS coordinates are stored as features if using a mapping-grade unit with a data dictionary, or as waypoints if using a recreational GPS unit. The GPS data will be differentially corrected to improve the accuracy of location coordinates. See SOP 4: Using the Global Positioning System, for more information on using a GPS unit.

Data Entry, Verification, and Documentation

Prior to leaving a field site, sampling crews will review the field data collection forms and verify the completeness, accuracy, and legibility of each form. As soon as is possible following sampling, a crew member will make a photocopy of each field form and ensure each copy is legible. Upon receiving the copies, the Botanist or Ecologist will proofread the datasheets, making sure that they have been filled out completely. Even after these steps are completed, some deficiencies in data recording may not be identified until all data sheets have been reviewed as a group. Originals will be kept at the Great Lakes Network Office and scans of the originals are stored on Network servers, which are backed up regularly and stored offsite.

Project staff enters plot data into the vegetation monitoring database as soon as possible following each site visit.

Data verification starts with the QA/QC steps that are detailed in SOP #17: Quality Assurance/Quality Control. As data are entered into the database, a suite of QA/QC procedures exist that compare the entered data with expected formats and accepted data value ranges or domains. For many of the variables, the MS Access database will not accept out-of-bounds data, and correction is mandatory. MS Access queries have also been developed to parse out incorrectly entered data. See Supplemental Document 2: Great Lakes Network General Vegetation Database Structure and User Guide for more detail.

A user's identification is assigned to each aspect of data handling, from collection through the final steps of QA/QC. On data sheets, the identity of the data collector(s) is recorded. Once entered, standard reports of data will be generated in MS Access and printed out. Two people will perform a final QA/QC check by reading the original datasheets and checking these values on the reports.

Executive Order 12906, mandates federal agencies to "...document all new geospatial data it collects or produces, either directly or indirectly..." using the Federal Geographic Data Committee Content Standard for Digital Geospatial Metadata. Vegetation monitoring meets the definition of geospatial data and, thus, GLKN is responsible for documenting all public datasets using metadata that meets that standard. Consult the GLKN Data Management Plan (Hart and Gafvert 2005) for additional details about metadata procedures and requirements.

Data Certification

Prior to distributing the data for any type of use, the project manager certifies the master vegetation monitoring database file according to procedures in SOP 17: Quality Assurance and Quality Control. Once all data are entered into the database, it is checked against the paper datasheets to confirm that all data are present. The data are then verified. Data verification in the project information management process indicates that the data have been entered for the period of record and that they are deemed complete but not yet certifiable. Verification does not indicate that the data are ready for distribution, only that the process of having the quality of the data assured and certified is underway. After data verification, a number of quality control and quality assurance measures are taken, and the data are certified. Data certification is a benchmark in the project information management process that indicates that the data are complete for the period of record, they have undergone and passed the quality assurance checks, and that they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies.

If this certification does not meet scheduled reporting requirements of the Network, reports can include a statement explaining that results are based on data that have not been certified. The statement should include an explanation of what significance this has for using preliminary data.

Data Distribution

GLKN has a number of different avenues for data distribution depending on the audience served and the degree of analysis and customization needed by the end-user. See Hart and Gafvert (2005) for more details. Individual data requests can be accommodated by developing queries to produce reports of the desired information.

Data Analysis and Reporting

Project staff will follow the procedures in SOP #13: Data Summary and Analysis and SOP 14: Reporting. Data summary statistics will typically include, but not be limited to:

- Mean
- Median
- Standard deviation
- Minimum

- Maximum
- Count
- Standard error
- Variance
- Range
- Mode
- Sum
- Kurtosis
- Skew

Data Folder and File Organization

All data from the vegetation protocol should be stored on the GLKN central server as soon as possible. The folder structure is shown in Figure 1.

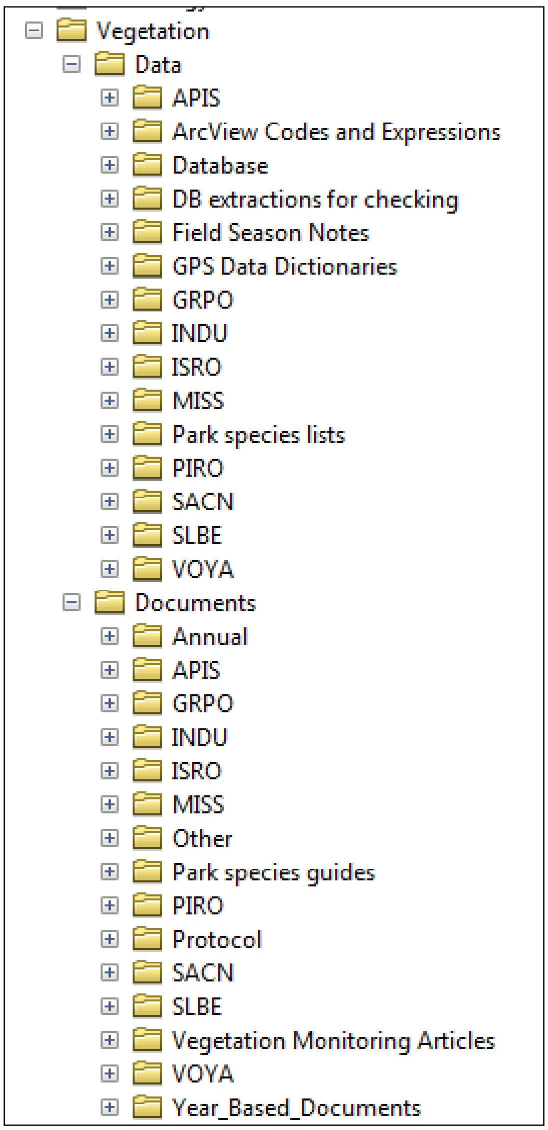

Figure 1. Great Lakes Network folder structure for information related to vegetation monitoring.

Data Archival and Distribution Procedures

Data archiving serves two primary functions: it provides a source from which to retrieve a copy of any data set when the primary dataset is lost or destroyed, and it provides a data record that is an essential part of the QA/QC process. Original data are archived at the Network office. Original data for printed forms are either the physical datasheets or exact and complete digital copies of the forms that capture all entries and notations. The unedited files are the original data for digital data.

All digital data have a duplicate file created at the earliest opportunity. The data files on field computers must not be erased until the integrity of these data files are verified on the duplicate storage medium. The removal of original data files from a field computer must be a balance of keeping memory available for new data collection and a need to keep data in their most original form for as long as possible. Field files should only be deleted when memory space is needed for new data collection, and the project manager and project crew leader will make every effort to ensure that this does not occur until the completion of the field season. Complete details of the GLKN server archiving procedure are found in the “Infrastructure” chapter of GLKN’s Data Management Plan (Hart and Gafvert 2005); the general strategy for data archiving is also described in this plan and its appendices.

12.4 Literature Cited

Hart, M., and U. Gafvert (editors). 2005. Data management plan: Great Lakes Inventory and Monitoring Network. GLKN/2005/20. National Park Service, Great Lakes Network Office, Ashland, Wisconsin.

Sanders, S. M., and J. Grochowski. 2014. Forest vegetation monitoring protocol, version 2.0: Great Lakes Inventory and Monitoring Network. Natural Resource Report NPS/GLKN/NRR—2014/XXX. National Park Service, Fort Collins, Colorado.

SOP 13: Data Summary and Analysis

VERSION 2.0 (6/1/12)

Sarah Johnson, Donald M. Waller, and Suzanne Sanders
University of Wisconsin – Madison

Suzanne Sanders, Erik A. Beever, and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Changes in analyses reflect the revised plot.	Necessary for consistency.	2.0

13.0 Introduction

This SOP provides information on analyses used to prepare reports on both static descriptions of terrestrial vegetation and changes in vegetation over time. This document also addresses the analyses used to evaluate the relationships among population, community, and environmental variables. There are many advanced approaches to analyzing complex ecological data sets such as those produced by this forest vegetation monitoring program and its associated Vital Signs. Priority should be given to the descriptive and statistical approaches described in this SOP. Several possible extensions that may provide the Network an opportunity to identify more complex relationships and interactions among multiple response and predictor variables are also described. Advances in complex analytical techniques will no doubt continue over time once data have been compiled over several sample periods. The Network should reassess their options at that time.

This SOP specifically focuses on analyses that will be used to test the following primary and secondary objectives:

Primary Objective Questions:

1) What is the rate and direction of change for key species?

2) Are plant communities changing?

Secondary Objective Questions:

1) Are there significant links between population and community variables in interpreting ecological change?

2) Are there significant relationships between changes in population and community variables and changes in environmental indicators associated with vegetation?

This protocol is designed to monitor many sites across several habitat types within each of nine national parks. This approach immediately raises the issue of whether and to what degree data from particular sites, habitat types, and parks should be aggregated for analysis. Aggregating data clearly has the advantage of increasing sample sizes and thus statistical power for analyses of ecological change. It also has the effect of averaging local site variation and so better detecting and identifying the more geographically widespread and longer-term trends that are the focus of the GLKN monitoring program. That is, more important systematic regional trends will emerge and not be obscured by the sampling error that occurs within individual sites. If sites within a given habitat type are aggregated for analysis with similar sites at other parks sampled in different years, aggregated analyses also gain the advantage of averaging the year-to-year variation that is otherwise confounded with park-to-park variation by the sampling design. Thus, the advantage of aggregating sites within habitat types can apply both when aggregating data within parks and when aggregating data across parks.

Although aggregating data within habitat types appears ecologically and statistically justified, aggregating data across habitat types could create problems both in terms of being able to detect ecological change and in terms of being able to correctly interpret the trends we detect. While such aggregation increases the sample size, it does so at the cost of inflating site-to-site (sampling) variance with the additional heterogeneity that exists among disparate habitat types. Introducing this among-habitat variance runs the real risk of not detecting significant trends that may be occurring within certain habitat types. This is because either such trends do not occur in other habitat types (swamping trends that only occur within one habitat type), or because trends may run in counter directions in different habitat types. This risk makes clear the importance of stratification, which will be done here via *post-hoc* analyses of plant community variation. Grouping sites into habitat types will typically be done by grouping into the expected climax cover type (Kotar and Burger 1996, Kotar and Burger 2000, Kotar et al. 2002, Burger and Kotar 2003). When this is not possible (e.g., if climax cover typing has not been done for a particular region or park), we will use cluster analysis to place the plots into groups of similar composition. This will be followed by non-metric, multidimensional scaling to confirm the groupings. Relatively few habitat types should be identified so as to avoid the small sample sizes that result from excessive subdividing.

13.1. Static Descriptions

After each field season, all data are analyzed to produce annual summaries on the status of terrestrial vegetation in the park sampled that year. These annual summaries provide the Network with current status information relevant to policy and management decisions. A variety of analytical approaches are utilized to assess the status of 1) environmental variables associated with terrestrial vegetation, 2) population (species-level) variables, 3) community structure variables, and 4) community composition variables at each park and across parks in the Great Lakes region. Individual plots are the unit of replication for all analyses.

Environmental Variables

Assessing the status of various environmental variables associated with terrestrial vegetation is an important first step prior to evaluating complex relationships among environmental and vegetation response metrics. Many of the environmental variables to be assessed, including proposed evaluations, are listed in Table 1. Details on some of these environmental variables are provided in other SOPs linked to this Forest protocol. Numerous other landscape-level variables not listed in Table 1 may be obtained from GIS or public databases (e.g., those that document climate trends).

Exploratory Data Analysis: All continuous data variables will be evaluated with descriptive statistics such as means and standard errors. Bar charts will be used to compare sites, habitats, or parks (Table 1). Categorical data, consisting of binary variables (e.g., presence/absence) and variables with greater than two categories, will be summarized in tables and bar charts. The tables will list all sites and will indicate presence or absence of all binary variables of interest. Summaries of these data will be presented in clustered bar graphs to make comparisons among sites at the habitat, park, and/or regional scales. Similarly, categorical data with greater than two categories (e.g., logging history) will be presented in tables and in clustered bar graphs.

Inferential Data Analysis: For some key variables (i.e., presence of forest pathogens, ungulate browse), we will determine if there are statistically significant differences among habitats or regions within a park to identify areas that may warrant more immediate management or more intensive monitoring.

Chi-square goodness of fit tests will be used to assess significant differences in the presence of earthworms and ungulate browse (Table 1) among different habitats or regions within a park. We will test the null hypothesis of no difference among habitats or regions in the relative proportion of sites with pest presence.

If the assumptions of homogenous variances and normality are met, **Analysis of Variance (ANOVA)** will be used to assess differences in continuous variables such as total fuel loads among groups (e.g., habitats or regions). Residual plots and differences in the magnitude of standard deviations between groups will be evaluated to determine if the variances are homogenous, and Q-Q plots will be evaluated to ascertain that there are no strong departures from normality. Non-parametric **Mann-Whitney U** or **Kruskal-Wallis** tests will be conducted if these assumptions are not met, even after attempting standard data transformations. In the case of ANOVA, significant main effects will be further evaluated with Tukey's HSD post-hoc test to distinguish among groups (Sokal and Rohlf 1995, Von Ende 2001).

Table 1. Planned static descriptions and analyses for tracking trends of various environmental variables that are associated with vegetation metrics. The geographic area refers to the size of area in which each of the variables was assessed within a given site; note that woody debris is actually measured along linear transects instead of within a specific area. Inferential analyses suggested for static descriptions are intended to be used to assess differences among habitats or regions within parks. The landscape variables that are listed here are intended to be included in the 'environmental matrix' for ordination analyses as well as included as predictor variables in more complex analyses described later in the SOP; they do not necessarily need to be evaluated individually in the manner that is suggested for the other variables in this table.

Environmental Variables	**Data Type**	**Geographic Area**	**Static Descriptions**	**Analyses for Tracking Change**
Soil Horizon Depths (m^2)	Continuous	4 m^2	bar charts, ANOVA	t-test, repeated measures ANOVA
Presence of Forest Pathogens	Categorical	900 m^2	tables or bar charts, X^2	logistic regression
Presence of Earthworms	Categorical	4 m^2	tables or bar charts, X^2	logistic regression
Ungulate Browse Presence	Categorical	213 m^2	tables or bar charts, X^2	logistic regression
Coarse Woody Material (m)	Continuous	150 m	bar charts, ANOVA	t-test, repeated measures ANOVA
Total Fuel Loads (m^2)	Continuous	900 m^2	bar charts, ANOVA	t-test, repeated measures ANOVA
Logging History Categories	Categorical	ca.1 ha site area	NA	NA
Fire History Categories	Categorical	ca. 1 ha site area	NA	NA
Forest Patch Size	Continuous	(from GIS)	NA	NA
Distance to Roads	Continuous	(from GIS)	NA	NA
Distance to Open Water	Continuous	(from GIS)	NA	NA

Taxonomy

Correct identification and documentation of plant species is an important aspect of monitoring. Unknown species should be identified as soon as possible and corrections made in the database prior to continuing with any analyses. It is likely that the field crew members, Botanist, and Terrestrial Ecologist will improve his/her identification skills over the season, and it is imperative that they go back and make any needed changes to species that possibly were misidentified at sites sampled earlier in the season. Frequent quality control assessments will be made by the Network Botanist and Terrestrial Ecologist that will consist of field-checking crew member identifications and the quality of their entered data. Nonetheless, the large amount of data collected suggests that there will be a number of plants that cannot be identified, in particular because species flower/fruit at different times throughout the growing season. In many cases, identifying to genus (or even family) will be all that is possible. For all parks, the Integrated Taxonomic Information System (ITIS) will serve as the nomenclatural authority.

Population Variables

We will evaluate the status of key indicator species (Table 2) that we select from the tree, shrub, and herb layers. Species lists will be constructed after each sampling period, and the Network Botanist and Terrestrial Ecologist, along with local resource managers, will select key species based on their susceptibility to various factors such as deer browse, pathogens, or reduced natural disturbance frequency. Table 2 lists various species-specific metrics and the scale at which they will be evaluated within a given park after each sample period. Table 3 lists the proposed methods of data evaluation for these variables.

Exploratory Data Analysis: Descriptive statistics (e.g., means, standard deviations, skewness, and kertosis) will be computed and the data checked for approximate normality and homogenous variances. Bar charts will be used to compare the frequency of key indicator species at the site, habitat, and park levels. Species frequency is calculated as the number of sample units that a species is observed within a given site. For example, the frequency of understory vascular plants will be calculated as the proportion of $1m^2$ quadrats within which a species is present.

Histograms will be generated to evaluate the distribution of total basal area (m^2/ha) for key individual tree species within each habitat or park. These distributions will be based on 2.5 cm size classes. Both relativized and unrelativized frequencies will be assessed with these distribution graphs.

Inferential Data Analysis: In most cases, there likely will be no reason to conduct inferential statistical analyses on population variables for static assessment reports. However, exceptions that would make such static assessments of interest to resource managers may include the need to compare current abundances of a key species between or among areas in a park with different management or disturbance histories. In the case of tree density, we will use standard **2-sample t-tests** or **ANOVAs** (greater than two regions) to test the null hypothesis that the abundance of a particular species is equivalent between or among specific regions. For evaluating differences in the frequency of key herb or shrub species between different regions, we will conduct non-parametric replicated ***G*-tests for goodness of fit** (Sokal and Rohlf 1995). We will test the null

Table 2. Key species and functional groups that will be evaluated in analyses of population-level change at each park. Species may be added or removed from this table over time, depending on unforeseen species loss or invasions and the observed statistical power to track changes in these species within or across parks.

	Park								
Species	**APIS**	**GRPO**	**INDU**	**ISRO**	**MISS**	**PIRO**	**SACN**	**SLBE**	**VOYA**
Trees and Shrubs									
Abies balsamea (balsam fir)		X		X					
Acer saccharum (sugar maple)	X			X	X	X	X	X	
Ailanthus altissima (tree-of-heaven)			X				X		
Fagus grandifolia (beech)			X			X		X	
Fraxinus spp. (ash)	X	X	X	X	X	X	X	X	X
Pinus resinosa (red pine)	X	X				X	X	X	X
Pinus strobus (white pine)	X	X		X	X	X	X	X	X
Populus deltoides					X				
Tsuga canadensis (eastern hemlock)	X					X	X	X	
Taxus canadensis (Canada yew)	X	X		X		X	X	X	X
Herbs and Functional Herb Groups									
Arisaema triphyllum (jack-in-the-pulpit)	X	X	X	X	X	X	X	X	X
Actaea spp. (baneberry)	X	X	X	X	X	X	X	X	X
Carex spp.	X	X	X	X	X	X	X	X	X
Osmorhiza spp. (sweet root)	X	X	X	X	X	X	X	X	X
Broad-leaved lily & 'lily-like' herbs[1]	X	X	X	X	X	X	X	X	X
Abiotically pollinated herbs	X	X	X	X	X	X	X	X	X
Biotically pollinated herbs	X	X	X	X	X	X	X	X	X
Abiotically dispersed herbs	X	X	X	X	X	X	X	X	X
Biotically dispersed herbs	X	X	X	X	X	X	X	X	X
Ferns and fern-allies	X	X	X	X	X	X	X	X	X

[1]*Clintonia borealis*, *Maianthemum* spp.*,* *Streptopus* spp., *Trillium* spp., *Polygonatum* spp., and *Uvularia* spp.

hypothesis that the proportion of quadrats occupied by a given species remains constant between different park regions. *G*-tests are very useful for inferring differences in species abundance across a region, in that individual *G* values from particular sites that may often fall short of significance can be combined across sites to obtain more powerful tests of overall change (Wiegmann and Waller 2006). Such tests also allow one to calculate *G*-heterogeneity values, which provide a measure of the consistency of shifts across sites or regions. Because Type I errors may occur with so many *G*-tests, Holm's (1979) correction will be used for the reported *P*-values.

We also may wish to compare basal area distributions of key tree species between, for example, a burned and unburned region of a park. We will employ the non-parametric **Kolmogorov-Smirnov two-sample test** to test the null hypothesis of no difference between two empirical sample distributions (Sokal and Rohlf 1995). To conduct the test, we will calculate the relative expected frequencies of the key tree species within each size class by dividing the frequencies observed within each region by the sample size of that region. We then will calculate the absolute value of the difference (*d*) of each of these relative frequencies for each size class. The maximum unsigned difference (*D*) is considered the largest *d* value. To calculate a test statistic, *D* is multiplied by the product of the sample sizes for the two sample periods. This test statistic is then compared to a critical value to determine the probability of observing a difference of that magnitude (or greater) between the two distributions (Sokal and Rohlf 1995). In the case that the distributions are significantly different, the density-diameter distributions will be referenced in order to determine which size classes may be represented to a greater or lesser degree in the burned and unburned regions.

Community Structure

We will evaluate the distribution of standing vegetation structure in park forests. This will involve assessing the total size of trees and the relative abundance of the herbaceous and groundlayer vegetation across sites (Tables 3 and 4).

Exploratory Data Analysis: Total basal area of trees will be averaged over sites and displayed in bar graphs to compare standing structure within habitats or parks. These data on tree and sapling diameters will be combined, and the relative frequency of trees within 2.5 cm diameter classes will be graphed. Similar graphs will be constructed to evaluate the size distributions of standing dead trees among habitats and parks.

We also will compare relative frequency of shrubs (Table 4), regardless of species, among different habitats or regions within a park. Similarly, we will evaluate the relative frequency of all herbaceous and woody groundlayer vegetation among different habitats or regions. We will again employ bar graphs for these descriptive comparisons.

Table 3. Specific population-level (for key species) and community-level response metrics to be used in analyses. Note that relativizing many of these metrics for analyses (in addition to their raw form) will also offer important information.

	Vegetation Layer	Specific Metrics	Geographic Area
Population Variables			
	Trees and Saplings	Basal area/ha	900 m^2
		Density/ha	900 m^2
		Frequency	900 m^2
		Alive:dead ratio	900 m^2
		Basal area-density distributions	900 m^2
	Seedlings	Density/ha	30 m^2
	Shrubs	Frequency	213 m^2
	Groundlayer	Frequency	30 m^2
Community Variables			
	Trees and Saplings	Total basal area/ha	900 m^2
		Total density /ha	900 m^2
		Species richness	900 m^2
		Mean similarity to other sites	900 m^2
	Shrubs	Frequency	213 m^2
		Species richness	213 m^2
		Non-native:native ratio	213 m^2
		Mean similarity	213 m^2
	Groundlayer	Species richness	1 m^2, 30 m^2, 5,000 m^2
		Non-native:native ratio	30 m^2
		Rel. abund. of functional groups	30 m^2
		Mean similarity	30 m^2
		Floristic quality index (FQI)	30 m^2

Table 4. Planned static descriptions and analyses for tracking trends of various population and community variables. The inferential statistical tests that are listed under the 'static descriptions' column will not always need to be conducted (see text). K-S test refers to the Kolmogorov-Smirnov 2-sample test.

Variables	**Static Descriptions (and Possible Analyses)**	**Analyses for Tracking Change**
Population (single species) variables		
Basal area (trees)	bar charts, t-test, ANOVA	t-test, repeated measures ANOVA
Density (trees)	bar charts, t-test, ANOVA	t-test, repeated measures ANOVA
Dead:alive ratio (trees)	bar charts, X^2	t-test, repeated measures ANOVA
Density-basal area distributions (trees)	bar charts, K-S test	K-S test
Relative abundance (frequency of a species in any vegetation layer)	bar charts, t-test, ANOVA, *G*-tests	*G*-tests
Community structure variables		
Total basal area/ha (trees)	bar charts, t-test, ANOVA	t-test, repeated measures ANOVA
Tree total density/ha (trees)	bar charts, t-test, ANOVA	t-test, repeated measures ANOVA
Relative frequency (all shrubs)	bar charts, *G*-test	*G*-test
Total density-basal area distributions (trees)	bar charts, K-S test	K-S test
Total density-basal area distributions of dead trees	bar charts, K-S test	K-S test
Relative frequency (all herbs)	bar charts, *G*-test	*G*-test
Community composition variables		
Species richness	bar charts, ordination, t-test, ANOVA	t-test, repeated measures ANOVA, ordination
Mean similarity	bar charts, ordination	t-test, repeated measures ANOVA, ordination
Non-native:native ratio	bar charts, ordination, X^2	t-test, repeated measures ANOVA, ordination
Relative abundance (frequency) of different functional groups	bar charts, ordination, t-test, ANOVA	t-test, repeated measures ANOVA, ordination
Floristic quality index (FQI)	bar charts, ordination, t-test, ANOVA	t-test, repeated measures ANOVA, ordination

Inferential Data Analysis: As mentioned above for population variables, we will not always need to conduct inferential statistical analyses for static assessments of community structure. These analyses only need be conducted if park managers have *a priori* interest in determining if there are differences in, for example, tree basal area among different habitats or regions with contrasting management or disturbance histories. We will compare total tree basal area or average shrub cover between or among habitats or regions with **2-sample t-tests** or **ANOVAs**, and will use the **Kolmogorov-Smirnov two-sample test** to evaluate differences in total basal area distributions between two habitats or regions. *G*-tests will be used to assess departures from an equivalent relative distribution of all herbaceous or woody groundcover between different habitats or regions.

Community Composition

We will use several descriptive approaches to evaluate the status of community composition in parks after each sample period (see Tables 3 and 4). In addition to total species richness, we also are interested in the relative abundance of the various species making up this sum richness. Besides calculating the number of non-native species relative to native species, we will also evaluate the relative abundance of species with different morphological or life history traits ('functional traits'). Differential assemblages of species with different functional traits may elucidate patterns in composition that reflect specific disturbances. For example, Wiegmann and Waller (2006) documented species losses over a 50-year period in northern Wisconsin. The declining species were typically those that rely on animals for pollination and/or dispersal and that are sensitive to herbivory by deer; whereas, increases were noted in abiotically pollinated or dispersed species, especially graminoids.

We also will determine the degree of similarity between sites with respect to the identity and abundance of species at a site compared to all other sites, and we will evaluate the quality of sites based on the identity of the species present.

Exploratory Data Analysis: Descriptive statistics, including means and standard errors, will be generated to evaluate species richness (number of species) within and among sites of a given habitat and/or park. These exploratory analyses will be conducted separately for each forest layer: trees, saplings, shrubs, seedlings, and herbs. Species richness of herbs will be assessed at the levels of 1m^2, 30 m^2 quadrats, and within 5,000 m^2 walkthrough areas at each site. Species richness does not take into account composition; hence, it is recommended that separate evaluations be conducted for native and non-native species richness. The ratio of native to non-native species will be assessed to identify regions within each park that may be more highly invaded by exotic species.

It is of particular importance to recognize that the number of species encountered in a given sample generally reflects the area sampled (the typical species–area curve) and/or the number of individuals encountered. This makes it necessary to use a standard area or number of individuals when comparing diversity patterns across habitats or parks, e.g., by constructing 'rarefaction' curves (Smith et al. 2000, Gotelli and Colwell 2001). Species–area and species–individual curves can be created with the free program EstimateS (Colwell 2005). Examples of these graphs can be viewed in Johnson et al. (2006).

To examine similarity in community composition among sites and to identify groups of sites of similar habitat, **nonmetric multidimensional scaling (NMDS)** ordination may be conducted in PC-ORD (McCune and Grace 2002). This will be achieved through the following main steps:

1) Construct primary matrices containing species frequency values within a given forest strata for all sites.

2) Create secondary matrices containing environmental variables associated with each site. These environmental variables can be quantitative or categorical and can include: depth of various soil horizons, presence (or abundance) of pests and pathogens, deer browse frequency or intensity, cover type as determined by dominant tree species, and logging history categories. Descriptive site metrics, such as native to non-native species ratio, or relative site richness will also be included in this secondary matrix.

3) Conduct ordination analyses following procedures outlined in McCune and Grace (2002). We will use the Sørensen (Bray-Curtis) distance measure (Beals 1984) for ordinations. Separate ordinations will be performed for trees, shrubs, and herbs (the herb dataset will also include woody shrub and seedling species sampled within ‘herb’ plots). Sites falling close together in ordination space are more similar in composition than are plots lying further apart. Hierarchical cluster analysis will be used to define community types or ‘habitats’ among sites. Choice of linkage method and distance measure will be made following the guidelines in McCune and Grace (2002).

Other ways to identify sites may also be used. For example, forest type grouping by the Kotar classification method (Kotar and Burger 1996, Kotar et al. 2002) classifies ‘site potential,’ or the expected climax forest type, which is based on hydrology and nutrient availability and assessed by the current understory species.

Inferential Data Analysis: After identifying groups of sites with hierarchical cluster analysis, we will use the **Multi-response Permutation Procedure (MRPP)** to test the null hypothesis of no difference between two or more groups. MRPP is a nonparametric procedure recommended for ecological community data, as it can be used without meeting the typical assumptions of multivariate normality and homogeneity of variances (McCune and Grace 2002). The same distance measure selected for ordination analyses (Sørensen) will be applied to these MRPP analyses. This analysis will be conducted with PC-ORD, which provides an estimate of the effect size and a p-value. The effect size is estimated with the ‘chance-corrected within-group agreement’ (A) statistic that provides an estimate of the difference between within-group homogeneity and that which would be expected at random. If $A = 1$, then sites within each group are identical, whereas $A = 0$ if groups of sites are as different as would be expected by chance. Statistical significance among groups will depend largely on the effect size and sample size, and McCune and Grace (2002) recommend that care be taken in determining whether or not statistical significance translates into ecological significance.

13.2. Detecting Change

Each park will be visited and surveyed every nine years. Once a given park has been sampled a second time, tests for changes in metrics will commence. It will be possible to test for trends with more sensitivity and to evaluate changes in trends once the third sampling event for any given park is complete. In addition to investigating changes in environmental variables and population and community vegetation variables, we also will be assessing the relationships among all of these variables. Such tests, however, depend on an important initial step: taxonomy synchronization, which is described below.

Environmental Variables

Exploratory Data Analysis: For each metric (see Table 1), we will compute descriptive statistics, including means and standard errors, which we will then present in bar charts with bars clustered by sample year. Data from sites within specific habitats will be combined for these analyses, but we also will provide summaries across all sites at the park level.

Inferential Data Analysis: We will take a similar approach to that described in the 'Static Descriptions' section above, but we will extend our analyses so we can look at significant changes in variables over time. We will determine if there are significant increases or decreases in the presence of key variables (i.e., forest pathogens, earthworms, ungulate browse) over time across sites within specific habitats or regions within a park. We will use **Chi-square goodness of fit** tests to test the null hypothesis of no difference between sample periods in the relative proportion of sites with pests or pathogens present among habitats or regions.

Parametric **paired *t*-tests** can be used to assess changes between two sample periods for continuously distributed metrics (e.g., total fuel loads; see Table 1) when the standard assumptions of homogenous variances and normality are met. **Repeated measures ANOVA** will be used to assess changes in metrics once more than two sample periods are completed. Analyses will be conducted separately for each park or with 'park' added as a factor to the ANOVA. The repeated measures ANOVA models will include time (years) as a within-subject factor and several possible between-subject variables, depending on the questions being asked. The within-subject factor refers to the response variable being measured repeatedly for all sites, and the between-subject factors refer to the response variable being measured on sites within independent groups of sites exposed to different conditions. Examples of between-subject variables that we may use include: cover class, presence of pests or pathogens, and park when data are aggregated across parks to look for regional trends (see Table 1 for list of environmental variables). The factors will be included into the ANOVA model so as to correctly represent the nested structure. The standard assumptions of ANOVA will be checked, but we also will check the sphericity assumption specific to repeated measures ANOVA. Mauchly's test for sphericity will be used to assess whether the variance-covariance matrix is such that the magnitude of differences between any two years of the within-subject variable (time) are equal (Von Ende 2001). Von Ende (2001) states that this assumption often is not met when the model includes time as a within-subject factor. If the sphericity assumption is not met, then a correction factor (i.e., Huynh-Feldt Epsilon) will be used to adjust the degrees of freedom, because F-statistics for within-subject factors and their interactions with other variables become inflated with departures from sphericity (Von Ende 2001).

Significant differences in time will be assessed with *a priori* within-subject contrasts, and significant between-subject effects will be followed up with Tukey's HSD post-hoc test to distinguish among groups (Sokal and Rohlf 1995, Von Ende 2001). Profile plots with the response variable on the y-axis, time (sample period) on the x-axis, and groups plotted with different symbols will aid in the interpretation of significant interaction terms. For significant interaction terms, contrasts will be constructed and used in univariate analyses (i.e., t-test or ANOVA) to assess significant differences between groups among sample periods. Contrasts will be constructed to assess significance between specific groups at specific time intervals to avoid inflating the Type I error rate with multiple unneeded analyses. Holm's (1979) adjustment will be conducted on all p-values reported from these contrast assessments to further limit the probability of making Type I errors with multiple analyses.

Taxonomic Synchronization

As data will be collected by different botanists among parks and among years, there is the potential for errors in identification to occur. In addition, updated taxonomy may result in different species names being used across sample periods. To address these issues, the taxonomy must first be synchronized among sample periods before conducting analyses. The following steps outline this process:

1) Generate a list of all species found within each site for all sample periods.

2) Run database queries to produce tables that present the frequency of each species at each site by sample year.

3) The Network Botanist reviews this list to address any taxonomic discrepancies among years. For example, this exercise may indicate that the Botanist identified *Dryopteris intermedia* at all sites one year, but that another Botanist in another year only recorded *D. carthusiana* at these sites. In this case, these two species are known to be somewhat difficult to differentiate in the field, and without numerous voucher specimens (which may not be allowed by some parks), one would not be able to discern which Botanist was correct.

4) Document all decisions to lump species or to change species identifications in the metadata (see SOP 13). Changes should not be made to the original datasets, but instead be saved to a 'synchronized' dataset directly linked to the metadata.

5) Repeat this process with the raw data each time new data become available.

Changes in Population Variables

Typical plant community datasets are full of zeros or low numbers, reflecting the fact that most species are infrequent across plots and across sites (McCune and Grace 2002). We likely will have limited power to detect significant changes in the abundance of individual species within sites and habitat types (Johnson et al. 2006), though data aggregated across the region may prove to be informative. We will thus be circumspect when making inferences about population changes. As more power can be attained with aggregated or composite indicators, we will place most of our emphasis on composite groupings of species based on functional traits or taxonomic relatedness (Johnson et al. 2006). The following proposed analyses will refer to 'species,' but this term should be replaced with 'composite indicator' in cases where species-level analyses are not being conducted. The metrics and the proposed analyses to evaluate them are listed in Table 4.

Exploratory Data Analysis: For groundlayer vegetation, we will generate species lists and compute the frequency of occurrence for key species for each sample period. We will calculate the change in these species' frequencies between each successive sample period and present these results in histograms or line graphs. By plotting positive and negative values, the histograms will clearly depict increasing or decreasing frequencies of species.

We will evaluate changes in average basal area and average density of key tree species by presenting these data, along with standard errors, in bar charts. Changing ratios of alive and dead individuals of these key species also will be monitored through time; we will present those data in stacked bar graphs. We will use clustered bar graphs for cases where we wish to compare the metrics over time between or among habitats or regions in a park. Because we also will have abundance and size information for trees, we will produce density-size distribution curves for select tree species. This will include species susceptible to browse, as well as those with known regeneration or disease problems. The data on tree and sapling diameters will be combined and the relative frequency of trees within 2.5 cm diameter classes will be presented in line or bar graphs at the habitat or park levels.

Inferential Data Analysis: Changes in species abundance over time will be evaluated using non-parametric replicated ***G*-tests for goodness of fit** and **repeated measures analysis of variance (ANOVA)**. These analyses will allow us to determine whether individual species' (or composite groups') abundances are significantly increasing, declining, or remaining constant.

Replicated *G*-tests will be used to analyze the frequency data collected for herbs, shrubs, and seedlings (see Table 4). We will test the null hypothesis that the proportion of quadrats occupied by a given species remains constant over repeated sampling intervals. *G*-tests are very useful for inferring changes in species abundance across a region because individual *G* values from particular sites that may often fall short of significance can be combined across sites to obtain more powerful tests of overall change (Wiegmann and Waller 2006). Such tests also allow one to calculate *G*-heterogeneity values, which provide a measure of the consistency of shifts across sites or regions. Because Type I errors may occur with so many *G*-tests, Holm's correction may be used when reported *P*-values are being considered.

Repeated measures ANOVA will be used to analyze continuously distributed variables such as tree basal area and density (see Table 4). The procedures for this analysis are described above. We will determine if the density-diameter distributions of key species are significantly changing with time by implementing the **Kolmogorov-Smirnov two-sample test**. This will provide a sensitive test of the null hypothesis that the density-diameter distributions for trees sampled one year is the same as the sample distribution observed in a second sample year. This test is described in more detail in section 13.1.

Changes in Community Structure

We will evaluate the distributions of the relative sizes of individuals within each stratum between sample periods to evaluate how community structure is changing. These comparisons of structural changes should provide insight into successional and regenerative processes in the parks. They can also be used to assess how vegetation is being affected by other drivers of change such as deer. Basic successional processes predict that tree stem density will decrease and stand basal area will increase over time. Tracking structural changes over time will also allow us to make connections with other Vital Signs, such as bird communities that depend on this structure for food and shelter.

Exploratory Data Analysis: Community structure will be assessed by examining the size distribution of all species combined across sites within specific habitats or regions of parks. Response variables to be analyzed include tree basal area, tree density, and shrub frequency (see Table 4). Tables and graphs, or both, that present means and measures of variability (e.g., standard errors) will be generated to provide a descriptive view of changes in size metrics through time. Total tree density-size distributions will be constructed for each sample period, and we will identify shifts in overall forest structure within specific habitats or regions. Diameter size classes (2.5 cm classes) will be presented on the x-axis of these graphs. Similarly, we will evaluate changes in the size distributions of standing dead trees among habitats and parks.

We will calculate the instantaneous rate of change (lnλ) in average basal area and average density between two sample periods by using the equation

$$\ln(\overline{X}_{\text{year } 6}) - \ln(\overline{X}_{\text{year } 1}) = \ln\lambda.$$

We will use bar charts to evaluate the instantaneous rate of change in these metrics by graphing lnλ for each site within a specific habitat or region of a park.

Inferential Data Analysis: Separate **repeated measures ANOVAs** (or **paired t-tests** if there are only two sample periods) will be conducted for each response variable to determine how these structural metrics are changing over time within each park. These response variables will be transformed if they do not meet the ANOVA assumptions of homoscedasticity and normality.

We will implement the **Kolmogorov-Smirnov two-sample test** to determine if there are differences in the density-diameter distributions of total tree structure, regardless of species, between time periods. The procedures for this test are outlined above in section 13.1.

Changes in Community Composition

The understory and overstory data will be evaluated (see Table 3) to determine whether species richness has changed, whether the ratio of non-natives to natives has shifted, whether sites have become more or less similar in species composition and relative frequency, and whether site quality is changing, reflecting changes in the identity of species at a site. The magnitude and direction of change for each of these components also will be assessed.

Exploratory Data Analysis: Descriptive statistics and graphs will be generated to compare metrics associated with each forest layer through time prior to conducting more rigorous statistical analyses. These initial data summaries should include assessments on the following metrics: 1) mean quadrat richness (1 m^2 herb plots only), 2) mean site-level richness of the groundlayer, 3) ratio of non-natives to natives, 4) mean site-level shrub richness, 5) mean tree richness, 6) mean coefficient of conservatism (FQI, see below), and 7) site similarity (see below).

We will determine if the biological integrity of sites has changed over time by tracking changes in the Floristic Quality Index (FQI). FQI is a highly sensitive quantitative tool that assesses the quality of a site, specifically the degree of degradation, by taking into consideration the identity of species at these sites (Swink and Wilhelm 1979, 1994). Use of a FQI is dependent upon coefficients of conservatism (*C*) that are assigned to all species in the flora by trained botanists. Values of *C* range from 0 to 10, with 10 referring to those species that are very sensitive to degradation; hence, they are never found outside of intact natural communities. Weedy species that show no devotion to specific habitats are represented by *C* values of 0 (Swink and Wilhelm 1994). All non-native species will be scored a '0' for these analyses. The original formula for computing FQI has been demonstrated to confound *C* with species richness (Rooney and Rogers 2002), so it is suggested that average of *C* ($\overline{C}$) be used as the index of floristic quality (Wilhelm and Masters 1994, Francis et al. 2000, Rooney and Rogers 2002). Values of *C* have been assigned to floras in Illinois (Taft et al. 1997), Michigan (Herman et al. 1997), and Wisconsin (Bernthal 2003). Wisconsin *C* values will be applied to species lists associated with sites sampled in southern Minnesota (Saint Croix National Scenic Riverway and Mississippi River and National Recreation Area), while Ontario's *C* values (Oldham et al. 1995) will be applied to the species list produced in northern Minnesota at Voyageur's National Park and Grand Portage National Monument. Because values are specific to habitats within each state, they may differ for species as one travels further away from that state, so we will consult with Minnesota master botanists to assure that these *C* values are suitable for species lists associated with Minnesota sites. We also will consult with Minnesota botanists if some of the species on our list are not on Wisconsin's or Ontario's list of species with *C* values. Isle Royale National Park was taken into consideration when assigning *C* values to Michigan's species (T. Reznicek, pers. communication), so we will use the Michigan database for that park, despite the fact that it likely is ecologically more similar to Minnesota and southern Ontario.

We will compute the mean *C* ($\overline{C}$) for each site, with *C* values for each species within 1 m^2 groundlayer quadrats weighted by abundance (frequency at a site). We will calculate the instantaneous rate of change (lnλ) in $\overline{C}$ between two sample periods by using the equation

$$\ln(\overline{C}_{\text{year 6}}) - \ln(\overline{C}_{\text{year 1}}) = \ln\lambda.$$

We will compare the instantaneous rate of change in $\overline{C}$ across sites within a specific habitat by graphing lnλ for each site using bar charts.

Similarly, we will compute the instantaneous rate of change in numerous other vegetation metrics at the site level such as groundlayer species richness, shrub species richness, frequency of woody vegetation in groundlayer quadrats, tree basal area, and tree density. We will then generate matrix scatterplots to look for trends between the rates of change among these variables, including the rate of change in $\bar{C}$. In addition, we will construct matrix scatterplots to look for relationships between these rates of change and static values (from the most recent sample year) among sites for each of these metrics (e.g., $\bar{C}$, groundlayer richness, average tree basal area).

Tests of similarity among sites will be conducted using a collective index of species composition and relative frequency. To do this, the degree of similarity of each site to all other sites in a given park will be determined using the Sørensen (Bray-Curtis) distance (*S*) for each pair of sites using the formula:

$$S_{jk} = 1 - [(\Sigma | x_{ij} - x_{ik} |) / \Sigma(x_{ij} + x_{ik})]$$

where x_{ij} and x_{ik} are the number of quadrats in which species *i* is found at site *j* or *k* (McCune and Grace 2002, Rooney et al. 2004). Values of *S* close to zero indicate low similarity of composition (relative abundance), whereas values close to 1 indicate strong similarity between sites. The ecological analysis programs PRIMER (PRIMER-E Ltd.) or R can be used to quickly generate similarity matrices.

Changes in similarity of community composition among sites sampled through time will be evaluated using NMDS ordination and vector change analyses. Separate ordinations will be conducted for trees, saplings, shrubs, and herbs (the herb dataset will include woody shrub and seedling species sampled within ‘herb’ plots). For each ordination, a primary matrix containing species abundances for all sites stacked by year will be overlain by an environmental matrix that includes a column for year and other columns containing a variety of environmental variables such as soil horizon depth, presence/absence of pathogens, deer browse frequency, cover type, and logging history. The ordinations will be graphed and vectors used to connect sites sampled during different years. The length and direction of these vectors will be analyzed to determine the magnitude of change through time and to determine if sites are changing in a consistent manner (i.e., whether sites are converging, diverging, or shifting composition parallel to each other).

Inferential Data Analysis: **Repeated-measures ANOVA** (or **paired t-tests** if less than three sample periods) will be used to determine if mean quadrat richness (1 m^2 herb plots only), site-level richness, ratio of non-natives to natives, $\bar{C}$, and site similarity values have significantly changed in each forest stratum through time. The same approach for repeated measures ANOVA will be used as outlined above. The ratio of non-natives to natives will be calculated using the same approach as documented in section 13.1. If it can be determined from these analyses that sites are becoming more similar over time, then it is concluded that biotic homogenization is occurring (Rooney et al. 2004, Olden and Rooney 2006). Reports of changes in similarity should not be made without considering the ecological context. Specifically, if biotic homogenization is increasing, then it should be noted whether this is based on species loss or gain.

Exploring Relationships Among Variables

Identifying links among variables will provide us with a better understanding of factors that likely are driving the changes that are observed in individual variables. We will use several analytical approaches to evaluate relationships within and among environmental, population, and community variables (Figure 1). These analyses are intended to be cursory investigations into the very complex linkages and interactions among numerous response and predictor variables. More elaborate and powerful analyses are suggested in the 'Possible Extensions' section of this document. In exploring these relationships, we can generate numerous questions about direct and indirect linkages among variables. For instance, are changes in the understory population and composition variables associated with changes in the overstory? Are these changes in the understory related to changes in environmental variables? Are changes in the overstory related to changes in environmental variables? Are changes in the shrub layer associated with changes in the overstory and/or changes in environmental variables? Can changes in some environmental variables be attributed to changes in other environmental variables? We will conduct exploratory and inferential analyses to address each of these questions, along with other questions that likely will arise.

These direct and indirect linkages among variables may be evaluated as static relationships, or they may be a function of changes among variables (Figure 1). We do not separate static descriptions and change detection in this section, as some of these variables can actually be combined in some analyses. For example, tree basal area (current year's data) and changes in tree BA may both be included as variables in analyses (e.g., as predictor variables in a multiple regression).

Exploratory Data Analysis: Scatterplots are a descriptive tool that will allow us to identify linear and non-linear relationships as well as no association between variables that we assume *a priori* to be related. We will generate matrix scatterplots to evaluate the strength of trends among these quantitative environmental, population, and community variables at the site level (Figure 1; also see Table 4). These scatterplots will include static metrics (from the most recent sample year) and rates of change for all variables. Relationships between some variables may be confounded by habitat type or some other variable used to group sites (e.g., presence or absence of deer). We will explore these relationships by plotting these different groups with markers of different shape or color.

Profile plots will be used to explore trends and interactions between quantitative and categorical variables over time. Quantitative responses will be plotted on the y-axis and time will be plotted on the x-axis. Sites grouped by different habitats or regions will be represented with separate lines on the plot. Intersecting lines will indicate that there is an interaction between this habitat grouping and time, with respect to the quantitative variable being graphed.

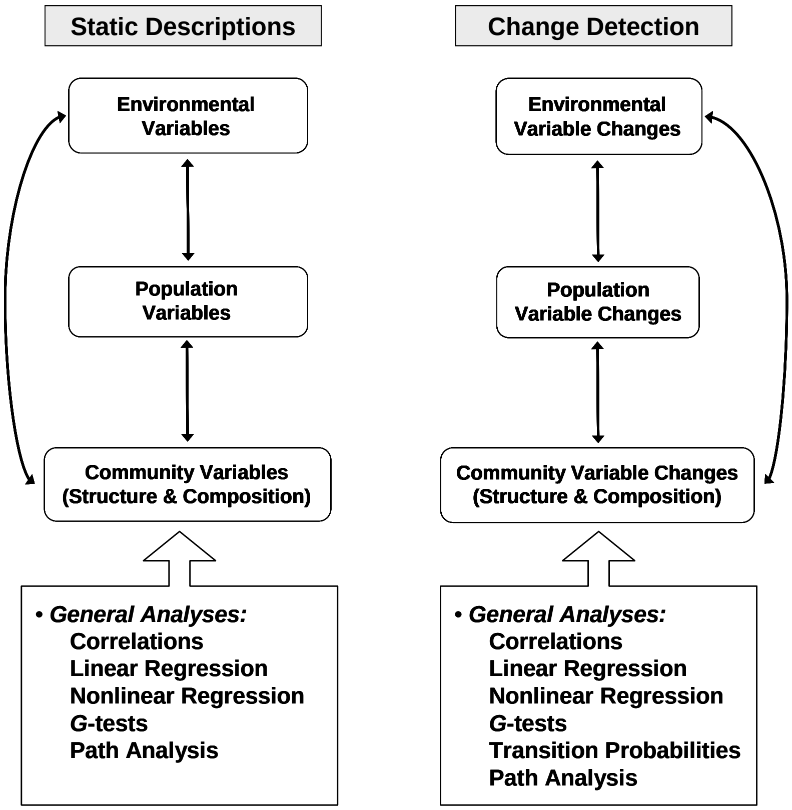

Figure 1. Relationships among environmental and vegetation variables, and suggested analyses. These relationships will be evaluated to detect changes among variables, and to make some static descriptions.

Inferential Data Analysis: We will conduct correlation analyses for all variable pairs that indicate a possible linear relationship. Unlike regression analysis, correlation analysis does not distinguish between predictor and response variables, but instead tests whether or not two variables vary together (interdependence; Sokal and Rohlf 1995). Correlation analysis is especially useful when the direction of dependence between two variables is not known *a priori*. **Pearson's product-moment correlation coefficients** will be computed if the data are bivariately normally distributed. In the case that these data do not meet that assumption, we will instead employ non-parametric **Spearman's rank correlations** (Sokal and Rohlf 1995). Correlation coefficients are a measure of the degree of a linear relationship between two variables. These values range from -1 to 1, with -1 indicating a strong negative relationship, 1 indicating a strong positive relationship, and 0 indicating no linear relationship between the two variables. Standard statistical packages also test the null hypothesis that the two variables are uncorrelated. We will implement Holm's (1979) correction on all reported *P*-values. We will avoid drawing strict inferences regarding causation before fully exploring the ecological significance of these results.

We will use **multiple regression analysis** to identify all predictor variables (quantitative or categorical) that significantly explain some of the variation in a continuous response variable (e.g., $\bar{C}$). Partial correlation coefficients will provide information about the degree to which a single variable is correlated with the predictor variable when the effect of all other variables is held constant. We will only include response variables that appear from the scatterplots to be linearly associated with the predictor variables.

Categorical predictor variables, such as deer presence, will be entered into the regression analysis as 'dummy variables'—deer presence will be scored as '1' and absence scored as '0'. We will use Q-Q plots to check that the residuals are normally distributed, and we will construct residual plots to check that these data meet the assumption of homoscedastic error variances. If our data do not meet these assumptions, we will consider employing standard data transformations on the response variable (Y), the predictor variables (X) secondarily, and both response and predictor variables lastly. Sokal and Rohlf (1995) recommend considering logarithmic transformations on the predictor variable(s) in cases where proportional changes in the predictor variable result in a linear response by the response variable. This may apply to the relationship of tree BA and tree density—we generally expect that tree BA may increase with successive decreases in density. We will avoid complex transformations that may impede our ability to make meaningful interpretations of the results (Sokal and Rohlf 1995). Standard statistical packages should report values ('tolerances' or 'variance inflation factors') that indicate the degree of collinearity between predictor variables; we will remove variables from our model to avoid collinear relationships. In addition to reporting the adjusted R^2 values and overall *P*-value for the regression model, we also will report partial correlation coefficients, *t*-statistics, and *P*-values for each predictor variable and interaction term in the model.

We will use **non-linear regression** to assess statistical relationships between variables not fitting elliptical or circular patterns in the scatterplots (Sokal and Rohlf 1995). Standard multiple regression equations will be fitted with increasing powers of X so as to produce a line that better fits the non-linear data. We generally will not attempt polynomial equations with powers of X greater than the cubic term, as one degree of freedom is lost with each polynomial term that is added to the equation. We will proceed with the typical procedures for analyzing data with multiple regression analysis; however, we will not report significance for the coefficients of the powers of predictor variables (Sokal and Rohlf 1995).

We will explore the effect of continuous variables on categorical response variables (or a combination of categorical and quantitative response variables) with **logistic regression analysis**. In contrast with linear regression, where the response variable is continuous, logistic regression will allow us to determine predictor variables that significantly explain variation in a categorical response variable. These response variables are typically one of two possible values—present/absent or yes/no—and will be coded as 1 or 0. Thus, in logistic regression, the mean of the distribution will equal the proportion of ones. For example, if evidence of earthworms (coded 1) is documented at 42 sites and no evidence of earthworms (coded 0) is found at 58 of 100 sites assessed, the mean of this distribution is 0.42. In logistic regression, the natural log of this probability will be determined (the logit) and maximum likelihood estimation will be used to estimate the probability of an event occurring (earthworm presence, in this case). Besides probability, logistic regression can also be used to determine the variance in the dependent variable explained by the predictor variable and to order the importance of predictor variables if multiple ones are tested (Sokal and Rohlf 1995).

Understanding a phenomenon in nature most often involves understanding the numerous factors and interactions leading to the event state. Multiple regression analysis offers the ability to deal with correlation among predictor variables to explore the effect that each of these variables has on the response variable when the effect of all other variables is held constant. However, multiple regression only considers one response variable, and is limited by not having the capability to test relationships between multiple predictor variables. **Path analysis** is an analytical approach that allows one to test potentially complicated patterns of causation among a set of several predictor variables (Mitchell 2001). The first step in path analysis is to construct a diagram that reflects hypothesized relationships among variables (for example see Figure 2). These hypothesized causal relationships will be constructed *prior* to any exploratory analyses to avoid biasing the results. Quantitative and categorical variables can be included, but categorical variables will be entered into these analyses as 'dummy' variables (0s and 1s). It is recommended that there be 10-to-20 times the number of observations in the data set than there are number of factors included in the path analysis. Some of the major assumptions of path analyses include: 1) that causality be considered (logical order of variables), 2) that the effects be linear, and 3) that the effects be additive. The analysis also assumes that the residuals are normally distributed, so transformation of some variables may need to be considered (Mitchell 2001). Multiple regression equations will be analyzed for all response variables such as they are represented in the diagram. Standardized partial regression coefficients will be generated via each of these analyses. These constitute the path coefficients which can then be combined to determine the direct and indirect effects of predictor variables. Direct effects represent the proportion of variance in the response variable that can be attributed now to one specific predictor variable that affects the response variable directly. However, a given predictor variable may have *indirect* effects on a given response variable via the other variables (the products of the path coefficients connecting them). These direct and indirect effects can be summed to calculate the total effect of that predictor variable on a given response variable. This exercise allows us to determine if the direct and indirect effects differ in magnitude or in sign. These results will be presented visually in path diagrams with variably-sized arrows to indicate the magnitude of relationships between variables (with dashed lines depicting negative relationships) (Mitchell 2001). There is sometimes more than one path diagram that can be constructed to test hypothesized relationships among variables. Path analysis will be followed with **structural equation modeling** to evaluate the explanatory power of competing models (Mitchell 2001). Grace's (2006) book also provides a helpful resource for structural equation modeling and path analysis.

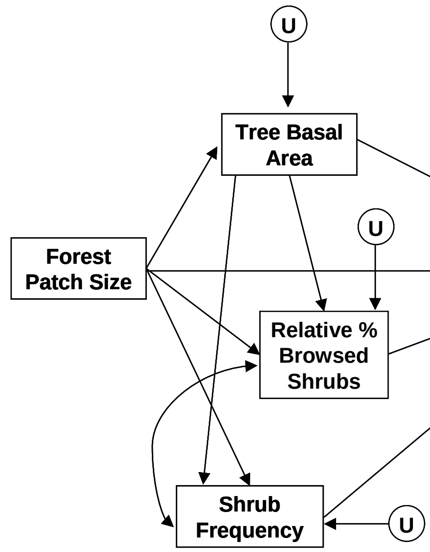

Figure 2. Example path diagram showing hypothesized relationships among variables considered to influence Forest Quality Index ($\bar{C}$) among sites. Residual variance, or "unknown" factors are represented as "U". Direct causal relationships are presented with single-headed arrows on straight lines. Double-ended arrows on the curved line represents a correlation with unknown directionality.

13.3. Possible Extensions

As time, resources, and expertise allow, we will consider applying a number of advanced analyses to our data. Some of these possible analyses are discussed below. However, this is not meant to be an exhaustive treatment of all possible analyses. As we become more familiar with these complex, long-term data, we will surely develop a better sense of what analyses will best serve our needs.

Classification and Regression Tree Analyses

Once groups of sites have been identified, classification and regression tree analyses could be used to determine if specific environmental variables (see Table 1) predict site groupings (or communities). Regression tree analysis uses a recursive algorithm to identify environmental predictor variables associated within homogenous subsets of the overall dataset. This recursive partitioning approach identifies ecological relationships in the data that linear models may not capture. Other advantages of using regression trees include: 1) they are not affected by multicollinearity; 2) they easily deal with a mix of quantitative, ranked, and categorical variables, of which there can by more than two categories; 3) they are not affected by missing values; and 4) they provide a useful visual representation to facilitate interpretation (Urban 2002).

These data can be compiled for all sites within a park or across multiple parks (for those with available data), and regression tree analysis can be conducted to determine if understory structure can be attributed to specific environmental site characteristics. Such an evaluation will highlight sites or specific habitats within (and possibly among) parks that may currently be experiencing negative effects from pests, pathogens, or some other driver of change.

Classification and regression tree analysis can be used to determine whether sites changing in a similar manner are associated with specific environmental predictor variables. To do this, homogeneous groups of sites based on similarity of vector changes must first be identified using a clustering technique such as the flexible-beta linkage method in PC-ORD (McCune and Grace 2002). This clustering of sites should be based on the change matrix (McCune and Grace 2002: p 77). The standard Sørensen (Bray-Curtis) distance measure should not be used in this case, as it does not perform well when applied to vectors with negative exponents. Instead, the measure of Euclidean, Relativized Euclidian, or Correlation distance should be selected (M. Fulton, Bemidji State University, pers. comm.). Environmental site characteristics (see Table 1) can then be assessed to determine what influence they may have had on the organization of sites within clusters by using regression tree analyses available through a variety of commercial software such as S-PLUS (S-PLUS®, Insightful, Inc.) or SPSS AnswerTree 3.1 (SPSS® Inc., Chicago, IL) as well as freeware (QUEST, CRUISE, GUIDE, and LOTUS) that can be downloaded from W. Loh's website (http://www.stat.wisc.edu/~loh/).

Information-Theoretic Analyses

Rather than testing innumerable single-variable hypotheses about change, for several variables (e.g., absolute herbaceous cover, relative forb cover, frequency or cover of an individual forb species) we will utilize information-theoretic analyses to compare, in a strength-of-evidence framework, the relative plausibility of numerous competing models to determine which combination of variables best explains variability in those response variables.

This approach ranks models of varying complexity not only on their fit to the data, but also with a criterion of parsimony (i.e., using the least complicated model possible to describe dynamics succinctly). Information-theoretic approaches use a likelihood framework to rank models based upon how much information is lost when a given model is used to portray 'truth.' The true model is defined as one that represents reality without any error (i.e., a model that would contain all of the information about the system under investigation) (Hobbs and Hilborn 2006). Akaike's Information Criterion (Akaike 1973) thus estimates the expected value of information lost with the equation:

$$\mathrm{AIC} = -2 \ln(L) + 2K$$

where L is the likelihood associated with the maximum likelihood estimates of the model parameters, given the data set, and K denotes the number of parameters in the model (including all error terms). For this approach to be confirmatory rather than exploratory, the set of competing models must be specified before any analyses are undertaken (Burnham and Anderson 2002). In addition to computing AIC (or AIC_c for small sample sizes, QAIC for overdispersed data, or BIC for a Bayesian approach), we will also calculate ΔAIC, Akaike weight, and the evidence ratio for each model. Though these approaches are designed more to rank various models rather than identify importance of individual factors, we will calculate relative importance of each factor. Model averaging will be performed if we are interested in using the models to predict future values of vegetation. All analytical procedures will follow guidelines of Burnham and Anderson (2002). Beever et al. (2003, 2006) provide illustrations of uses of information-theoretic analyses to understand dynamics of natural resources in wilderness areas. See Table 5 for an example of a partially-filled-out table for a vegetation metric that might be especially important for the Great Lakes ecoregion.

Artificial Neural Networks (ANNs)

Knowledge of past and current vegetation composition and environmental variables (see Table 1) can be used to predict future vegetation composition in Network parks. Artificial neural networks (ANNs) can be useful for forecasting community composition, as these models make inferences based on generalized patterns in complex ecological data. ANNs take a non-mechanistic approach, so they are very pragmatic models for dealing with unforeseen and unidentified mechanisms responsible for current and changing vegetation composition (Tan and Smeins 1996).

Table 5. Total herbaceous frequency, all understory species combined, at Apostle Islands National Lakeshore during vegetation monitoring at 35 sites during 2007–2019. Presumably, 'Year' would account for interannual fluctuations in weather and other random factors. 'Deer' is the finest-scale estimate of density of white-tailed deer (*Odocoileus virginianus*) at the site the year before the vegetation sampling. 'Cmty' denotes the vegetative community that is present at a site. A "+" sign means that all factors united by the symbol are put into the model; a "*" sign means that in addition to those two factors each being in the model, the interaction of the two factors is also present in the model. The null model has no factors (other than the error term), and gives evidence of how relatively meaningful the models are. All column definitions follow Burnham and Anderson (2002).

Model #	Model description	# Parameters	-2*LOG(l)	AICc	ΔAICc	Akaike weight	Evidence ratio
1	Year	2	35.4	54.7	0	0.45	1
2	Deer density (="Deer")	2	42	56.8	2.1	0.15	2.89
3	Veg. cmty type (="Cmty")	2	35.3	56.9	2.2	0.15	3.03
4	Year + Cmty	3	37	58.6	3.9	0.06	6.98
5	Year + Deer	3	41.7	58.8	4.1	0.06	7.62
6	Year + Cmty + Deer	4	41.7	58.8	4.1	0.05	7.65
7	Cmty + Deer	3					
8	Year + Tree Cover	3					
9	Year * Cmty	4					
10	Null	1	102.6	108.7	54	0	$>10^6$

13.4. Literature Cited

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. Pages 267-281 *in* B. N. Petrov and F. Csaki, editors. The second international symposium on information theory. Akad´emiai Kiado, Budapest, Hungary.

Beals, E. W. 1984. Bray-Curtis ordination: An effective strategy for analysis of multivariate ecological data. Advances in Ecological Research 14:1-56.

Beever, E. A., P. F. Brussard, and J. Berger. 2003. Patterns of extirpation among isolated populations of pikas (*Ochotona princeps*) in the Great Basin. Journal of Mammalogy 84:37-54.

Beever, E. A., M. Huso, and D. A. Pyke. 2006. Multi-scale responses of soil stability and invasive plants to removal of non-native grazers from an arid conservation reserve. Diversity and Distributions 12:258-268.

Bernthal, T. W. 2003. Development of a floristic quality assessment methodology for Wisconsin. Wisconsin Department of Natural Resources, Bureau of Integrated Science Services. PUB-SS-986 2003, Madison, Wisconsin.

Burger, T. L., and J. Kotar. 2003. A Guide to Forest Communities and Habitat Types of Michigan. The Department of Forest Ecology and Management, University of Wisconsin, Madison, Wisconsin.

Burnham, K. P., and D. R. Anderson. 2002. Model Selection and Inference: A Practical Information-Theoretic Approach, 2nd edition. Springer-Verlag, New York, New York.

Colwell, R. K. 2005. EstimateS: Statistical estimation of species richness and shared species from samples. Version 7.5. User's guide and application published at: http://purl.oclc.org/estimates.

Francis, C. M., M. J. W. Austen, J. M. Bowles, and W. B. Draper. 2000. Assessing floristic quality in southern Ontario woodlands. Natural Areas Journal 20:66-77.

Gotelli, N. J., and R. K. Colwell. 2001. Quantifying biodiversity: Procedures and pitfalls in the measurement and comparison of species richness. Ecology Letters 4:379-391.

Grace, J. B. 2006. Structural Equation Modeling and Natural Systems. Cambridge University Press, Cambridge, United Kingdom.

Herman, K. D., L. A. Masters, M. R. Penskar, A. A. Reznicek, G. S. Wilhelm, and W. W. Brodozicz. 1997. Floristic quality assessment: Development and application in the state of Michigan (USA). Natural Areas Journal 17:265-279.

Hobbs, N. T., and R. Hilborn. 2006. Alternatives to statistical hypothesis testing in ecology: A guide to self teaching. Ecological Applications 16:5-19.

Holm, S. 1979. A simple sequentially repetitive multiple test procedure. Scandinavian Journal of Statistics 6:65-70.

Johnson, S. E., E. L. Mudrak, and D. M. Waller. 2006. A comparison of sampling methodologies for long-term monitoring of forest vegetation in the Great Lakes Network national parks. GLKN 2006/06. National Park Service, Great Lakes Network Office, Ashland, Wisconsin.

Kotar, J., and T. L. Burger. 1996. A Guide to Forest Communities and Habitat Types of Central and Southern Wisconsin. Department of Forestry, University of Wisconsin, Madison, Wisconsin.

Kotar, J., and T. L. Burger. 2000. Field Guide to Forest Habitat Type Classification for North Central Minnesota. Terra Silva Consultants, Madison, Wisconsin.

Kotar, J., J. Kovich, and T. L. Burger. 2002. A Guide to Forest Communities and Habitat Types of Northern Wisconsin, second edition. Department of Forestry, University of Wisconsin, Madison, Wisconsin.

McCune, B., and J. B. Grace. 2002. Analysis of Ecological Communities. MjM Software Design, Gleneden Beach, Oregon.

Mitchell, R. J. 2001. Path Analysis. Pages 217-234 *in* S. M. Scheiner and J. Gurevitch, editors. Design and Analysis of Ecological Experiments. Oxford University Press, Inc., Oxford, United Kingdom.

Olden, J. D., and T. P. Rooney. 2006. On defining and quantifying biotic homogenization. Global Ecology and Biogeography 15:113-120.

Oldham, M. J., W. D. Bakowski, and D. L. Sutherland. 1995. Floristic quality assessment system for southern Ontario. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario.

Rooney, T. P., and D. A. Rogers. 2002. The modified floristic quality index. Natural Areas Journal 22:340-344.

Rooney, T. P., S. M. Wiegmann, D. A. Rogers, and D. M. Waller. 2004. Biotic impoverishment and homogenization in unfragmented forest understory communities. Conservation Biology 18:787-798.

Smith, W., A. Solow, and C. Chu. 2000. An index of the contribution of spatial community structure to the species-accumulation curve. Ecology 81:3233-3236.

Sokal, R. R., and F. J. Rohlf. 1995. Biometry, 3rd edition. W. H. Freeman and Company, New York, New York.

Swink, F., and G. Wilhelm. 1979. Plants of the Chicago Region, 3rd edition. Morton Arboretum, Lisle, Illinois.

Swink, F., and G. Wilhelm. 1994. Plants of the Chicago Region, 4th edition. Indiana Academy of Science, Indianapolis, Indiana.

Taft, J. B., G. Wilhelm, D. Ladd, and L. A. Masters. 1997. Floristic quality assessment for vegetation in Illinois, a method for assessing vegetation integrity. Erigenia 15:1-24 and Appendix.

Tan, S. S., and F. E. Smeins. 1996. Predicting grassland community changes with an artificial neural network model. Ecological Modeling 84:91-97.

Urban, D. L. 2002. Classification and regression trees. Pages 222-232 *in* B. McCune and J. B. Grace, editors. Analysis of ecological communities. MjM Software Design, Gleneden Beach, Oregon.

Von Ende, C. N. 2001. Repeated-measures analysis: Growth and other time dependent measures. Pages 134-157 *in* S. M. Scheiner and J. Gurevitch, editors. Design and Analysis of Ecological Experiments. Oxford University Press, Inc., Oxford, United Kingdom.

Wiegmann, S. M., and D. M. Waller. 2006. Biotic homogenization in forest understories: Identity and traits of historical "winners" and "losers." Biological Conservation 129:109-123.

Wilhelm, G., and L. A. Masters. 1994. Floristic changes after five growing seasons in burned and unburned woodland. Erigenia 13:141-150.

SOP 14: Reporting

Version 2.0 (6/1/12)

Suzanne Sanders, Joan Elias, and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	The timing for reports has been modified; resource briefs were added.	Reporting has changed since the inception of monitoring.	2.0

14.0 Introduction

A primary goal of the NPS Servicewide I&M Program is to ensure that the results and knowledge gleaned from monitoring are shared with all appropriate parties, especially the parks and their natural resource managers. Because the Network's main focus is to assist parks with monitoring needs, we will strive to provide park managers with clear, meaningful products to convey our findings.

While the Network primarily addresses concerns of the parks, this monitoring program has the potential to serve a much broader community. For example, monitoring projects can provide a starting point for external scientific research (especially to establish cause-effect relationships), and can provide insights for adaptive management on other public lands. The Network is also accountable to multiple organizations within the federal government, including the NPS I&M Program and the U.S. Congress. To ensure accountability and to meet the requests of all parties, we will provide the types of reports and communications detailed below.

14.1 Annual Summary Reports

A summary report will be produced annually for the Vital Signs associated with the vegetation protocol that were monitored during the previous year. The park resource managers are the primary audience for the annual summary reports. These summaries will document our efforts and convey the findings of the previous field season. At a minimum they will provide:

- a brief introduction that describes why that Vital Sign is being monitored;
- an outline of the sampling strategy, including the number of sites sampled, parameters measured, and analyses performed;
- data summaries, including tables and figures to enhance visual presentation, as well as a text explanation of the findings;
- any other relevant or significant findings; and
- a limited discussion section in which important results are interpreted.

The Terrestrial Ecologist and Botanist will take the lead in writing the report and will coordinate an internal review. Drafts of annual summary reports will be completed by 15 March for a four-week review period by the parks. The final reports will be provided to parks by 1 June of the year following the fieldwork.

14.2 Resource Briefs

Resource briefs will be produced annually, with one being developed for the park in which work was completed the previous year. Topical briefs that include information about more than one park may also be produced. These briefs will be one to two pages in length and will emphasize the results and management implications of our monitoring. Park superintendents and other park employees not working in resource management are the primary audience. However, resource briefs are intended to be written in a manner that they may also be provided to the public. Text and photos are given to the Network Science Writer, who puts them into the necessary format and provides a draft version for review by the Terrestrial Ecologist and Botanist. Resource briefs will be completed by 15 March of the year following monitoring.

14.3 Analysis and Synthesis Reports

Detailed reports in which data are analyzed and synthesized will be produced on a periodic basis, typically after a complete sampling cycle of all parks. For the forest monitoring protocol, analysis and synthesis reports will be written every nine years. They will be written in the format of a scientific journal article (abstract, introduction, methods, results, discussion, literature cited) and will contain in depth analyses as outlined in the protocol (Sanders and Grochowski 2014) and SOP 13: Data Summary and Analysis. Further, these comprehensive reports will:

- place the observed results in both a regional and historical context by relating them to other published literature;
- discuss the significance of the results in terms of environmental change; and
- provide management recommendations based on the findings.

The Terrestrial Ecologist and Botanist will take the lead in writing the analysis and synthesis reports, and will coordinate an internal review. The target audiences for these reports are the parks (primarily the natural resource managers), the Network, and both regional and Servicewide I&M programs. Outside of the National Park Service, the target audience includes the four state departments of natural resources (Indiana, Michigan, Minnesota, and Wisconsin) and the broader scientific community.

Drafts of analysis and synthesis reports will be completed by 31 May of the year that follows completion of the nine-park monitoring cycle. The parks will have a 30-day period for comment and input. In addition, these drafts may also be sent to outside sources for further review. The extent of review will depend on the analytical complexity of the methods and the gravity of inference and recommendations. The final reports will be due on 1 September of the year following completion of the monitoring cycle.

14.4 Scientific Journal Articles

Because the vegetation monitoring protocol is designed with rigorous standards for sampling design and analysis, monitoring results are expected to be highly defensible and meet the standards of the peer-review process. The publication of monitoring results in scientific journals will allow the Network to reach the scientific community in a way that internal NPS reports typically do not. Further, peer-reviewed publications can promote collaborative investigation by members of the scientific community, either independently or in cooperation with the Network. Ultimately, this process should foster a greater understanding of ecosystem components and processes.

14.5 Other Communications

While reports are a definitive method of documenting the progress of each program, other means of communication can further disseminate information to a broader audience. To this end, we will provide the following additional types of communications:

Briefings to park biologists: The project manager will offer to present the findings from the monitoring program to the biologists (and other interested staff) at the park in which monitoring was conducted the previous year. These presentations will occur at the park, or in another logical venue such as a regional meeting or workshop. Presentations will provide a concise synopsis of monitoring results as well as management considerations.

Conference presentations: When possible, the project manager will present monitoring results at regional and national scientific conferences. Such presentations will allow the Network to reach the broader scientific community as well as land managers and conservation practitioners. Potential conferences include those sponsored by the Ecological Society of America, Society for Conservation Biology, The Wildlife Society, the Natural Areas Association, and the George Wright Society. At a more local scale, the Western Great Lakes Research Conference and the St. Croix Research Rendezvous are valuable venues for information exchange.

14.6 Literature Cited

Sanders, S. M. and J. Grochowski. 2014. Forest vegetation monitoring protocol, version 2.0: Great Lakes Inventory and Monitoring Network. Natural Resource Report NPS/GLKN/NRR—2014/XXX. National Park Service, Fort Collins, Colorado.

SOP 15: Procedures after the Field Season

Version 2.0 (6/1/12)

Suzanne Sanders and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/12	Suzanne Sanders and Jessica Grochowski	Administrative and logistical changes were added or modified.	Changes were required or necessary for smooth running of the program.	2.0

15.0 Introduction

The procedures associated with completing the field season must be performed in earnest once sampling is completed, and continued through the following April. The purpose of this SOP is to identify these procedures, thereby promoting better project management. Please note that the procedures noted here from November through April overlap with pre-season procedures listed in SOP 1: Preparations and Equipment Setup Prior to Field Season.

July

- Submit personnel actions to terminate seasonal employees. These are submitted to the Administrative Technician and must be completed at least three pay periods prior to their effective date. At this time, also notify the IT manager of the terminations so that the closing of computer accounts and email addresses can be scheduled.

August

- Fill out EPAPs (employee performance and appraisal) and the employee checkout form.
- Perform reviews of field crew members and go over the employee checkout form with each of them. Send the original EPAP and checkout form to the regional office and a copy of the checkout form to the GLKN Administrative Technician. Copies of the EPAP should be provided to the employees, the GLKN Network Coordinator, and the Administrative Technician.

September

- Finish entering data and begin checking data.
- Rename pictures of unknown plants.
- Check the renamed photopoint pictures against the original numbered pictures.
- If any species previously unknown to occur in a park were observed, add these to the park species list, and to NPSpecies.

October

- Finish checking data.
- Run queries to ensure that all species located during the season have values assigned for nativity, coefficient of conservatism, pollination and dispersal modes, life history, and growth form. If not, enter these into the database.
- Review protocol and make changes.
- Begin data analysis and report writing.

November

- Continue data analysis and report writing.

December

- Continue data analysis and report writing.

January

- Data analysis and report writing.

February

- Data analysis and report writing.

March

- Data analysis and report writing.
- Present draft annual summary report to the park for review.
- Work with Network Science Writer to draft a resource brief about the previous year's work.
- Present results at the technical committee meeting or some other venue in or near the park where monitoring occurred.

April

- Data analysis and report writing.
- Revise annual summary report following park review

May

- Present final copy of annual summary report to the park.
- Present analysis and synthesis report to all parks. They will then have 30 days to review it.

September

- Present final copy of analysis and synthesis report to parks.

SOP 16: Procedures for Revising the Protocol

Version 1.0 (7/1/08)

Suzanne Sanders, Joan Elias, and Jessica Grochowski
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #

16.0 Introduction

Because of the long-term nature of the National Park Service's monitoring program, the projects must necessarily accommodate change. Refined field methods, advances in analysis techniques, and feedback from field crews and project managers can all contribute to improving the monitoring protocol. The purpose of the current SOP is to define a systematic and routine process for incorporating these changes into the protocol.

16.1 Steps for Revising the Protocol

1. Attempt to incorporate the changes by first modifying only the SOP(s), without making changes to the protocol narrative. However, if it is clear that changes will also be needed in the narrative, then revise it as well.

2. Make all revisions using the Track Changes feature of Microsoft Word. For minor changes, at least one other person must review the revision. If the change(s) is/are more extensive, a discussion of the changes by Network staff is warranted before acceptance of the revision(s). Solicit reviews from outside of the Network (and outside of the National Park Service, if possible) for major changes. Examples of major changes include modifications of the sampling design, significantly altered field methods, and revised analysis techniques.

3. Record the changes in the revision history log of the appropriate SOP(s) and/or in the narrative, as appropriate. Include the date of revision, full name(s) and affiliation(s) of author(s), description of and reasons for the changes, and section of SOP or narrative where changes were made.

4. Rename the version of the SOP(s) and/or narrative. For minor changes, only revise the version number after the decimal point (e.g., change V. 1.1 to V. 1.2). For major changes, revise the number before the decimal point (e.g., V. 2.3 to 3.0). Also change the version number of the SOP or protocol in the header or footer, as appropriate.

5. Notify the Network Data Manager of the change(s) so that the metadata of the project database will be updated.

6. Distribute the revised version to all appropriate parties, including the members of the field crew and appropriate GLKN staff. The revised version must also be posted on the Network's website.

7. Maintain a library of previous versions. Such historical information may be crucial for understanding, interpreting, and analyzing data.

SOP 17: Quality Assurance/Quality Control

Version 2.0 (6/1/12)

Jessica Grochowski and Suzanne Sanders
NPS – Great Lakes Network

Revision History Log:

Previous Version #	Revision Date	Author(s)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	6/1/2012	Suzanne Sanders and Jessica Grochowski	We revised our resample procedure.	The new method provides immediate feedback.	2.0

17.0 Introduction

The success of the vegetation monitoring protocol is dependent upon the integrity of the data. This SOP details procedures for ensuring the data collected are of the highest possible quality, addressing standards to follow both while in the field and afterward.

17.1 Field Procedures

Quality Assurance/Quality Control Procedures for All Plots

The standard data collection methods detailed in SOP #6: Field Methods and Data Collection should be followed precisely. This will ensure accurate data collection and allow consistency between observers. In addition, each field team will be supplied with a checklist of criteria to address prior to leaving a field site. This is designed to minimize human error, especially for parameters that cannot be easily obtained once a field team has departed a site. These include ensuring that:

- The parking location for the boat/car is documented, and any relevant notes on plot access are included.
- The Kotar and/or NVCS forest type is recorded.
- All transects have coarse woody material recorded.
- All groundlayer species listed have at least one box checked.
- Any parameter for which no data were collected (e.g., no CWM on a transect) is marked as such.
- All tree species on the groundlayer sheet have abundance numbers associated with them.

Quality Assurance/Quality Control Check Plots

The work of each crew member conducting vegetation monitoring will be resampled by the Ecologist and/or the Botanist at the beginning and in the middle of the field sampling season. The resampling will occur on the original sample date. The Ecologist or Botanist will sample a transect at the same time as the crew member, and all data will be compared while still at the transect or quadrat. Any discrepancies will be discussed at the transect or quadrat with the crew member, and the Ecologist and/or Botanist will be responsible for compiling the data to be used for long-term analysis. The initial data recorded by the crew member and the Ecologist or Botanist will be retained for comparison purposes.

To reduce the problems associated with trampling, no individual plot should be resampled more than once every 10 years.

17.2 Data Processing

Global Navigation Satellite System Data

All GPS points will be differentially corrected within 30 days of collection. This circumvents any losses in CORS station data collection frequency that may occur in archived data.

Vegetation Data

Standard queries will be run following the completion of data entry. These queries are intended to reveal standard mistakes resulting from data entry errors or certain recording errors in the field. These queries include checks for the following:

- multiple entries of an individual species within any transect in the groundlayer data
- multiple entries of an individual species within any browse circle
- coarse woody material pieces entered that are less than 7.5 cm diameter at intercept
- trees entered with DBH <2.5 cm
- tree species entered as seedlings in the groundlayer without counts

To locate and amend potential errors resulting directly from the manual entry process, all entered data will be checked by one person reading the original data sheets and a second person checking the MS Access report generated for each site/parameter.

NPS 920/124450, April 2014

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov