



Appalachian National Scenic Trail Plot-Based Forest Monitoring Protocol

Natural Resource Report NPS/NETN/NRR— 2013/633



ON THE COVER

A hiker walks along the Appalachian National Scenic Trail between Hughes Gap and Iron Mountain Gap in Tennessee.
Photograph by: Brenda Wiley

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Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.3 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	May 2010	Fred Dieffenbach Geri Tierney	Revised NETN forest monitoring plan to describe activities on the Appalachian National Scenic Trail	
1.01	December 2011	Fred Dieffenbach	Integrated comments following 2010 field season	
1.02	December 2011	Ed Sharron	Formatted and merged report into one document	
1.03	January 2012	Fred Dieffenbach	Reconciled comments from Mitchell, Miller, and Tierney. Revised sampling frame to be mid-elevation (not mid-high elevation) based on experience from 2010 sampling season where high elevation sampling was found to be difficult leading to plot rejection	
1.04	August 2012	Brian Mitchell	Updated budget, minor edits for consistency	Internal review
1.05	October 2012	Fred Dieffenbach	Reconcile final comments	Internal review

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Background and Introduction

This protocol was initially developed to support the Forest Health component of a decision support system (DSS) enhancement project¹ funded by the National Aeronautic and Space Administration (NASA). Recognizing the potential for forest health monitoring separate from the DSS project, this protocol was developed to promote monitoring of forest vegetation as well as monitoring of a host of related issues including landscape fragmentation and land use change in close proximity to the Appalachian National Scenic Trail (APPA). APPA is a member park of the Northeast Temperate Network (NETN), which is a unit of the National Park Service (NPS) Inventory and Monitoring Program (I&M). APPA is nearly 2,180 miles long, has a corridor that is nominally 1,000 feet wide, and passes through 14 states. Due to the conformation of the APPA (long and narrow), adverse impacts in its vicinity can have disproportionately strong effects on the quality of the resources that characterize it. This protocol includes methods for collecting data to assess the health and ecological integrity of forested ecosystems found along APPA, and is a modified version of the NETN forest monitoring protocol (Tierney et al. 2011). The changes reduce gear requirements to a level appropriate for backcountry work, make the protocol cheaper and faster to implement, and make it suitable for a less skilled field crew. Data collected according to this protocol will provide insight into concerns such as invasive exotic species, atmospheric deposition and ozone pollution, climate change, and visitor impacts.

The region through which APPA passes is predominantly forested but includes many open fields and exposed, rocky areas. Within the forested systems, which are the focus of this protocol, key stressors include land use change and habitat fragmentation on lands adjacent to the APPA corridor. Due to the relatively high position in the landscape occupied by APPA, its viewshed may be affected by land use change and fragmentation occurring at a distance. The scoping process and these stressors are described in the APPA Vital Signs Monitoring Plan (Dieffenbach 2011).

Justification

In October 2004, NETN and APPA staff convened a meeting of park staff and managers, government scientists, and other stakeholders to identify key “Vital Signs” or indicators of ecological condition for APPA. Subsequent to that meeting, NETN, APPA, and the Appalachian Trail Conservancy (ATC) co-hosted a workshop in 2006 to explore the possibility of using the Appalachian Trail corridor as an ecological monitoring bellwether. The workshop led to the launch of the A.T. MEGA-Transect program that aims to promote the Appalachian Trail corridor to professional researchers and citizen scientists for ecological research and monitoring. Forest health is among the 12 vital signs identified for monitoring within APPA.

The 2004 meeting produced the report entitled: Appalachian Trail Vital Signs (http://science.nature.nps.gov/im/units/appa/Downloads/reports/APPA_FinalReport_VsSummary_02012006_rf.pdf), and the 2006 workshop lead to the document titled: Welcome to the

¹ The Appalachian Trail (A.T.) Decision Support System (DSS) is an Internet-based data analysis and dissemination utility that, when finished, will improve decision support by giving users access to remote sensing and geospatial data. <http://www.edc.uri.edu/ATMT-DSS/default.html>

A.T. MEGA-Transect

(<http://science.nature.nps.gov/im/units/appa/Downloads/reports/ATMEGATransectReport.pdf>).

The APPA Vital Signs Monitoring Plan (Dieffenbach 2011) references this protocol as one of three primary options for assessing forest health along the Appalachian Trail corridor.

While NETN currently lacks the funding and staff to implement this protocol, it is a rigorous and specific approach for quantifying forest health within the APPA corridor. It is important to have this protocol available in case APPA, NETN, or a partner organization is able to implement monitoring in the future.

Goals and Objectives

Our overall goal is to assess the current status of forest resources within the Appalachian Trail corridor, and to create a process that promotes monitoring. To do so, we interpret and report the ecological integrity of APPA forested systems from data obtained through this protocol as well as data from other sources including the U.S. Forest Service. Ecological integrity can be assessed by comparing key elements or attributes of an ecosystem to a reference area or to historical measurements or modeling efforts. The NASA DSS project provides one means for reporting Appalachian forest resources, but the methodology outlined in this protocol can also be used to assess the health of resources independent of the NASA DSS project. Implementation of this protocol will help guide NPS land management, exotic species control, NPS internal development, and national pollution control legislation². Monitoring objectives for each component of the APPA forest protocol are listed in Table 1.

Existing Monitoring Programs

The U.S. Forest Service (USFS) Forest Inventory and Analysis Program (FIA) has been monitoring forest resources on a regional basis across the U.S. since the 1930s. Beginning in the 1990s, a Forest Health Monitoring (FHM) component was developed by the USFS and the Environmental Protection Agency (EPA) Environmental Monitoring and Assessment Program (EMAP), and later incorporated into the FIA program. FIA protocols have undergone extensive development by the USFS with academic and other government agency partners (USFS 2005, <http://fia.fs.fed.us/library/field-guides-methods-proc/>), and have been used to develop a substantial and ongoing database revealing regional trends in forest resource capacity and health across the region and the country (<http://fia.fs.fed.us/tools-data/>). In addition, NETN has developed a Forest Health monitoring protocol, which is being implemented at parks throughout the Northeast (Tierney et al. 2011). The APPA protocol is adapted from the NETN protocol, which incorporates many FIA procedures and is designed to be FIA “compliant.” In an effort to understand the forest resources characteristic of the Appalachian Region, we have acquired data from FIA for the region surrounding APPA with the intention of analyzing these data from an APPA perspective.

² The condition of resources along the APPA is used to illustrate issues of National concern, including pollution.

Table 1. Appalachian National Scenic Trail Forest Monitoring Protocol objectives³.

Metric Category	Metric	Monitoring Objectives	Vital Sign
Landscape Structure Metrics	Forest patch size	Determine status and trend in forest patch size.	Forest Vegetation, Land cover, Land use
	Anthropogenic land use	Determine proportion of surrounding area in natural cover and in anthropogenic land use.	Forest Vegetation, Land cover, Land use
Stand structure and composition Metrics	Stand structural class	Determine status and trend ¹ in the distribution of forest structural classes across each park, and compare to that expected under natural disturbance regimes.	Forest Vegetation
	Snag abundance	Estimate status and trend in snag abundance and size class distribution.	Forest Vegetation
	Coarse woody debris (CWD)	Determine status and trend in coarse woody debris volume.	Forest Vegetation
	Canopy closure	Determine status and trend in canopy closure in mature stands. Examine correlation between canopy closure and climatic stress, storms, pest and pathogen outbreaks and other disturbances. To be developed.	Forest Vegetation
	Photo point	Provide visual reference of plots.	Forest Vegetation
Tree Metrics	Tree condition	Semi-quantitatively assess condition of trees by species.	Forest Vegetation, Exotic Animals-Early Detection
	Tree growth and mortality rates	Determine growth and mortality rates of canopy tree species. Examine correlation between these rates and air pollution, pest or pathogen outbreaks, climatic stress or other known stressors.	Forest Vegetation, Acidic Deposition & Stress, Ozone
	Tree regeneration	Determine status and trend in quantity and composition of tree seedlings establishment in forest understory.	Forest Vegetation, White-tailed Deer Herbivory
Understory Metrics	Indicator species	Determine status and trend in exotic plant species cover. Determine change in cover or extent of species indicative of deer browse pressure and other stress.	Forest Vegetation, White-tailed Deer Herbivory, Acidic Deposition & Stress, Ozone

Several states in the region have undertaken monitoring programs for state-owned forests. For example, in New York, permanent plots were established and monitored in forests on state lands during 2000 - 2002 (Manion et al. 2003). Likewise, Maine, established a long-term monitoring program within state ecological reserves, including those near Acadia NP (Cutko 2005). Both of these programs used modified versions of FIA protocols. The Vermont Monitoring Cooperative, a partnership between the University of Vermont, USFS, and the Vermont Agency of Natural Resources has been coordinating long-term natural resource monitoring efforts and research on federal and state lands since 1990. Other states that APPA passes through have likely also implemented monitoring programs.

³ All metrics presented in table 1 relate to conditions present along APPA, but are compared to results from other locations thereby making it possible to assess condition of resources along APPA.

The only organized monitoring program operated by APPA staff assesses the status and condition of rare plants and unique communities. In the past, APPA has attempted to monitor water quality, but that program has slowly disappeared. The long, but narrow configuration of APPA makes the administration of a focused monitoring program expensive and complicated. For this reason, monitoring performed by other agencies, researchers, and organizations plays a significantly larger role in the APPA resource management program than almost any other park. Ongoing work performed by others will not simply complement the APPA environmental monitoring program; it will create the underlying structure and framework for any APPA-specific monitoring, including forest health monitoring. As such, the focus of the NETN's APPA program is to collaborate with existing programs on methods, sampling design, and, in some cases, co-location of sampling points. This protocol is specifically designed to provide in-depth data not available through existing programs in a way that is targeted to APPA resources and compatible with the approach of encouraging co-location of monitoring whenever possible (Dieffenbach 2011).

Sampling Design

Approach

The APPA Plot-Based Forest Monitoring Protocol is generic enough to assess the health of forest resources throughout the Appalachian Trail region, but the NASA DSS pilot implementation specifically targeted forest resources typical of mid-high elevation segments of the Appalachian Trail. Like the NETN forest monitoring protocol from which it was derived, the APPA Plot-Based Forest Monitoring Protocol is designed to monitor forest ecosystem integrity in a standardized and cost-efficient manner, and allow statistical inference of status and trends with sufficient statistical power. The protocol facilitates comparison of APPA data with other NPS and regional data such as that from the USFS FIA program.

This protocol is designed to assess stand structure and composition; tree condition, regeneration, and growth and mortality rates; snag abundance; coarse woody debris volume; understory indicator plants; surrounding landscape; and forest floor condition—all in a network of permanent plots scattered throughout 10 mid-elevation watershed segments. Data describing stand structure and composition allows comparison of the current distribution of stand structural classes in APPA forested stands with expected distributions under natural disturbance regimes. Tree condition is semi-quantitatively assessed to provide information on tree health problems (current condition, positive or negative). Tree growth and mortality rates are assessed through repeat sampling of the same trees. Tree growth serves as an early-warning indicator of vigor, positive or negative, in canopy trees of a particular species or region, which may be followed by changes in mortality rates. While mortality is also a natural occurrence, it is a useful metric that can be used to assess the condition of APPA forest resources in comparison to other forest resources in the region. Tree regeneration data provide an early warning indicator of overstory composition change, and may be indicative of things such as browsing pressure and light penetration. Monitoring understory indicator plant species composition and abundance helps determine the impacts of multiple stressors upon native plant communities, and provide information on the abundance of invasive exotic species. Snags and coarse woody debris are key structural features providing habitat for wildlife and fungi, and are impacted by park hazard tree removal, silvicultural policies, site condition, competition, species composition, among many others. Forest floor condition is monitored for trampling impacts, as well as for the presence of earthworms. Finally, photographs document the appearance of plots to provide visual reference. Additional detail justifying the selection of these measures is included in SOP 14 - Analyzing and Reporting Ecological Integrity in this protocol and in the NETN Forest Monitoring Protocol (Tierney et al. 2011).

Stand canopy closure (or its inverse—canopy openness) is suggested as a discrete quantitative measurement that is directly applicable to understory light regimes and may serve as a useful indicator of stand-level disturbance. Canopy closure can naturally vary for a number of reasons,

and human activity is increasingly altering forest disturbance regimes and thus canopy structure. NETN is continuing to explore effective ways to implement this metric⁴.

Satellite imagery is used to monitor change in the landscape context of forest plots over time. Calculation of the forest patch size is a useful measure of the habitat available to fauna requiring interior forest patch habitat. Likewise, calculation of the proportion of forest cover, natural non-forest cover, and anthropogenic land use within the immediate area surrounding plots provide additional measures of fragmentation and anthropogenic stress.

Sampling Frame

Because a modest (100 plot) field-based sampling program is likely insufficient to characterize the many forest types along the Appalachian Trail, this protocol limits sampling to forests in a randomized sample of all potential mid-elevation segments (Figure 1), where segments are defined by the intersection of the APPA land area (i.e., corridor) and individual Hydrologic Unit Code (HUC) level 10 hydrologic units (Figure 2)⁵. Mid-elevation forests were chosen because they are more sensitive to climate change and other stressors⁶. Because the Appalachian Trail follows ridgelines for a large portion of its length, the watershed lines break the corridor transversely as well as longitudinally. In the north, (i.e., New England) mid-elevation is defined as > 450 m above sea level (asl) and in the south mid-elevation is defined as > 600 m asl. To be included in the sampling frame, the entire segment had to be above the aforementioned threshold values and at least 250 ha in size, but a minimum segment length (i.e., a minimum trail length within the segment) was not established. The 250 ha minimum size came from the decision that one plot per 50 ha was an appropriate density, and that five points was the minimum number of points per segment needed to document spatial variability within the segment.

⁴ Concurrent with the development of this protocol is the creation of the NASA funded A.T. Decision Support System that utilizes satellite imagery. Thus, while the stand canopy closure metric may not be indicative of specific causes for canopy openings, it is nonetheless can serve to direct management attention to specific locations and is detectable by satellite.

⁵ The APPA corridor varies in width, thus, the width of each segment will vary based on the width of the corridor at that point and the angle at which the Hydrologic Unit Code (HUC) boundary intersects the corridor. For example, if the HUC boundary follows a ridgeline, the corridor may be bisected by the HUC yielding segments that are narrower than the corridor itself. Conversely, if the HUC boundary crosses the corridor at an oblique angle, the width of the associated segment may be as wide as the entire corridor at that point.

⁶ High elevation forests exist along the APPA but consist of stunted vegetation that fails to satisfy the overstory criteria contained in this protocol. Because the transition between mid- and high-elevation is based on a structural difference, a discrete elevation where this transition occurs was not established.

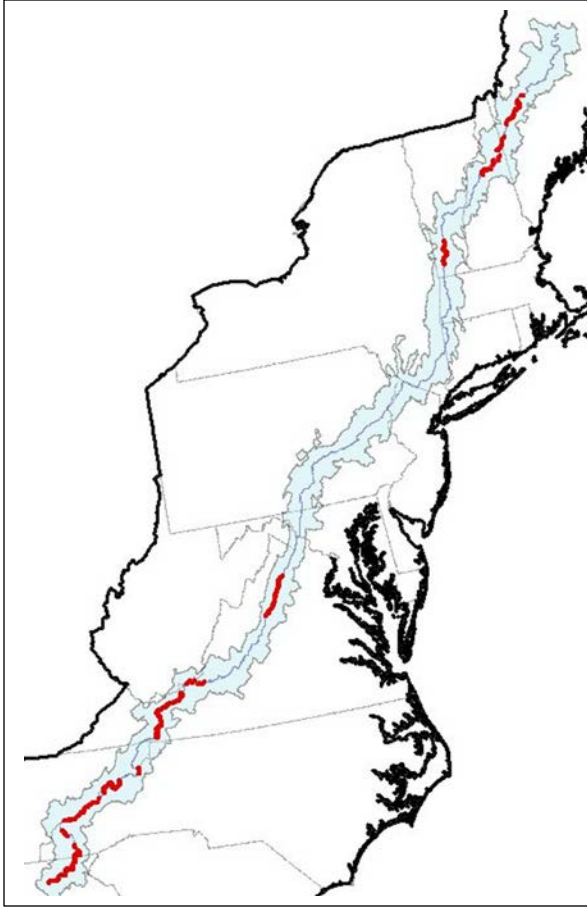


Figure 1. Sampling frame showing all potential segments meeting area and elevation criteria (red).



Figure 2. Segments defined by the boundaries of HUC10 hydrologic units (thick black line) and the APPA land area

Spatial Allocation

A two-stage sampling design was used to achieve a spatially balanced selection of segments and a spatially balanced selection of permanent plots within each segment. In the first stage, 10 segments⁷ (four in the north and six in the south) were selected from a total of 39 segments that were at least 250 ha in size and at least 450 m asl in the north and 600 m asl in the south (Figure 3; Table 2) using generalized random tessellation stratified sampling (GRTS) (McDonald 2004). This design employs random and site selection, allowing for statistical inference while also providing balanced spatial coverage and flexibility for post-stratification of segments based on ecological system, association, or other criteria as needed. Further, GRTS sampling allows the sample size to be adjusted as needed (e.g., select additional segments) after sampling has begun without sacrificing spatial balance. Ten segments are probably too few to provide precise inference to the entire population of segments, but these segments can function as index sites for other segments of similar elevation and forest type.

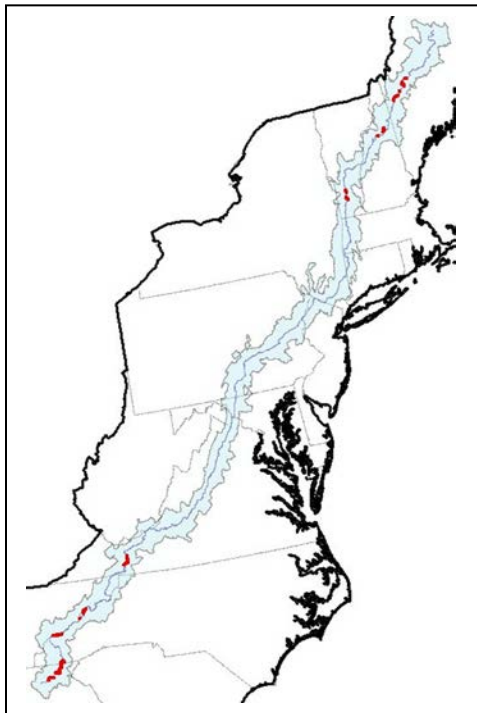


Figure 3. Selected sampling segments (red).

Table 2. Summary statistics for potential and selected sampling segments.

Category	Count	Hectares			Elevation (m)		
		Min	Max	Avg	Min	Max	Avg
Potential Segments	39	261	1,508	574	456	2,017	1,078
Selected Segments	10	261	908	525	457	2,017	1,094

⁷ The number of segments selected was based on expert judgment given a limited budget for a pilot study. Additional segments could be selected if desired, and if sufficient funding is available.

In order to achieve balanced spatial coverage within the selected sampling segments, in the second stage an array of randomly placed sampling points was generated using GRTS (McDonald 2004). Allocation of points within segments was proportional to the area of each segment (one point for every 50 ha). Number of plots per segment ranged between five and 18, for a total of 105 plots in the 10 segments (Table 3).

Table 3. Descriptive statistics for selected sampling segments.

Hydrologic Unit	State	Region	Plots	Hectares	Min Elevation (m)	Max Elevation (m)	Average Elevation(m)
0103000304	ME	North	11	559	606	1,288	935
0104000101	ME	North	18	908	457	1,245	821
0108010304	NH	North	5	261	1,230	1,877	1,485
0108010703	VT	North	8	383	672	1,203	835
0306010201	GA/NC/TN	South	11	547	841	1,648	1,176
0313000105	GA	South	7	342	866	1,357	1,063
0601010203	VA	South	15	750	732	1,246	934
0601010514	NC/TN	South	6	290	678	1,419	970
0601020101	NC/TN	South	8	425	1,346	2,017	1,605
0602000201	GA	South	16	781	807	1,427	1,120

Temporal Allocation

The APPA Plot-Based Forest Monitoring Protocol requires repeat sampling of permanent plots, since many metrics can only be calculated after a second visit (e.g., tree growth and tree mortality). A variety of temporal schedules are possible, and once monitoring is implemented the revisit schedules to simplify data analyses must be consistent. It is unlikely that funding will be available to monitor all plots within a single year, so a panel design is needed. Following the NETN Forest Monitoring Protocol (Tierney et al. 2011), we recommend unconnected panels to be monitored every 4 or 5 years. One approach would be to conduct field monitoring of northern segments in year 1, southern segments in year 2, and data analysis and reporting in year 3 and 4 before conducting field work again in the northern segments in year 5 (a 4-year revisit interval). Another approach would be to monitor two segments each year, for a 5-year revisit interval, with data analysis and reporting ongoing. Prior to implementation, long-term funding for ongoing monitoring must be secured.

Detectable Level of Change

The power to detect change in forest health within each segment is a function of the variability of the metrics evaluated, the sample size, and the magnitude of the change. A thorough investigation of power must wait until repeat plot data are available (about 6 years after protocol implementation). However, analyses of the power of the NETN forest monitoring program

(Miller et al. 2012) support the sample size decision. These analyses indicate that 105 total plots will be well beyond the size needed to detect changes of 20% if the change occurs uniformly across the plots. Detecting change within a single segment is more difficult, and if metrics are highly variable then it will not be possible to detect reliably change among five to 18 plots. In this case, post-stratification by ecological type and removal of plots not in the dominant ecological type could reduce variability and improve power. Post-stratification does not affect the randomization of the design, since it alters the population being sampled. In other words, post-stratifying by focusing on plots within one forest type allows for evaluation of the population of potential plots within that forest type; randomly selected plots within that forest type are still randomly selected, even if the original design included plots in other forest types.

Methods

Forests are highly valued ecosystems for the many economic, ecological and recreational benefits they provide. For this reason, methods for sampling forest vegetation are numerous and well developed. We have chosen to adopt or adapt existing procedures rather than “reinvent the wheel” by creating new procedures that duplicate existing efforts. Particularly since the addition of procedures for monitoring forest condition in the 1990s, the FIA program provides well researched and documented protocols for monitoring forest resources (see Existing Monitoring Programs, above). In addition, adoption of the FIA conventions within the NETN protocol will allow APPA to compare conditions within the sampled segments to data from nearly 4,700 FIA plots within a zone around the APPA corridor known as the HUC10 shell (the distal boundary of all HUC10 watersheds that are within 5-miles of the APPA corridor; Figure 4).

The standard operating procedures (SOPs) that follow this narrative provide detailed, step-by-step instructions for data collection and analysis. These SOPs include instructions on preparation, site selection and plot establishment, and data management and analysis in addition to data collection. It is essential for successful monitoring to follow carefully established methods.

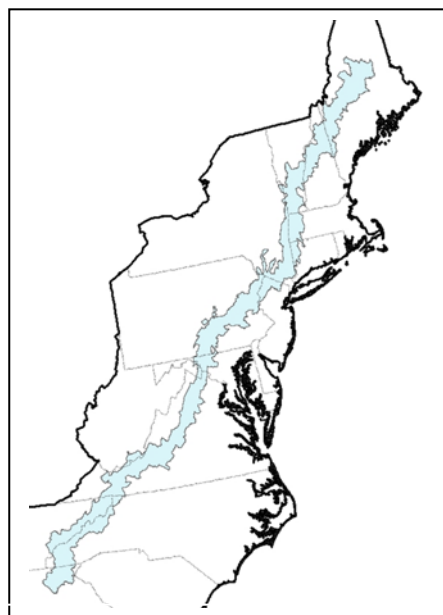


Figure 4. HUC 10 Shell.

Plot Layout

We developed a network of 105 plots within the 10 sampled segments. The number of plots per segment was proportional to segment area with no segment having fewer than five plots (smaller sample sizes were deemed insufficient to document variability between plots within a given segment). The plot layout (Figure 5) resembles the FIA monitoring plots, relying on an 11-meter radius circular plot.

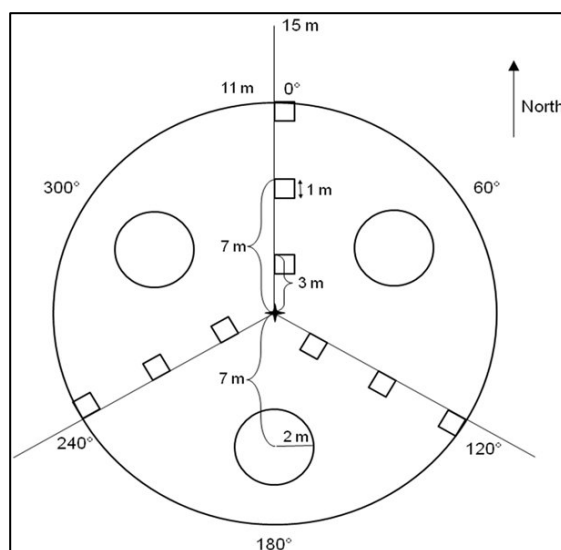


Figure 4. APPA plot layout showing 11-m radius circular tree plot with three nested 2-m radius regeneration microplots, nine 1-m² vegetation quadrats, and three 15-m CWD transects.

Forest Measurements

Within each plot, basic information describing the site (e.g., slope, aspect, and terrain position; SOP 8 – Stand and Site Measurements) is collected to allow proper interpretation of other data collected. Photographs are taken of the plot and understory to document change in appearance over time (SOP 7 – Photopoint Procedures). Stand structure and composition, and disturbance are qualitatively assessed from visual inspection (SOP 8). Each tree ≥ 10 cm diameter-at-breast-height (DBH) is marked and measured for status (live/dead), size (DBH), and

condition (SOP 9 – Tree Measurements). These data yield information on tree growth, mortality and condition, and stand structure and composition. To assess advance regeneration and the effects of deer browsing (SOP 10 – Microplot Measurements) tree seedlings are quantified by species and size class in circular 2-m radius microplots. Composition and abundance of understory indicator plants within 1-m² quadrats are recorded to yield information related to the impacts of key stressors, including exotic species invasion (SOP 12 – Quadrat Measurements). Coarse woody debris (CWD) is quantified along 15-m line intersect transects originating at plot center (SOP 11 – Coarse Woody Debris Measurements). Forest floor condition is assessed by visual inspection for microtopography,⁸ trampling, and evidence of earthworm presence (SOP 8).

A three-person crew can install and measure a plot following this protocol in about 2.5 hours, in addition to travel time, assuming that the plot in question is not composed of extremely dense trees or exhibits other unusual characteristics.

Wherever possible, the NETN and APPA protocols follow FIA conventions (USFS 2005) including definitions and size thresholds of items to be measured. However, the SOPs are adapted to fit specifically NETN and APPA objectives, and thus are not identical to the FIA protocol. Significant departures contained in the APPA protocol include:

- The APPA protocol uses metric rather than English measuring units for better compatibility with the scientific community.
- Both APPA and FIA employ fixed area plots; however, APPA uses single, circular plots that differ in size, shape, and arrangement from FIA, which uses a cluster of four, 7.3-m radius circular subplots. The APPA's segment-based sampling frame is more discrete than the FIA's, so clustered subplots were not needed.
- The APPA protocol monitors all trees ≥ 10 cm DBH on these plots, rather than ≥ 12.7 cm (5 in) DBH as does FIA, to better calculate ecological stand structure and composition indices (e.g., Peet et al. 1998, Tyrrell et al. 1998).
- The APPA protocol uses simpler rules than FIA for measuring DBH of forked trees because FIA rules were found by NETN to be too difficult to use by crew members of average or shorter height.
- The APPA protocol uses a larger size cutoff for CWD (≥ 10 cm diameter) than FIA (≥ 7.5 cm). The FIA size cutoff corresponds to a 100-hour fuel burning threshold which is less relevant to ecological monitoring in the Northeastern U.S. The 10-cm threshold is preferred because it is consistent with the NETN size cutoff for trees, more straightforward to measure in-situ, and often used by ecological studies in the Northeastern U.S. (Harmon and Sexton 1986, Pyle and Brown 1998).
- The APPA protocol does not monitor lichen communities as an indicator of atmospheric deposition.
- The APPA protocol also does not monitor fine woody debris.

⁸ Microtopography indicates site history. Lack of microtopography indicates the site has been plowed prior to establishment of second-growth forest.

Landscape Context

We calculate two landscape context metrics indicative of fragmentation and the influence of adjacent land use and stressors on the ecological condition of the plot. These metrics are forest patch size and neighborhood anthropogenic land use (SOP 13 – Landscape Context). Change over time is monitored using satellite imagery.

QA/QC

Approximately 5% of sampled plots must be resampled annually to determine reliability of data collection. Additional requirements for quality control and quality assurance are specified within SOP 4 – Data Management & Quality Assurance/Quality Control.

Data Management and Analysis

In the field, data is entered onto APPA datasheets (Appendix A) designed for accurate and complete data collection. These data are transcribed to and stored in an APPA version of the NETN MS Access forest database. See SOP 4 – Data Management & Quality Assurance/Quality Control for additional details on data management procedures.

Forest metrics are calculated from raw data as shown in SOP14 – Analyzing and Reporting Ecological Integrity. NETN plans to estimate both status and trend over time of specific measures within forested systems in each sampled segment. The analytical approach is described in Tierney et al. 2011, and is based on a general linear model that partitions spatial and temporal variability to allow assessment of change over time, as is done by the FIA program (Woodall and Williams 2005).

Reporting

Assessing and reporting the ecological integrity of park resources is a major goal of the NASA DSS and the APPA environmental monitoring program. Ultimately, a vital sign is useful only if it provides information which guides management decisions or quantifies the successes or limitations of past decisions. Ecological integrity must be assessed from data and presented in a format that can be clearly understood by managers, scientists, policy makers, and the public.

Assessing Ecological Integrity

The NETN uses the concept of “ecological integrity” to inform management decisions affecting park ecosystems, and a similar approach is appropriate for APPA. The “ecological integrity” of an ecosystem is a measure of the structure, composition, and function of an ecosystem as compared to pristine or benchmark ecosystems operating within the bounds of natural or historic disturbance regimes (Karr and Dudley 1981, Parrish et al. 2003). Assessment of ecological integrity is a challenging undertaking (NAS 2000). Useful attributes for assessment of ecological integrity change predictably in response to stressors, discriminate between anthropogenic and natural variability, and are easy to measure and interpret (Karr and Chu 1999). Determination of ecological integrity must consider the natural or historic range of variability inherent in natural systems (Landres et al. 1999), and variation in ecosystem attributes among successional stages. As global change alters background environmental conditions beyond historical levels, interpretation of ecological integrity in this fashion will be challenging.

In order to identify key aspects of forest composition, structure and function most relevant to the assessment of ecological integrity, NETN developed a conceptual ecological model for terrestrial systems within NETN parks. This model highlights linkages between NETN terrestrial ecosystems, known stressors and agents of change acting within NETN parks, and key attributes and ecological processes of these systems. This model is presented in the Conceptual Ecological Model Appendix of the NETN Monitoring Plan (Mitchell et al. 2006); it uses a suite of metrics for assessing the ecological integrity of APPA forests (Table 1). Justification for each metric is included within SOP 13 - Analyzing and Reporting Ecological Integrity.

To assess ecological integrity using these metrics, we have used data, models, and expert opinion from the scientific literature to establish assessment points that distinguish expected or acceptable conditions from those that warrant concern, further evaluation, or management action (Bennetts et al. 2007). Assessment points for rating ecological integrity are based upon natural or historic variability. Estimates of historical or natural variation in ecosystem attributes provide a reference for gauging the effects of current anthropogenic stressors, while at the same time recognize the inherent natural variation in ecosystems across space, time, and stages of ecological succession (Landres et al. 1999). Documentation of metric and rating development is presented within SOP 14 – Analyzing and Reporting Ecological Integrity. The interpretation of ecological integrity is a useful but developing conservation application, and ratings will be reviewed and updated as new information becomes available.

Scorecard

The APPA Plot-Based Forest Monitoring Protocol will follow the NETN scorecard format to clearly and concisely report ecological integrity to a wide audience. A successful ecological

scorecard should transparently convey status and trend in key ecological parameters in a way that is meaningful to the public, managers, and other stakeholders (Harwell et al. 1999).

NETN has developed a scorecard reporting framework to visually convey status and trends in each metric of forest integrity using the NPS stoplight symbology, which uses color to convey integrity rating—Good, Caution and Significant Concern are conveyed respectively as green, yellow or red circles. It also uses an embedded arrow to convey the direction of trend observed across sampling intervals (increasing, stable or decreasing). For transparency, actual data values are noted on the scorecard in addition to ratings.

These data can be aggregated into higher levels of the NPS Ecological Monitoring Framework for reporting at the national level.

Reporting Schedule

Reporting the condition of forest resources based on ground based sampling is entirely dependent on whether funding is available to implement and sustain ground based forest monitoring as described in this protocol. As this protocol is implemented, we will follow the NETN approach of developing standard graphical and statistical summaries of vital sign measurements.

Following each field season, an annual report will be prepared summarizing the year's work. This will include routine summaries for each measure. Assuming the protocol is implemented and sustained, a trend report will be prepared to document more detailed analyses after 5-10 years of operation.

Operational Requirements

Personnel Requirements and Training

This forest monitoring protocol is best staffed by a project leader, and a crew of three members one of whom is designated the crew leader, as outlined in SOP 2 – Preparation and Equipment List. The forest crew leader, and preferably each member of the forest crew, should have sound woody plant identification skills for the region in which sampling is planned and exposure to forest sampling methods. Unless this protocol is being implemented by NPS, neither the field staff nor the project leader will be NPS employees. In a typical non-NPS implementation, NPS staff will provide guidance and assistance but data collection, data input, and reporting will be handled by the organization responsible for the project. Where the protocol requires GIS mapping support or other technical support, it will be provided by NETN personnel including the APPA environmental monitoring coordinator and NETN data manager.

To secure field personnel, the organization conducting the hiring may wish to advertise the positions at eastern universities, as well as nationally on environmental job websites such as the Society for Conservation Biology job database (<http://www.conbio.org/jobs>) or listserves such as the Ecological Society of America's listserve (ecolog-l@listserv.umd.edu). NETN may also find it useful to network with regional environmental professors and professionals to identify skilled seasonal staff.

All field personnel must fully understand this protocol and participate in training sessions as described in SOP 2 – Preparation and Equipment List.

Annual Workload and Field Schedule

Workload for monitoring forest resources along the APPA will depend on funding availability, who will implement the program, and the number of segments to be sampled. Assuming that it will be implemented by a university-led research team, and that monitoring will occur in one region but not both during a given season, the following workloads (based, in part, on numbers from the 2010 season) can be anticipated:

- Project Leader – 0.1 Full Time Equivalent (FTE) or 5 weeks. This includes time for recruiting and training field staff, participating in field work and QA/QC activities, and producing the annual monitoring report.
- Field Staff – 0.25 FTE or 13 weeks. This includes field work prep, training, and 8 weeks of field work, data entry and data management.
- Local Coordinators (APPA Resource Manager and/or ATC Staff) – 0.02 FTE or 1 week. This includes logistical support for field activities, reviewing and distributing reports, and public communications about the project.
- APPA Environmental Monitoring Coordinator – 0.02 FTE or 1 week. This includes annual operational review, coordinating with field staff, and report reviews.
- NETN Data Manager – 0.02 FTE or 1 week. This includes participating in the annual operational review and QA/QC.

The window of opportunity to monitor forest resources along the APPA is regionally dependent, with the northern region being more restrictive than the south. Training should be conducted during the late spring of the year, late enough for leaves and flowers to emerge but not so late that the survey season is shortened. Assuming a university-led team that is further constrained by the academic year, field work, including QA/QC should be conducted between June and late July, and data entry and management should be completed during late July and early August.

Facility and Equipment Needs

A list of necessary equipment is included in SOP 2 – Preparation and Equipment List.

Startup Costs and Budget Considerations

Initial costs for this protocol include the purchase of all equipment and supplies needed for one monitoring team. Equipment excludes personal hiking and camping equipment. A complete set of equipment should cost approximately \$2,000.

Annual costs would be approximately \$44,200 per year. This excludes equipment, and time spent by NPS staff coordinating with project staff and providing logistical support. The budget breaks down roughly as follows:

- \$10,000 – Project manager or PI salary
- \$23,400 – Field staff
- \$2,000 – Equipment and supplies
- \$2,200 – Transportation, meals, and lodging
- \$6,600 – Overhead, 17.5%

Literature Cited

- Bennetts R. E, Gross J. E, Cahill K, and others. 2007. Linking monitoring to management and planning: assessment points as a generalized approach. *The George Wright Forum* **24**: 59–77.
- Cutko, A. 2005. Ecological Reserves monitoring: project update, June 2005. Maine Natural Areas Program, Augusta, Maine, 24 pp.
- Dieffenbach, F. 2011. Appalachian National Scenic Trail vital signs monitoring plan. Natural Resource Report NPS/NETN/NRR—2011/389. National Park Service, Fort Collins, Colorado.
- Harmon, M. E. and J. Sexton. 1986. Guidelines for measurements of woody detritus in forest ecosystems. Publication No. 20. US LTER Network Office, University of Washington, Seattle, Washington.
- Harwell, M. A., V. Myers, T. Young, et al. 1999. A framework for an ecosystem integrity report card. *BioScience* **49**: 543-556.
- Karr J. R. and D. R. Dudley. 1981. Ecological perspective on water-quality goals. *Environmental Management* **5**: 55-68.
- Karr, J. R. and E. W. Chu. 1999. Restoring life in running waters: better biological monitoring. Island Press, Washington, D.C.
- Landres, P. B., P. Morgan, and F. J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications* **9**: 1179-1188.
- Manion, P. D., B. D. Rubin, D. Faber-Langendoen, and D. J. Leopold. 2003. Forest Health Monitoring Project for northern New York. State University of New York, College of Environmental Science and Forestry, Syracuse, New York.
- McDonald, T. L. 2004. GRTS for the Average Joe: A GRTS Sampler for Windows. http://www.west-inc.com/biometrics_reports.php.
- Miller, K. M., B. R. Mitchell, and J. S. Wheeler. 2012. Forest health monitoring in the Northeast Temperate Network: 2011 summary report. Natural Resource Technical Report NPS/NETN/NRTR—2012/604. National Park Service, Fort Collins, Colorado.
- Mitchell B. R., W. G. Shriver, F. Dieffenbach, et al. 2006. Northeast Temperate Network Vital Signs Monitoring Plan. Woodstock (VT): National Park Service. Technical Report NPS/NER/NRTR - 2006/059. (<http://science.nature.nps.gov/im/units/NETN/monitor/monitor.cfm>)
- NAS. 2000. Ecological Indicators for the Nation. National Academy Press, Washington DC.
- Parrish, J. D., D. P. Braun, and R. S. Unnasch. 2003. Are we conserving what we say we are? Measuring ecological integrity within protected areas. *Bioscience* **53**: 851-860.

- Peet, R. K., T. R. Wentworth, and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. *Castanea* **63**: 262-274.
- Pyle, C. and M. M. Brown. 1998. A rapid system of decay classification for hardwood logs of the eastern deciduous forest floor. *Journal of the Torrey Botanical Society* **125**: 237-245.
- Tierney, G., B. Mitchell, K. Miller, J. Comiskey, A. Kozlowski, and D. Faber-Langendoen. 2011. Northeast Temperate Network long-term forest monitoring protocol: 2011 revision. Natural Resource Report NPS/NETN/NRR—2011/404. National Park Service, Fort Collins, Colorado.
- Tyrrell, L. E., G. J. Nowacki, T. R. Crow, *and others*. 1998. Information about old growth for selected forest type groups in the eastern United States. USDA Forest Service General Technical Report- NC-197. St. Paul, Minnesota.
- U.S. Forest Service. 2005. Forest Inventory and Analysis: National Core Field Guide, Version 3.0.
- Woodall, C. and M. S. Williams. 2005. Sampling protocol, estimation, and analysis procedures for the down woody materials indicator of the FIA program. General Technical Report NC-256. U.S. Forest Service, North Central Research Station, St. Paul, Minnesota.

Appendix A: APPA Plot-Based Forest Monitoring datasheet (Version 1.04)

Appendix A: APPA Plot-Based Forest Monitoring datasheet (continued).

APPA Forest Monitoring Datasheet 1.04

Park	APPA	Plot	Date	Contacts			
Plot Data				Purpose	Color	Date	Initials
GRTS	Lat	Lon	Accuracy	Entered to DB	☐		
Orientation		Aspect		100% Check	☐		
Slope Meas. CWD: UP		BR	BL	Plot: High	Low		
Physiographic Class _____				Validation	☐		
Xeric: 11= Dry Tops, 12=Dry Slopes, 19= Other Xeric. Mesic: 21= Flatwoods, 22=Rolling Uplands, 23= Moist Slopes and Coves, 26= Floodplains and Bottomlands, 29=Other Mesic. Hydric: 31- Swamps/Bogs, 32= Small Drains, 39= Other Hydric					☐		
Directions							
Brief Description							
Stand Data							
Crown Closure	<10%	10-25%	25-50%	50-75%	>75%	Earthworms	0 1 9
Stand Structure	1=Even-Aged	3=Multi-Aged	4=Mosaic	5=Early Successional			
Deer Browse Index	Microtopography: 0 1 9			Stand Height (m)	Tree 1	Tree 2	Tree 3
Water on Plot _____				Angle to Top (+)			
0= none, 1= perm. stream or pond, 2= swamp/bog/marsh, 3= ditch/canal				Angle to Base (-)			
4= temporary stream, 5= flood zone, 6= vernal pool, 7= Other Water				Horiz. Distance (m)			
Cover Classes for following estimates: <1%, 1-5%, 5-25%, 25-50%, 50-75%, 75-95%, 95-100%							
% Bare Soil	% Rock	% Trampled		% Non-Vascular		% Lichen	
% Surf. Water	% Vasc. Low (< 0.5m)		% Vasc. Mid (0.5-2m)		% Vasc. High (2-5m)		
Disturbances (Threshold Classes: 1=25% of all trees, 2=50% of 1 tree species, 3=25% of soil or vegetation)							
Disturbance Code	Threshold			% Class (multiples of 10)	Notes		
Disturbance 1:	1	2	3				
Disturbance 2:	1	2	3				
Disturbance 3:	1	2	3				
10=Insect Damage (ID), 11=ID on ground veg, 12=ID to trees (sdlgs&saps) 20=Disease Damage (DD), 21=DD to ground veg, 22=DD to trees (sdlgs&saps) 30=Fire (nat or prescribed), 40=Animal Damage, 41=beaver damage to veg, 42=porcupine, 43=deer/ungulate, 44= bear, 45=rabbit, 46= livestock, 47 =beaver flooding, 50=Weather damage, 51=ice/snow, 52= wind, 53=flooding from weather, 54=drought, 55=earth movement/ avalanches, 60=Vegetation (suppression, competition, or vines), 70=Unknown/unsure, 80=Other Human caused, 90= Silvicultural Treatment 91=Overstory removal, 92=Selective Cutting, 93=Site Preparation, 94= Artificial Regeneration, 95=Other Silvicultural Disturbance							
Plot Notes							
Photopoint							
Panoramic series	Photographer:			Photo notes			
First:	Tripod Height: m						
Last:	Vertical:						
Canopy:	Microplot:						

Page ____ of ____

Plot, Stand and Soil

Field Check ☐ Initials: _____

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Tree

Appendix A: APPA Plot-Based Forest Monitoring datasheet (continued).

APPA Forest Monitoring Datasheet 1.04

Tree Saplings (1-10cm dbh; No scribe <7.5 cm dbh)

[illegible]Shrub %Cover (>=30 cm tall)

% Classes: <1, 1-5, 5-10, 10-25, 25-50, 50-75, >75

[illegible]

Park	APPA	Plot#	Date:
------	------	-------	-------

Tree Seedling Tally (≥ 15 cm tall, < 1 cm dbh)

[illegible]

Notes:	
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CWD (≥ 10 cm diam, ≥ 1 m long) (Record slope are on plot datasheet)

[illegible]

Notes:	
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Page ____ of ____

Field Check ☐ Initials:

Appendix A: APPA Plot-Based Forest Monitoring datasheet (continued).

APPA Forest Monitoring Datasheet 1.04										Park	APPA	Plot#	Date
Quadrat Data NOTE: If recording a species as a Germinant, write a G after the species name. Cover classes = <1, 1-2, 2-5, 5-10, 10-25, 25-50, 50-75, 75-95, 95-100%.													
Characteristics	UP-3	UP-7	UP-11	BR-3	BR-7	BR-11	BL-3	BL-7	BL-11	Notes			
Sampled													
Trampled													
%Soil													
%Rock													
%Stem													
%Wood													
Sphagnum													
NS Bryophyte													
Lichen													
Species - Native	UP-3	UP-7	UP-11	BR-3	BR-7	BR-11	BL-3	BL-7	BL-11	ID Conf.	Coll?		
<i>Ageratina altissima</i>													
<i>Aralia nudicaulis</i>													
<i>Arisaema triphyllum</i>													
<i>Asarum canadense</i>													
Cyperaceae (sedge)													
<i>Clintonia borealis</i>													
<i>Dennstaedtia punct.</i>													
<i>Erythronium american.</i>													
<i>Eurybia divaricata</i>													
<i>Hepatica nobilis</i>													
<i>Maianth.</i> _____													
<i>Medeola virginiana</i>													
Orchids													
Other Ferns (not listed)													
Poaceae (grass)													
<i>Podophyllum peltatum</i>													
<i>Polygonatum</i> _____													
<i>Polystichum acrost.</i>													
<i>Sanguinaria canadensis</i>													
<i>Streptopus</i> _____													
<i>Thelypteris novebor.</i>													
<i>Trillium</i> _____													
<i>Uvularia</i> _____													
Additional Species (ID conf)													

Page ____ of ____

Field Check ☐ Initials: _____

Quadrat

Appendix A: APPA Plot-Based Forest Monitoring datasheet (continued).

APPA Forest Monitoring Datasheet 1.04			Park	APPA	Plot#	Date					
Quadrat Data			NOTE: If recording a species as a Germinant, write a G after the species name. Cover classes = <1, 1-2, 2-5, 5-10, 10-25, 25-50, 50-75, 75-95, 95-100%.								
Species - exotic	UP-3	UP-7	UP-11	BR-3	BR-7	BR-11	BL-3	BL-7	BL-11	ID Conf.	Coll?
Aegopodium podagrar.											
Alliaria petiolata											
Ampelopsis brevipedunc.											
Berberis thunbergii											
Berberis vulgaris											
Cardamine impatiens											
Celastrus orbiculatus											
Cynanchum louiseae											
Cynanchum rossicum											
Euonymus alatus											
Euonymus fortunei											
Glechoma hederacea											
Heracleum mantegazz.											
Hesperis matronalis											
Ligustrum obtusifolium											
Ligustrum vulgare											
Lonicera japonica											
Lonicera spp. (exotic)											
Luzula luzuloides											
Lysimachia nummularia											
Microstegium vimineum											
Polygonum caespitosum											
Polygonum cuspidatum											
Polygonum perfoliatum											
Polygonum sachalinense											
Pueraria montana											
Ranunculus ficaria											
Rosa multiflora											
Rubus phoenicolasius											
Vinca minor											
Wisteria sinensis											
Additional Species (ID conf)											

Field Check ☐ Initials:

Appendix A: APPA Plot-Based Forest Monitoring datasheet (continued).

[illegible]

Appendix A: APPA Plot-Based Forest Monitoring datasheet (continued).

APPA Forest Monitoring Datasheet 1.04	
GRTS Rejection Information	
Park	APPA
GRTS #	
Crew	
Lat (DD)	Lon (DD)
GPS Accuracy	Date
Brief Description	
Reason for Exclusion	
Plot Center is <15m from: ☐ Park Boundary ☐ Mowed Area ☐ Perm. Water Body ☐ Perennial Stream ☐ Road	
Plot Habitat	
☐ <60% tree species cover	
Safety Concern (Describe below)	

Appendix A: APPA Plot-Based Forest Monitoring datasheet (continued).

APPA Data Entry Codes 1.04	
Physiographic classes	
Xeric: 11= Dry Tops, 12=Dry Slopes, 19= Other Xeric	
Mesic: 21=Flatwoods, 22= Rolling Uplands, 23=Moist Slopes and Coves 26=Floodplains and Bottomlands, 29= Other Mesic	
Hydric: 31=Swamps/Bogs, 32=Small Drains, 39=Other Hydric	
Stand Structure (6 and SW occur in ACAD only)	
1= Even-aged, 3= Multi-aged, 4= Mosaic, 5= Early Successional	
Crown Closure % Cover Classes	
1= <10%, 2= 10 - 25%, 3= 25 - 50%, 4= 50 - 75%, 5 = >75%	
Water on Plot	
0= none, 1= perm. stream or pond, 2= swamp/bog/marsh, 3= ditch/canal 4= temp. stream, 5= flood zone, 6= vernal pool, 7= Other Water	
Disturbance Codes	
Threshold: 1= >25% of all trees, 2= 50% of one species, 3= 25% soil or veg. 10=Insect Damage (ID), 11= ID on ground veg, 12= ID to trees (sdgls & saps) 20= Disease Damage (DD), 21= DD to ground veg, 22= DD to trees (sdgls & saps) 30= Fire (nat or prescribed), 40= Animal Damage, 41= beaver damage to veg. 42=porcupine, 43=deer/ungulate, 44=bear, 45=rabbit, 46= livestock, 47= beaver flooding 50=Weather damage, 51=ice/snow, 52= wind (incl. hurricane & tomodo) 53=flooding from weather, 54=drought, 55= earth movement/ avalanches 60= Vegetation (suppression, competition or vines), 70= Unknown/ unsure 80= Other Human caused, 90=Silvicultural Treatment, 91=Overstory removal 92=Selective Cutting, 93=Site Prep., 94- Artificial Regeneration, 95= Other Silvicultural	
Tree Measurements	
Status: First Letter: A=Alive, D=Dead, R=Recruit Second Letter: L=Leaning, F=Fallen, B=Broken, C=Cut, M=Missed (by prev. sampling) Other codes: NL = Not located, EX = Excluded Impossible codes: DL, AC, RC, RM	
CrownClass: 1= OpenGrwn, 2= Dom, 3= Codom, 4= Intermed, 5= Sub-can 6= GapExp.	
Condition: AD= advanced decay, BWA= balsam wooly adelgid, BBD= beech bark dis., G= burl/gall, BC= butternut canker, EHS= elongate hemlock scale, EAB= emerald ash borer, EB= epicormic branching, GM= gypsy moth, HWA= hemlock wooly adelgid, ID= insect damage, DBT= large dead branches, CW= Open wounds/cankers, SW= sirex wood wasp, SB= spruce budworm, SOD= sudden oak death, VIN= vines in crown, OD= other, H= healthy	
BBD Scale: 1= no BBD, 2= scales present & some cracks, 3= cracked w/ cankers 4= Severe bark cracking and large cankers	
HWA Scale: 1=no HWA, 2=HWA or EHS present, but foliage healthy, 3=HWA or EHS present and 10-25% of needles have chlorosis and/or necrosis, 4= severe, >25% of foliage affected by needle loss on fine twigs, chlorosis and/or necrosis.	
Foliage Cond: C= chlorosis, N= necrosis, H= holes, S=sm. lvs, W= wilting, L= leaf loss O=other	
Foliage % class: 1-10%, 10-50%, 50-90%, 90-100%	

Appendix B: Slope Table

Appendix B: Slope Conversion Table

For each combination of slope and slope distance, read horizontal distance (m) from table.

[illegible]

Horizontal distance shown in italics does not differ from slope distance. Blank cells exceed 11 m horizontal distance.

Appendix B: Slope Table (continued).

Appendix B: Slope Conversion Table
For each combination of slope and slope distance, read horizontal distance (m) from table.

Slope in degrees																														
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30					
Slope distance	5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.7	4.7	4.7	4.6	4.6	4.6	4.5	4.5	4.5	4.4	4.4	4.3					
	5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.8	4.8	4.8	4.7	4.7	4.7	4.6	4.6	4.5	4.5	4.5	4.4					
	5.2	5.2	5.2	5.1	5.1	5.1	5.1	5.1	5.1	5.0	5.0	5.0	4.9	4.9	4.9	4.9	4.8	4.8	4.8	4.7	4.7	4.6	4.6	4.5	4.5					
	5.3	5.3	5.3	5.2	5.2	5.2	5.2	5.2	5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.8	4.8	4.8	4.7	4.7	4.6					
	5.4	5.4	5.4	5.3	5.3	5.3	5.3	5.3	5.2	5.2	5.2	5.2	5.1	5.1	5.1	5.0	5.0	5.0	4.9	4.9	4.9	4.8	4.8	4.7	4.7					
	5.5	5.5	5.5	5.4	5.4	5.4	5.4	5.4	5.3	5.3	5.3	5.3	5.2	5.2	5.2	5.2	5.1	5.1	5.1	5.0	5.0	4.9	4.9	4.8	4.8					
	5.6	5.6	5.6	5.5	5.5	5.5	5.5	5.5	5.5	5.4	5.4	5.4	5.3	5.3	5.3	5.3	5.2	5.2	5.2	5.1	5.1	5.0	5.0	4.9	4.9					
	5.7	5.7	5.7	5.6	5.6	5.6	5.6	5.6	5.5	5.5	5.5	5.5	5.4	5.4	5.4	5.4	5.3	5.3	5.2	5.2	5.2	5.1	5.1	5.0	5.0					
	5.8	5.8	5.8	5.7	5.7	5.7	5.7	5.7	5.6	5.6	5.6	5.6	5.5	5.5	5.5	5.5	5.4	5.4	5.3	5.3	5.3	5.2	5.2	5.1	5.1					
	5.9	5.9	5.9	5.8	5.8	5.8	5.8	5.8	5.7	5.7	5.7	5.6	5.6	5.6	5.5	5.5	5.5	5.4	5.4	5.3	5.3	5.3	5.2	5.2	5.1					
	6.0	6.0	6.0	5.9	5.9	5.9	5.9	5.9	5.8	5.8	5.8	5.7	5.7	5.7	5.6	5.6	5.6	5.5	5.5	5.5	5.4	5.4	5.3	5.3	5.2					
	6.1	6.1	6.1	6.0	6.0	6.0	6.0	6.0	5.9	5.9	5.9	5.9	5.8	5.8	5.8	5.7	5.7	5.7	5.6	5.6	5.6	5.5	5.5	5.4	5.3					
	6.2	6.2	6.2	6.1	6.1	6.1	6.1	6.1	6.0	6.0	6.0	6.0	5.9	5.9	5.9	5.8	5.8	5.7	5.7	5.7	5.6	5.6	5.5	5.5	5.4					
	6.3	6.3	6.3	6.2	6.2	6.2	6.2	6.2	6.1	6.1	6.1	6.1	6.0	6.0	6.0	5.9	5.9	5.8	5.8	5.8	5.7	5.7	5.6	5.6	5.5					
	6.4	6.4	6.4	6.3	6.3	6.3	6.3	6.3	6.2	6.2	6.2	6.2	6.1	6.1	6.1	6.1	6.0	6.0	5.9	5.9	5.8	5.8	5.7	5.7	5.6					
	6.5	6.5	6.5	6.4	6.4	6.4	6.4	6.4	6.3	6.3	6.3	6.2	6.2	6.2	6.1	6.1	6.1	6.0	6.0	5.9	5.9	5.8	5.8	5.7	5.7					
	6.6	6.6	6.6	6.5	6.5	6.5	6.5	6.5	6.4	6.4	6.4	6.3	6.3	6.3	6.2	6.2	6.2	6.1	6.1	6.0	6.0	5.9	5.9	5.8						
	6.7	6.7	6.7	6.6	6.6	6.6	6.6	6.6	6.5	6.5	6.5	6.4	6.4	6.4	6.3	6.3	6.3	6.2	6.2	6.1	6.1	6.0	6.0	5.9						
	6.8	6.8	6.7	6.7	6.7	6.7	6.7	6.7	6.6	6.6	6.6	6.5	6.5	6.5	6.4	6.4	6.3	6.3	6.3	6.2	6.2	6.1	6.1	6.0						
	6.9	6.9	6.8	6.8	6.8	6.8	6.8	6.7	6.7	6.7	6.7	6.6	6.6	6.6	6.5	6.5	6.4	6.4	6.4	6.3	6.3	6.2	6.1	6.1						
	7.0	7.0	6.9	6.9	6.9	6.9	6.9	6.8	6.8	6.8	6.8	6.7	6.7	6.7	6.6	6.6	6.5	6.5	6.4	6.3	6.3	6.2	6.2	6.1						
	7.1	7.1	7.0	7.0	7.0	7.0	7.0	6.9	6.9	6.9	6.9	6.8	6.8	6.8	6.7	6.7	6.6	6.6	6.5	6.5	6.4	6.4	6.3	6.3						
	7.2	7.2	7.1	7.1	7.1	7.1	7.1	7.0	7.0	7.0	7.0	6.9	6.9	6.8	6.8	6.8	6.7	6.7	6.6	6.6	6.5	6.5	6.4	6.4						
	7.3	7.3	7.2	7.2	7.2	7.2	7.2	7.1	7.1	7.1	7.1	7.0	6.9	6.9	6.9	6.9	6.8	6.8	6.7	6.7	6.6	6.6	6.5	6.4						
	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.2	7.2	7.1	7.1	7.1	7.0	7.0	6.9	6.9	6.8	6.8	6.7	6.7	6.6	6.5						
	7.5	7.5	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.2	7.2	7.2	7.1	7.1	7.0	7.0	6.9	6.9	6.8	6.7	6.7	6.6						
	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.3	7.3	7.3	7.2	7.2	7.1	7.1	7.0	7.0	6.9	6.9	6.8	6.8	6.7						
	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.4	7.4	7.4	7.3	7.3	7.2	7.2	7.1	7.1	7.0	6.9	6.9	6.8	6.7						
	7.8	7.8	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.5	7.5	7.4	7.4	7.3	7.3	7.2	7.2	7.1	7.1	7.0	6.9	6.9	6.8						
	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.7	7.7	7.7	7.6	7.6	7.6	7.5	7.5	7.4	7.4	7.3	7.3	7.2	7.2	7.1	7.0	6.9						
8.0	8.0	7.9	7.9	7.9	7.9	7.9	7.8	7.8	7.8	7.7	7.7	7.7	7.6	7.6	7.5	7.5	7.4	7.4	7.3	7.3	7.2	7.1	7.1							
8.1	8.1	8.0	8.0	8.0	8.0	8.0	7.9	7.9	7.9	7.8	7.8	7.7	7.7	7.7	7.6	7.6	7.5	7.5	7.4	7.3	7.3	7.2	7.1							
8.2	8.2	8.1	8.1	8.1	8.1	8.0	8.0	8.0	8.0	7.9	7.9	7.8	7.8	7.7	7.7	7.6	7.5	7.5	7.4	7.4	7.3	7.2	7.2							
8.3	8.3	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.0	8.0	7.9	7.9	7.8	7.7	7.7	7.6	7.6	7.5	7.5	7.4	7.3	7.3							
8.4	8.4	8.3	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.1	8.1	8.0	8.0	7.9	7.9	7.8	7.8	7.7	7.7	7.6	7.5	7.5	7.4							
8.5	8.5	8.4	8.4	8.4	8.4	8.3	8.3	8.3	8.2	8.2	8.2	8.1	8.1	8.0	8.0	7.9	7.9	7.8	7.8	7.7	7.6	7.6	7.5							
8.6	8.6	8.5	8.5	8.5	8.5	8.4	8.4	8.4	8.3	8.3	8.3	8.2	8.2	8.1	8.1	8.0	8.0	7.9	7.9	7.8	7.7	7.7	7.6							
8.7	8.7	8.6	8.6	8.6	8.6	8.5	8.5	8.5	8.4	8.4	8.4	8.3	8.3	8.2	8.2	8.1	8.1	8.0	7.9	7.9	7.8	7.8	7.7							
8.8	8.8	8.7	8.7	8.7	8.7	8.6	8.6	8.6	8.5	8.5	8.5	8.4	8.4	8.3	8.3	8.2	8.2	8.1	8.0	8.0	7.9	7.8	7.8							
8.9	8.9	8.8	8.8	8.8	8.8	8.7	8.7	8.7	8.6	8.6	8.6	8.5	8.5	8.4	8.4	8.3	8.3	8.2	8.1	8.1	8.0	7.9	7.9							
9.0	9.0	8.9	8.9	8.9	8.9	8.8	8.8	8.8	8.7	8.7	8.7	8.6	8.6	8.5	8.5	8.4	8.3	8.3	8.2	8.2	8.1	8.0	7.9							
9.1	9.1	9.0	9.0	9.0	9.0	8.9	8.9	8.9	8.8	8.8	8.7	8.7	8.7	8.6	8.6	8.5	8.4	8.4	8.3	8.2	8.2	8.1	8.0							
9.2	9.1	9.1	9.1	9.1	9.1	9.0	9.0	9.0	8.9	8.9	8.8	8.8	8.7	8.7	8.6	8.6	8.5	8.5	8.4	8.3	8.3	8.2	8.1							
9.3	9.2	9.2	9.2	9.2	9.2	9.1	9.1	9.1	9.0	9.0	8.9	8.9	8.8	8.8	8.7	8.7	8.6	8.6	8.5	8.4	8.3	8.2	8.1							
9.4	9.3	9.3	9.3	9.3	9.2	9.2	9.2	9.2	9.1	9.1	9.0	9.0	8.9	8.9	8.8	8.8	8.7	8.7	8.6	8.5	8.4	8.3	8.2							
9.5	9.4	9.4	9.4	9.4	9.3	9.3	9.3	9.3	9.2	9.2	9.1	9.1	9.0	9.0	8.9	8.9	8.8	8.7	8.7	8.6	8.5	8.4	8.3							
9.6	9.5	9.5	9.5	9.5	9.4	9.4	9.4	9.4	9.3	9.3	9.2	9.2	9.1	9.1	9.0	9.0	8.9	8.8	8.8	8.7	8.6	8.5	8.4							
9.7	9.6	9.6	9.6	9.6	9.5	9.5	9.5	9.5	9.4	9.4	9.3	9.3	9.2	9.2	9.1	9.1	9.0	8.9	8.9	8.8	8.7	8.6	8.5							
9.8	9.7	9.7	9.7	9.7	9.6	9.6	9.6	9.5	9.5	9.5	9.4	9.4	9.3	9.3	9.2	9.2	9.1	9.0	9.0	8.9	8.8	8.7	8.6							
9.9	9.8	9.8	9.8	9.8	9.7	9.7	9.7	9.6	9.6	9.6	9.5	9.5	9.4	9.4	9.3	9.2	9.2	9.1	9.0	8.9	8.8	8.7	8.6							

Horizontal distance shown in italics does not differ from slope distance. Blank cells exceed 11 m horizontal distance.

Appendix B: Slope Table (continued).

Appendix B: Slope Conversion Table
For each combination of slope and slope distance, read horizontal distance (m) from table.

		Slope in degrees																																
Slope distance		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30								
	10.0	9.9	9.9	9.9	9.9	9.8	9.8	9.8	9.7	9.7	9.7	9.6	9.6	9.5	9.5	9.4	9.3	9.3	9.2	9.1	9.1	9.0	8.9	8.8	8.7	8.7								
	10.1	10.0	10.0	10.0	10.0	9.9	9.9	9.9	9.8	9.8	9.8	9.7	9.7	9.6	9.5	9.5	9.4	9.4	9.3	9.2	9.2	9.1	9.0	8.9	8.8	8.7								
	10.2	10.1	10.1	10.1	10.1	10.0	10.0	10.0	9.9	9.9	9.9	9.8	9.8	9.7	9.6	9.6	9.5	9.5	9.4	9.3	9.2	9.2	9.1	9.0	8.9	8.8								
	10.3	10.2	10.2	10.2	10.2	10.1	10.1	10.1	10.0	10.0	9.9	9.9	9.8	9.8	9.7	9.7	9.6	9.5	9.5	9.4	9.3	9.2	9.1	9.0	8.9	8.8								
	10.4	10.3	10.3	10.3	10.3	10.2	10.2	10.2	10.1	10.1	10.0	10.0	9.9	9.9	9.8	9.8	9.7	9.6	9.6	9.5	9.4	9.3	9.3	9.2	9.1	9.0								
	10.5	10.4	10.4	10.4	10.4	10.3	10.3	10.3	10.2	10.2	10.1	10.1	10.0	10.0	9.9	9.9	9.8	9.7	9.7	9.6	9.5	9.4	9.4	9.3	9.2	9.1								
	10.6	10.5	10.5	10.5	10.5	10.4	10.4	10.4	10.3	10.3	10.2	10.2	10.1	10.1	10.0	10.0	9.9	9.8	9.8	9.7	9.6	9.5	9.4	9.4	9.3	9.2								
	10.7	10.6	10.6	10.6	10.6	10.5	10.5	10.5	10.4	10.4	10.3	10.3	10.2	10.2	10.1	10.1	10.0	9.9	9.8	9.8	9.7	9.6	9.5	9.4	9.4	9.3								
	10.8	10.7	10.7	10.7	10.7	10.6	10.6	10.6	10.5	10.5	10.4	10.4	10.3	10.3	10.2	10.1	10.1	10.0	9.9	9.9	9.8	9.7	9.6	9.5	9.4	9.4								
	10.9	10.8	10.8	10.8	10.8	10.7	10.7	10.7	10.6	10.6	10.5	10.5	10.4	10.4	10.3	10.2	10.2	10.1	10.0	10.0	9.9	9.8	9.7	9.6	9.5	9.4								
	11.0	10.9	10.9	10.9	10.9	10.8	10.8	10.8	10.7	10.7	10.6	10.6	10.5	10.5	10.4	10.3	10.3	10.2	10.1	10.0	10.0	9.9	9.8	9.7	9.6	9.5								
	11.1	11.0	11.0	11.0	11.0	10.9	10.9	10.9	10.8	10.8	10.7	10.7	10.6	10.6	10.5	10.4	10.4	10.3	10.2	10.1	10.1	10.0	9.9	9.8	9.7	9.6								
	11.2					11.0	11.0	11.0	10.9	10.9	10.8	10.8	10.7	10.7	10.6	10.5	10.5	10.4	10.3	10.2	10.2	10.1	10.0	9.9	9.8	9.7								
	11.3								11.0	11.0	10.9	10.9	10.8	10.7	10.7	10.6	10.5	10.5	10.4	10.3	10.2	10.2	10.1	10.0	9.9	9.8								
	11.4									11.0	11.0	10.9	10.8	10.8	10.7	10.6	10.6	10.5	10.4	10.3	10.2	10.2	10.1	10.0	9.9	9.8								
	11.5										11.0	10.9	10.8	10.8	10.7	10.7	10.6	10.5	10.4	10.3	10.2	10.2	10.1	10.0	9.9	9.8								
	11.6											11.0	10.9	10.8	10.8	10.7	10.6	10.5	10.4	10.3	10.2	10.2	10.1	10.0	9.9	9.8								
	11.7												11.0	10.9	10.8	10.8	10.7	10.6	10.5	10.4	10.3	10.2	10.2	10.1	10.0									
	11.8													11.0	10.9	10.8	10.8	10.7	10.6	10.5	10.4	10.3	10.2	10.2	10.1	10.0								
	11.9														11.0	11.0	10.9	10.8	10.7	10.6	10.5	10.4	10.3	10.2	10.2	10.1	10.0							
	12.0																	11.0	11.0	10.9	10.8	10.7	10.6	10.5	10.4									
	12.1																			11.0	10.9	10.8	10.7	10.6	10.5									
	12.2																				11.0	10.9	10.8	10.7	10.6									
	12.3																					11.0	10.9	10.8	10.7									
	12.4																						11.0	10.9	10.8	10.7								
	12.5																							11.0	10.9	10.8	10.7							
	12.6																								11.0	10.9	10.8	10.7						
	12.7																										11.0							

Horizontal distance shown in italics does not differ from slope distance. Blank cells exceed 11 m horizontal distance.

Appendix C: Indicator Species

Nativity	Life Form	Scientific Name	Common Name	Jurisdiction and Code	North	South
Exotic	Tree	<i>Acer ginnala</i> Maxim.	Amur maple	CT - PINB	X	
Exotic	Tree	<i>Acer platanoides</i> L.	Norway maple	CT - INB MA - P	X	X
Exotic	Tree	<i>Acer pseudoplatanus</i> L.	sycamore maple	CT - PIB MA - P	X	
Exotic	Forb	<i>Aegopodium podagraria</i> L.	bishop's goutweed	CT - IB MA - P VT - CBW	X	X
Exotic	Tree	<i>Ailanthus altissima</i> (Mill.) Swingle	tree of heaven	CT - IB MA - P NH - PIS VT - CBW	X	X
Exotic	Tree	<i>Albizia julibrissin</i>	Mimosa; silk tree		X	X
Exotic	Forb	<i>Alliaria petiolata</i> (M. Bieb.) Cavara & Grande	garlic mustard	CT - IB MA - P NH - PIS VT - CBW	X	X
Exotic	Vine	<i>Ampelopsis brevipedunculata</i> (Maxim.) Trautv.	Amur peppervine	CT - PINB MA - P	X	X
Exotic	Graminoid	<i>Arthraxon hispidus</i> (Thunb.) Makino	small carpgrass	CT - PIB MA - P	X	X
Exotic	Shrub	<i>Berberis thunbergii</i> DC.	Japanese barberry	CT - INB MA - P	X	X
Exotic	Shrub	<i>Berberis vulgaris</i> L.	common barberry	CT - IB MA - P NH - PIS	X	X
Exotic	Shrub	<i>Buddleja davidii</i>	butterfly bush		X	X
Exotic	Forb	<i>Cardamine impatiens</i> L.	narrowleaf bittercress	CT - IB MA - P	X	X
Exotic	Vine (woody)	<i>Celastrus orbiculatus</i> Thunb.	Oriental bittersweet	CT - IB MA - P NH - PIS NC - CCW VT - CBW	X	X
Exotic	Forb	<i>Centaurea biebersteinii</i> DC.	Spotted knapweed	CT - IB MA - P	X	X
Exotic	Vine	<i>Cuscuta</i> L. spp.	dodder	MA - P NC - CAW VT - CAW FED - NW	X	X
Exotic	Vine	<i>Cynanchum louiseae</i> Kartesz & Gandhi (syn	Louise's swallow-wort	CT - IB MA - P	X	

Appendix C: Indicator Species (continued).

Nativity	Life Form	Scientific Name	Common Name	Jurisdiction and Code	North	South
		<i>Cynanchum nigrum</i> , <i>Vincetoxicum nigrum</i>)		NH – PIS VT - CBW		
Exotic	Vine	<i>Cynanchum rossicum</i> (Kleopow) Borhidi	European swallow-wort	CT - IB MA - P NH - PIS	X	
Exotic	Vine	<i>Vincetoxicum hirundinaria</i> Medik.		VT - CAW	X	
Exotic	Vine	<i>Dioscorea oppositifolia</i>	Chinese yam		X	X
Exotic	Shrub	<i>Elaeagnus angustifolia</i> L.	Russian olive	CT - PIB	X	X
Exotic	Shrub	<i>Elaeagnus umbellata</i> Thunb.	autumn olive	CT - IB MA - P NH - PIS WV - NW	X	X
Exotic	Shrub	<i>Euonymus alatus</i> (Thunb.) Siebold	burningbush	MA – P CT - INB	X	X
Exotic	Vine	<i>Euonymus fortunei</i>	Wintercreeper		X	X
Exotic	Forb	<i>Euphorbia cyparissias</i> L.	cypress spurge	CT - PIB MA - P	X	X
Exotic	Graminoid	<i>Festuca filiformis</i> Pourr.	fineleaf sheep fescue	MA - P	X	X
Exotic	Shrub	<i>Frangula alnus</i> Mill. (syn. <i>Rhamnus frangula</i> L.)	glossy buckthorn	CT - INB MA – P NH - PIS VT - CBW	X	X
Exotic	Forb	<i>Glechoma hederacea</i> L.	ground ivy	CT - PIB	X	X
Exotic	Vine	<i>Hedera helix</i>	English ivy		X	X
Exotic	Forb	<i>Heracleum mantegazzianum</i> Sommier & Levier	giant hogweed	CT - PIB MA - P NH - PIS NC - CAW PA - NW VT - CAW	X	X
Exotic	Forb	<i>Hesperis matronalis</i> L.	dames rocket	CT - IB MA - P	X	X
Exotic	Vine	<i>Humulus japonicus</i> Siebold & Zucc.	Japanese hop	CT - PIB MA - P	X	X
Exotic	Forb	<i>Impatiens glandulifera</i> Royle	ornamental jewelweed	CT - PIB	X	
Exotic	Graminoid	<i>Imperata brasiliensis</i> Trin.	Brazilian satintail	MA - P NC - CAW VT - CAW FED - NW	X	X
Exotic	Graminoid	<i>Imperata cylindrica</i> (L.) P. Beauv.	cogongrass	NC - CAW VT - CAW FED - NW	X	X
Exotic	Forb	<i>Lespedeza cuneata</i>	Chinese lespedeza		X	X
Exotic	Shrub	<i>Lespedeza bicolor</i>	shrubby lespedeza		X	X

Appendix C: Indicator Species (continued).

Nativity	Life Form	Scientific Name	Common Name	Jurisdiction and Code	North	South
Exotic	Shrub	<i>Ligustrum</i> spp. (<i>obtusifolium</i> , <i>ovalifolium</i> , <i>sinense</i> , <i>vulgare</i>)	privet	CT - PIB MA - P NH - PIS	X	X
Exotic	Shrub	<i>Lonicera</i> spp. – <i>exotic</i> (<i>bella</i> , <i>maackii</i> , <i>morrowii</i> , <i>tartarica</i> , <i>xylosteum</i>)	exotic bush honeysuckles	CT - IB MA - P NH - PIS VT - CBW	X	X
Exotic	Vine (Woody)	<i>Lonicera japonica</i> Thunb.	Japanese honeysuckle	CT - IB MA - P NH - PIS VT - CBW	X	X
Exotic	Graminoid	<i>Luzula luzuloides</i>	forest woodrush		X	
Exotic	Forb	<i>Lysimachia nummularia</i> L.	creeping jenny	CT - PINB MA - P	X	X
Exotic	Graminoid	<i>Microstegium vimineum</i> (Trin.) A. Camus	Japanes stiltgrass	CT - IB MA - P	X	X
Exotic	Graminoid	<i>Miscanthus sacchariflorus</i> (Maxim.) Franch.	Amur silvergrass	MA - P	X	
Exotic	Graminoid	<i>Miscanthus sinensis</i> Andersson	Chinese silvergrass	CT - PINB	X	X
Exotic	Forb	<i>Myosotis scorpioides</i> L.	true forget-me-not	CT - IB MA - P	X	X
Exotic	Tree	<i>Paulownia tomentosa</i> (Thunb.) Siebold & Zucc. ex Steud.	princesstree	CT - PIB		X
Exotic	Tree	<i>Phellodendron amurense</i> Rupr.	Amur corktree	MA - P	X	X
Exotic	Forb	<i>Polygonum caespitosum</i> Blume, orth. var.		CT - PIB	X	X
Exotic	Forb	<i>Polygonum cuspidatum</i> Siebold & Zucc.(syn <i>Fallopia japonica</i>)	Japanese knotweed	CT - IB MA - P NH – PIS VT - CBW	X	X
Exotic	Vine	<i>Polygonum perfoliatum</i> L.	Asiatic tearthumb	CT - IB MA - P NC - CAW PA - NW	X	X
Exotic	Tree	<i>Populus alba</i> L.	white poplar	CT - PIB	X	X
Exotic	Vine (Woody)	<i>Pueraria montana</i> (Lour.) Merr.	kudzu	CT - PIB MA – P PA – NW WV - NW	X	X
Exotic	Forb	<i>Ranunculus ficaria</i> L.	fig buttercup	CT - IB MA - P	X	X
Exotic	Forb	<i>Ranunculus repens</i> L.	creeping buttercup	MA - P	X	X

Appendix C: Indicator Species (continued).

Nativity	Life Form	Scientific Name	Common Name	Jurisdiction and Code	North	South
Exotic	Shrub	<i>Rhamnus cathartica</i> L.	common buckthorn	CT - IB MA - P NH - PIS VT - CBW	X	X
Exotic	Shrub	<i>Rosa multiflora</i> Thunb.	multiflora rose	CT - IB MA - P NH - PIS PA - NW WV - NW	X	X
Exotic	Shrub	<i>Rubus phoenicolasius</i> Maxim.	wine raspberry	CT - PIB MA - P	X	X
Exotic	Forb/Vine	<i>Solanum dulcamara</i> L.	climbing nightshade	CT - PIB	X	X
Exotic	Graminoid	<i>Sorghum halepense</i> (L.) Pers.	Johnsongrass	MD - NW PA - NW WV - NW	X	X
Exotic	Forb	<i>Tussilago farfara</i> L.	coltsfoot	CT - IB MA - P	X	X
Exotic	Forb	<i>Valeriana officinalis</i> L.	garden valerian	CT - PIB	X	
Exotic	Forb	<i>Vinca minor</i>	periwinkle		X	X
Exotic	Vine	<i>Wisteria sinensis</i>	Wisteria vine		X	X
Native	Forb	<i>Ageratina altissima</i> var. <i>altissima</i> (formerly <i>Eupatorium rugosum</i>)	White snakeroot		X	X
Native	Forb	<i>Aralia nudicaulis</i>	Wild sarsaparilla		X	X
Native	Forb	<i>Arisaema triphyllum</i>	Jack in the pulpit		X	X
Native	Forb	<i>Asarum canadense</i>	Canadian wildginger		X	X
As a group	Graminoid	<i>Cyperaceae</i>	Sedge		X	X
Native	Forb	<i>Clintonia borealis</i>	Blue bead lily		X	X
Native	Forb	<i>Dennstaedtia punctilobula</i>	Hay-scented fern		X	X
Native	Forb	<i>Erythronium</i> spp. (<i>album</i> , <i>americanum</i>)	Trout lily		X	X
Native	Forb	<i>Eurybia divaricata</i>	White wood aster		X	X
Native	Forb	<i>Hepatica nobilis</i>	Hepatica		X	X

Appendix C: Indicator Species (continued).

Nativity	Life Form	Scientific Name	Common Name	Jurisdiction and Code	North	South
Native	Forb	<i>Maianthemum</i> spp. (<i>Canadense</i> , <i>racemosum</i> , <i>stellatum</i> , <i>trifolium</i>)	Canada mayflower, False Solomon's seal		X	X
Native	Forb	<i>Medeola virginiana</i>	Indian cucumber		X	X
As a group	Forb	Orchids	orchids		X	X
As a group	Forb	Other Ferns (not including those listed)	ferns		X	X
As a group	Graminoid	<i>Poaceae</i>	grasses		X	X
Native	Forb	<i>Podophyllum peltatum</i>	Mayapple		X	X
Native	Forb	<i>Polygonatum</i> spp. (<i>biflorum</i> , <i>pubescens</i>)	Smooth Solomon's seal		X	X
Native	Forb	<i>Polystichum acrostichoides</i>	Christmas fern		X	X
Native	Forb	<i>Sanguinaria canadensis</i>	Bloodroot		X	X
Native	Forb	<i>Streptopus</i> (<i>amplexifolius</i> , <i>lanceolatus</i>)	Twisted stalk		X	X
Native	Forb	<i>Thelypteris noveboracensis</i>	New York fern		X	X
Native	Forb	<i>Trillium</i> spp. (<i>catesbaei</i> , <i>cernum</i> , <i>cuneatum</i> , <i>erectum</i> , <i>flexipes</i> , <i>grandiflorum</i> , , <i>luteum</i> , <i>sessile</i> , <i>undulatum</i> , <i>vaseyi</i>)	Trillium		X	X
Native	Forb	<i>Uvularia</i> spp. (<i>grandiflora</i> , <i>perfoliata</i> , <i>sessifolia</i>)	Bellwort		X	X

Appendix C: Indicator Species (continued).

Code	NoxiousStatus	Code	NoxiousStatus
ADW	"A" designated weed	P	Prohibited
AW	A list (noxious weeds)	PAP1	Prohibited aquatic plant, Class 1
BDW	"B" designated weed	PAP2	Prohibited aquatic plant, Class 2
BW	B list (noxious weeds)	PIB	Potentially invasive, banned
CAT1	Category 1 noxious weed	PINB	Potentially invasive, not banned
CAT2	Category 2 noxious weed	PIS	Prohibited invasive Species
CAT3	Category 3 noxious weed	PN	Public nuisance
CAW	Class A noxious weed	PNW	Prohibited noxious weed
CBW	Class B noxious weed	PP	Plant pest
CCW	Class C noxious weed	PR	Permit required
CW	C list (noxious weeds)	PRNW	Primary noxious weed
IAP	Invasive aquatic plant	Q	Quarantine
IB	Invasive, banned	QW	Q list (temporary "A" list noxious weed,
ILAP	Invasive aquatic plant	RGNW	Regulated noxious weeds
INB	Invasive, not banned	RNPS	Regulated non-native plant species
NAW	Noxious aquatic weed	RNW	Restricted noxious weed
NP	Noxious plant	SNW	Secondary noxious weed
NUW	Nuisance weed	SP	Sale prohibited
NW	Noxious weed	WAWQ	Wetland and aquatic weed quarantine
NWSPQ	Noxious weed seed and plant quarantine		

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APPA

Version 1.02

Definitions

Designated office staff (DOS): Refers to the individual who receives daily field work plans and initiates emergency response services for the field monitors. The default DOS is the project leader.

Field monitor: Refers to all personnel engaged in field activities related to this protocol who may or may not be compensated for their work. Volunteer field monitors are required to have read and signed a Volunteer Agreement and all field staff are strongly encouraged to read and sign the Job Safety Analysis form before participating in any surveys.

Project leader: Refers to the individual responsible for coordinating implementation of the forest monitoring protocol. This individual may work for ATC, NPS, or another organization. The protocol lead is responsible for ensuring that forest health monitors are properly trained in NPS Safety procedures.

Overview

The Appalachian National Scenic Trail (APPA) and Northeast Temperate Network (NETN) considers the occupational health and safety of anyone collecting data, regardless of whether they are NPS employees, cooperators, or volunteers to be of paramount importance. Accordingly, we are committed to ensuring that all field crews are made aware of potential hazards and risks, and receive adequate guidance on pertinent safety procedures including, but not limited to incident reporting and emergency response. This SOP is intended to provide an introduction to safety issues that should be considered prior to commencing field work, and serves as a reference in case of an incident. Topics covered include emergency procedures and contacts, incident reporting, field preparation, and safe field procedures, but this SOP does not cover first aid and is not intended to supplant guidance provided by a medical or emergency professional.

Prior to commencing field work, the project leader must check with the local Appalachian Trail Conservancy regional office to determine if there are any trail closures or other important advisories that might affect the safety of the work. The regional office should also be consulted for the location of the nearest hospital to the area where field work will be conducted. It is imperative to determine the directions to the nearest hospital and establish the best, and most reliable way to establish contact with first responders and other emergency personnel in the event of an emergency. The project leader is responsible for ensuring that all field monitors have this information.

Due to the remote nature of the Appalachian National Scenic Trail, working in pairs is strongly and always encouraged.

Responding to an Incident

Life-Threatening Medical Emergency

1. Call 9-1-1.

2. As soon as it is practical to do so, inform your DOS. The DOS will notify NPS staff.

3. Complete Worker's Compensation paperwork.

Non-Emergency Incidents

1. Contact DOS immediately after incident. The DOS will contact other individuals that may need to know of the incident, such as the field monitor's supervisor.

2. Complete Worker's Compensation paperwork.

NOTE: Never discard original paperwork related to workers compensation claims (including information from doctor's visits, CA-1, CA-2, CA-16 or CA-17 forms).

Preparation

Field monitors are in the best position to assess a situation, and are ultimately responsible for maintaining a safe work environment. Because much of the work will be performed in remote locations, the field monitors are empowered to make the final decision regarding safety, and under no circumstance should anyone attempt to perform work at a pre-designated, or any other location if there are any questions about safety.

First Aid Kits

Prior to beginning any field work, field monitors must verify that they have a first aid kit and that it is fully stocked with supplies. Each first aid kit should have an itemized list of the supplies it should contain. Used items should be promptly replaced.

Communication and Planning

Field monitors must carry a Personal Locator Beacon (PLB) and a charged cell phone and/or two-way radio at all times while in the field. Given the remote nature of the Trail, a SPOT GPS messenger is recommended since it allows crews to check in via satellite. Know in advance if there are areas where cell coverage definitely does, or does not exist. If cell coverage does not extend to the planned work area and radio communication is not possible, know where coverage does exist and be prepared to evacuate to that area in the event of a non-life-threatening emergency (the PLB should be used for life-threatening emergencies). Plans should include identifying the nearest emergency services and emergency contact information (e.g., Figure S1.1) for the planned work area. Due to the conformation of the APPA this must be done on an ad-hoc basis prior to field work.

When working in pairs, be sure to establish a plan before splitting up. The plan does not need to be lengthy, and may simply establish a meeting place and time at the end of the field day. If plans change while in the field, crew members must notify each other (via radio, cell phone, or in person) AND under no circumstances should it be assumed that all members of the crew know about changes unless the change has been confirmed by EVERY crew member (via radio, cell phone, or in person).

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Monitoring staff must check in with a designated office staff (DOS) at the end of each field mission⁹, and monitoring teams shall not leave for home at the end of the mission until everyone involved with the mission is accounted for. A SPOT GPS messenger or similar device is highly recommended so that field monitors can check in with the DOS every day.

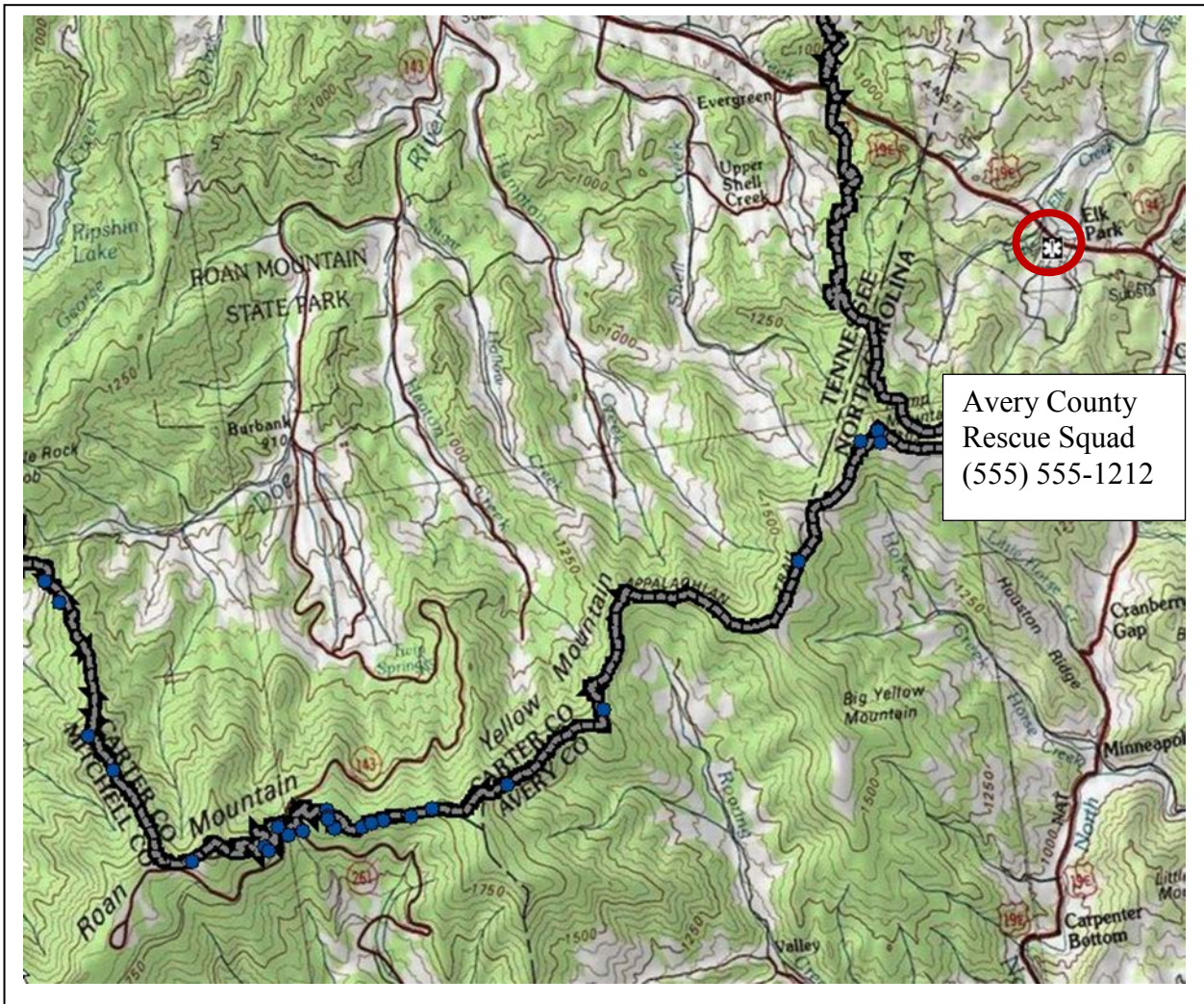


Figure S1.1. Potential monitoring locations on Roan Mountain with nearest rescue squad contact information.

Personal Gear

Each field monitor shall wear field appropriate clothing and footwear such as long pants, a hat and hiking boots. Depending on the weather, rain gear or warm clothing should be taken into the field and we strongly recommend that an extra set of clothing be packed at the start of the mission.

⁹ At the end of the day following a single day mission, or upon completion of a multi-day trip.

Backpacks

Field monitors will need to carry large packs over uneven terrain, and it is important for field monitors to understand appropriate ways to pack, lift and carry a heavy backpack to avoid serious back, neck and shoulder injuries. To avoid injury, field monitors should adhere to the following guidelines:

- Use a sturdy pack with padded and adjustable hip and shoulder straps.
- Put heavy items in the center of the pack and close to your back, with weight evenly distributed from side to side.
- Once packed, tighten the compression straps to minimize movement inside the pack during travel.
- Use your legs to lift the pack, and use slow, smooth movements. Keep your back straight, and keep the pack close to your body. Do not twist or bend at the waist to lift the pack, and do not swing the pack quickly over one shoulder.
- Always use both shoulder straps as well as the hip belt and chest straps.
- The pack should be positioned near the center of the back, and most of the weight should rest on your hips.
- Keep your pack organized, and only carry the necessary equipment, food and water to reduce weight.

Field Safety

Slip, Trip, Fall Prevention

Uneven terrain, slippery rocks, dense brush, time of day, and fatigue are all hazards that individually, or in combination can result in a slip, trip, or fall. The following guidelines can help minimize accidents (and injuries) related to slips, trips, or falls:

- Always wear appropriate footwear such as sturdy hiking boots
- Maintain situational awareness – pay attention to where you are going, and remain alert of potential hazards
- Walk at an appropriate pace that is suitable for all members of the field team and adjust pace for changes in terrain (e.g., slow down and take smaller steps on slippery surfaces)
- When hiking long distances, take breaks to avoid fatigue
- When navigating to a location off trail, choose the safest route (this may not be the shortest or most direct route). Avoid river crossings, excessively steep terrain and sudden drop-offs. Always be careful when navigating over piles of scree, and alert others of falling rocks.

Weather

Weather conditions in the eastern U.S. can be hazardous and can change quickly. The field monitors are responsible for planning their day according to the local weather forecast and for being aware of their surroundings and changing conditions. Know the location of nearby designated shelters, campsites, or alternate access points.

Thunderstorms

Thunderstorms may produce strong winds, rain, hail, lightning, tornadoes, or any combination thereof. All thunderstorms should be considered dangerous and should be avoided. If caught in a thunderstorm, seek shelter as soon as possible. Avoid high elevations, conductive materials, and

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tall structures such as trees or telephone poles. For more information on thunderstorms and ways to avoid injury, refer to the National Weather Service publication [Thunderstorms, Tornadoes, Lightning: Nature's Most Violent Storms](http://www.nws.noaa.gov/om/severeweather/resources/ttl6-10.pdf) (<http://www.nws.noaa.gov/om/severeweather/resources/ttl6-10.pdf>).

Excessive Heat and Sun

Field monitors should avoid “excess” exposure to the sun by wearing sunscreen and/or protective clothing. Field monitors should always carry ample water (2-3 liters) and food when working in the field. When working in hot weather, be sure to drink plenty of fluids and eat foods that replace electrolytes. It is important to frequently drink liquid to maintain hydration on a warm day, even if you don't feel thirsty.

Over exposure to heat and sun can cause dehydration, heat exhaustion, and / or heat stroke. While all are serious life threatening conditions, they are also preventable. Wear loose and light colored clothing, including a hat to block the sun's rays. If necessary, shift the field schedule to avoid working outside during the hottest part of the day. If a heat related issue is suspected, move into a shaded location and seek medical help.

Poor Air Quality

Summer ozone and particulate matter levels occasionally exceed federal health standards, even along relatively remote locations of the Appalachian Trail. Young children, seniors, and those suffering from asthma, chronic bronchitis, chronic obstructive pulmonary disease, or heart problems are especially sensitive to poor air quality and should minimize outdoor activity when poor air quality warnings are posted. The risks of occasional exposure to ozone and fine particulate matter are generally minimal for healthy individuals.

When poor air quality warnings occur, it is advisable for field monitors to avoid overly strenuous activities during the hottest part of the day (pollution levels tend to be lowest early in the morning), and to stick to lower elevations under a forest canopy.

To check local air quality forecasts, or learn more about health risks of air pollution, visit the AIRNow intergovernmental agency website: <http://www.airnow.gov/>.

Poisonous Plants and Animals

Both for safety and protection of park resources, it is never advisable for field monitors to eat wild plants while working on the Appalachian Trail, regardless of your confidence in plant identification. Field monitors should also keep a safe distance from wildlife and never handle potentially dangerous wildlife.

Deer ticks and Lyme Disease

Several species of ticks are commonly encountered in the eastern U.S., including the deer tick (*Ixodes scapularis*) which is a known vector of Lyme disease and Ehrlichiosis. The Center for Disease Control (CDC) maintains a clearinghouse of information about ticks, and the many diseases associated with tick bites (<http://www.cdc.gov/Features/StopTicks/>). Field monitors are advised to take the precautions outlined by CDC as well as those described below:

- Treat clothes with tick and insect repellent as described by the CDC.
- Always follow manufacturer's guidance before using repellents.

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- Wear long pants tucked into your socks and tuck your shirts into your pants. Long sleeves and gaiters may help.
- Check clothes and skin for ticks at the end of every field day. The earlier ticks are found and removed, the better your chances are of NOT acquiring a tick-borne illness.
- If you find a tick that is already embedded, use a specialized tick extraction device or fine-tipped tweezers to firmly grasp the tick close to your skin. Slowly and steadily pull the tick's body away from your skin. Be careful not to crush the tick's body to minimize the chances of it regurgitating fluids into the wound. Clean the bite area once the tick is removed with soap and water.
- If you receive a tick bite, file a worker's compensation CA-1 claim to get a CA-16. If you start to notice symptoms of Lyme or any other illness, use the CA-16 to get medical treatment. If you are a contractor, cooperator, or non-NPS volunteer, you should follow your organization's guidance.
- Keep an eye out for any early symptoms of tick borne diseases. Refer to the CDC web site for current information. New tests, currently under development, may be more reliable than existing methods at determining if you have contracted a tick-borne illness. If you develop any combination of symptoms identified by the CDC soon after a tick bite, seek medical attention.

More information on ticks and tick-borne ailments:

Center for Disease Control:

<http://www.cdc.gov/lyme/>

(also a free webinar on tick-borne diseases)

American Lyme Disease Foundation:

<http://www.aldf.com/>

Tick Management Handbook:

<http://www.ct.gov/caes/lib/caes/documents/publications/bulletins/b1010.pdf>

Bees, Wasps, and Yellow Jackets

If any field monitors are allergic to bee stings, they should alert their colleagues and make sure to carry appropriate medications. If they carry an epinephrine injector, they should make sure their colleagues know where it is carried and how to administer it. Maintain situational awareness, and be alert to potential hive and nest locations while hiking to plots and working on plots. Look for insects travelling in and out of one location (e.g., brush, ground holes, and hollow logs). If someone is stung, Benadryl and a cold compress may bring relief. If the stinger is left behind, scrape it off of skin. If the victim develops hives, asthmatic breathing, tissue swelling or a drop in blood pressure, seek medical help immediately.

Black Bears

Black bears range throughout the Appalachian region, but an encounter with a bear in the field is uncommon. Nevertheless, be alert for bears near dawn or dusk, and be especially aware of mother bears with cubs. Never approach cubs or come between a mother bear and her cubs. If a bear is encountered, face the animal but avoid eye contact, continually make noise, and slowly back away. Appear larger by standing tall, waving arms or a jacket over your head. Do not freeze or remain silent, and NEVER run from a black bear. If charged or attacked, throw non-food objects and shout loudly. If you are attacked, fight back aggressively.

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Poison Ivy

Poison ivy (*Toxicodendron* spp.) is present throughout the Appalachian Trail region, and can be very abundant in localized areas. When working in the vicinity of poison ivy, field monitors should avoid skin contact with any part of the poison ivy plant. Using a pre-exposure cream and wearing long sleeves and long pants, hats, and work or rubber gloves can help reduce skin contact with the plant, and if needed, use poison ivy wipes after contact. Field monitors should avoid rubbing their faces when working around poison ivy. After working in an area with abundant poison ivy, field monitors should gently wash exposed skin in cool water with poison ivy soap, and should change into fresh field clothes. At the end of a field day, field monitors should also wash potentially contaminated equipment. If a field monitor has a minor allergic reaction, use poison ivy cream to neutralize the irritant. If a serious allergic reaction occurs, the crew member should seek medical attention, notify the DOS and project leader as soon as possible, and file a workers compensation claim.

Poisonous Snakes

The following species of poisonous snakes may occur along the Appalachian Trail: copperhead (*Agkistrodon contortrix*), cottonmouth (*Agkistrodon piscivorus*), and timber rattlesnake (*Crotalus horridus*). The best course of action is to avoid all snakes by keeping them at a safe distance. When in poisonous snake country, maintain situational awareness – pay attention to where you put your hands and feet, and be aware around rock piles and bedrock outcrops.

- Treat all bites as if envenomation has occurred.
- Time is of the essence
- Call for assistance. Clearly identify the emergency as a snakebite incident, and identify the victim's location and the closest possible point of access for responders.
- In treating the victim, quickly remove rings, watches, shoes etc., before swelling begins.
- Provide first aid in accordance with level of training and get the victim to a hospital as quickly as possible.
- Reassure the victim by remaining calm – this benefits both the victim as well as others involved.
- If emergency services cannot reach the victim in a timely way, render first aid (to the level of training), and lead the victim slowly to an evacuation point. Encourage the victim to move slowly to maintain a normal heart rate.
- If working solo (not recommended), establish contact with emergency services and relay pertinent information as you walk slowly out of the woods. Focus on remaining calm and maintaining a normal heart rate.

Job Safety Analysis

JOB SAFETY ANALYSIS: Forest Health Monitoring Field Work on the Appalachian National Scenic Trail	JOB TITLE: APPA Forest Health Monitoring	☒ NEW
	DEPARTMENT: Northeast Temperate Network	☐ REVISED
	ANALYSIS BY: Fred Dieffenbach, APPA Environmental Monitoring Coordinator	☐ REVIEWED
		John Karish, NER I&M Program Manager

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Required and/or Recommended Personal Protective Equipment:

Required: Personal Locator Beacon and at least one additional method of communication (i.e., cell phone, two way radio, or SPOT GPS Messenger), first aid kit, rain gear, condition-appropriate footwear and clothing.

<u>Tasks</u>	<u>Potential Hazards</u>	<u>Recommended Action or Procedure</u>
Planning and Communication	Not being prepared and not following plan/itinerary. Communication breakdowns.	Plan ahead. Know where you will be going, the route to the monitoring sites, and any particular hazards associated with the route and monitoring sites. Check the weather forecast and plan accordingly. Check in with ATC regional office before and after field work to confirm the work is safely completed. Establish a Designated Office Staff (DOS) who you will advise about any changes, including cancellation of field work. If return will be delayed, contact the DOS before the agreed-upon check-in time to establish a new check-in time. Always carry at least two methods of communication (including a Personal Locator Beacon), and verify that they are operational before starting field work.
Emergency Preparedness	Not knowing emergency procedures. Not having emergency supplies.	Know who to contact and how to reach them in the event of an emergency. Have current CPR and first aid certification. Carry an appropriately well-supplied first aid kit.
General foot travel	Falling or tripping due to wet areas, poor footing, uneven terrain, loose/rolling rocks and heavy pack.	Use caution at all times. Walk carefully, watching footing. Wear appropriate boots for conditions. Stay aware of your feet. Address blisters and hot spots promptly. Avoid carrying excessive weight loads or unbalanced loads. Use extreme caution traversing wet rocks, streams, steep slopes or blowdown areas.
Working outdoors during storms	Being struck by falling trees or branches; being struck by lightning	Listen to the weather forecast each morning (television, radio and/or internet). Plan or adjust field work to avoid being caught in heavy weather. Postpone work if safety will be compromised by storm conditions. If you see or hear a thunderstorm coming, retreat from high ground and exposed areas. Go inside a sturdy building or vehicle, if possible. Make yourself the smallest target possible and minimize contact with the ground. During a thunderstorm, members of the crew should stay separated by at least 10 feet.
Poisonous plants, especially poison ivy	Contamination/toxicity from contact with poisonous plants	Learn to identify poison ivy in its many growth forms. Wear long sleeves and pants. Be aware of poison ivy and avoid coming in direct contact with it. Thoroughly wash hands, equipment, and clothes with Tecnu or similar specialized soap if you come into contact with poison ivy.

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<u>Tasks</u>	<u>Potential Hazards</u>	<u>Recommended Action or Procedure</u>
Working in bear territory	Black bear encounter	Be especially alert near dawn or dusk. Be especially aware of mother bears with cubs. Never approach cubs or come between a mother bear and her cubs. Face the animal, continually make noise – do not freeze or remain silent. Appear larger by standing tall, waving arms or jacket over your head. Slowly back away – do not approach a bear. Never run from a bear. Throw things and shout loudly. Fight back aggressively.
Bee, wasp, or yellow-jacket stings	Multiple stings from disturbing or stepping into nest areas	Be alert to hives in brush, ground holes, or hollow logs. Watch for insects traveling in and out of one location. If you are allergic to bee stings, advise team members before starting field work. Make sure you carry emergency medication with you at all times and that your partner knows where you keep it. Wear long sleeve shirts and trousers, tuck in shirt. Bright colors and metal objects may attract bees or wasps. If you are stung, apply a cold compress to reduce swelling. If stinger is left behind, scrape it off of skin. Do not use tweezers as this squeezes the venom sack, worsening the injury. If the victim develops hives, asthmatic breathing, tissue swelling or a drop in blood pressure, seek medical help immediately.
Bites from mosquitoes, black flies, and other insects	Itchy reactions to multiple bites	Wear long sleeves and pants. Avoid sitting on the ground or on logs, especially in dry sunny grassy areas. Use insect repellants in accordance with manufacturer's recommendations. Carry after-bite medication to reduce skin irritation.
Ticks	Contracting diseases transmitted from ticks	Use tick avoidance precautions, including pre-treating clothing with repellant, tucking pants into socks and shirt into pants when hiking. Wear clothes (including pants and long-sleeved shirts) that are light colored and check for ticks on clothing after traveling through vegetation. Conduct a thorough tick check every evening after completing field work. Know how to identify tick life forms, and the signs & symptoms of tick-borne diseases.

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<u>Tasks</u>	<u>Potential Hazards</u>	<u>Recommended Action or Procedure</u>
Venomous snakes	Being bitten by a venomous snake	Be alert for snakes in thick vegetation and rocky habitats. Look before putting hands or feet in places out of immediate view. Treat all bites as if envenomation has occurred. Immobilize the bitten area and keep it lower than the heart. Remove rings, watches, shoes, etc. before swelling begins in earnest. Seek medical attention immediately and/or call for help. Remain calm.
Walking through thick vegetation	Cut, scratched, or bruised by vegetation; eye or ear injuries	Shield your eyes and face with your hands, glasses, or hat when moving through tall thick brush. Keep your head and eyes pointed somewhat downward so your head hits obstacles before your eyes. Wear pants and long-sleeved shirts to protect bare skin. Look before you grab vegetation to avoid grasping thorny stems. Do not follow closely behind other people to avoid having branches snap back and hit you.
Crossing streams	Injuries from falling and/or drowning	Do not cross streams that are flowing quickly and higher than mid-calf; find another route. Thoroughly investigate area to find safest crossings. Wear appropriate foot gear for stream crossings. It is safer to wade through water, rather than rock hop across a stream trying to keep your boots dry. Unbuckle your pack and be prepared to jettison gear should you lose your balance or fall in. Use a sturdy pole or walking stick for balance.
Working in heat, humidity, or cold	Heat exhaustion, sunburn, dehydration, hypothermia	Evaluate the weather forecast each morning and plan field work accordingly. Carry and drink plenty of water. Take extra breaks during extreme weather events. Adjust the work routine to minimize exposure to extreme heat and humidity. Take adequate garments for all possible weather conditions. Choose clothing that will keep you warm even if it gets wet.
Hazard trees	Being struck by falling trees or branches	Look up. Be alert for widow-makers, storm damaged trees with large broken limbs, and unstable standing dead trees. Do not spend extended time in an area with hazard trees.
Carrying a pack and other equipment	Injuries from improper packing, adjustment, and lifting of backpacks. Injuries from improper carrying of gear	Learn how to properly pack, adjust, lift, and carry a pack. When hand-carrying gear, keep one hand free. If carrying long equipment, be aware of other people and never swing around quickly. Avoid allowing a long piece of equipment to project up and behind you, where you cannot see it.

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<u>Tasks</u>	<u>Potential Hazards</u>	<u>Recommended Action or Procedure</u>
Camping in back-country	Exposure, inadequate food and water supplies, water-borne diseases, bear encounters	Bring appropriate gear for spending nights outside, including a sleeping bag and a tent or bivy sack (do not count on finding space in a shelter). Carry sufficient food and water for the trip, including potential extensions due to weather or accidents. Carry two methods of water treatment (e.g., filter and iodine drops). If camping in areas with problem black bears, bring bear-proof containers for storing food and store food away from sleeping areas.

Appendix S1.A: Safety Forms

Safety Acknowledgment Form

By signing below, I certify that I have read the safety section of the Appalachian National Scenic Trail Plot-Based Forest monitoring protocol, including the Job Safety Analysis. I have shared any safety concerns or suggestions with the project proponent (APPA Natural Resource Manager, ATC regional coordinator, or project leader) and they have been addressed to my satisfaction.

Print Name: _____

Signature: _____

Date: _____

Please return this form to the designated monitoring coordinator.

These forms only need to be completed once for each volunteer, prior to any field monitoring activities. An annual review of the Job Safety Analysis is recommended for all field staff.

Forest Health Monitoring Trip Plan

This form must be completed and e-mailed to the Designated Office Staff in advance of your monitoring trip.

Name of monitor:

Cell phone number:

Home phone number:

Name of monitoring partner:

Partner cell phone number:

Partner home phone number:

PLB serial number:

Primary contact and contact numbers for PLB:

Secondary contact and contact numbers for PLB:

Date(s) of trip:

Start time:

End time:

Check-in time and date:

Warning: if you do not check in by this date and time, an attempt will be made to reach you by phone; if you do not respond, emergency services will be notified. Do not forget to check in!

Vehicle make, model, and license plate:

Planned parking location(s):

Route and site(s) to be monitored:

Note: the person receiving this trip plan must have a map of the route and monitoring sites.

Appendix S1.B Green-Amber-Red (GAR) Risk Assessment

This section of the Safety SOP describes application of the GREEN-AMBER-RED (GAR) Risk Assessment Model as outlined in the NPS Operational Leadership Student Manual (Version 2; July 2011) to the APPA Plot-Based Forest Monitoring Protocol. This GAR was written by the APPA Environmental Monitoring Coordinator (Fred Dieffenbach) on 3 May 2012, reviewed by the NETN Program Manager on 28 August 2012, and approved by the NPS Northeast Region I&M Program Manager (John Karish) on 24 October 2012.

The GAR model allows for a general assessment of a task or operation and generates communication concerning the risks of an activity (in this case, conducting the field-based activities of the APPA Plot-Based Forest Monitoring Protocol). The most important part of the process is the team discussions leading to an understanding of the risks and how they will be managed, and all monitoring staff should be involved in revising this GAR when monitoring is implemented.

The GAR is a seven step process. Each step is defined and explained in the context of the APPA Plot-Based Forest Monitoring Protocol below.

Step 1: Define the Mission or Task

The APPA Plot-Based Forest Monitoring Protocol includes a field-based monitoring activity: collecting forest health data at predetermined locations along the APPA. Monitoring staff are not likely to be NPS employees or volunteers working directly for NPS, NETN, or APPA. Rather, individuals collecting data in accordance with this protocol are likely to be volunteers working for ATC or an affiliated trail club, or as part of a university, college or independent research project. Field staff must work in groups of two or more, for safety as well as for efficient protocol implementation. Work under this protocol is generally conducted away from roads, and at times away from the APPA itself. Potential safety hazards (along with mitigation measures) have been identified in a Job Safety Analysis (JSA, above). Of specific concern is that field staff may be working in fairly remote areas with limited communication options in the event of an emergency. A serious injury due to a trip and fall while traversing uneven or steep terrain is possible and is the most significant risk encountered when conducting this activity.

Step 2: Define the Threats

The threats/hazards for this activity along with mitigation measures are described in the associated JSA.

Step 3: Assess Risk and Assign a Numerical Value

The numerical ranks (Table S1-1) were assigned by Fred Dieffenbach, the APPA Environmental Monitoring Coordinator.

The GAR process is described in the NPS Operational Leadership Student Manual (Version 2; July 2011). The activity risk can be visualized using the colors of a traffic light. If the total risk value falls in the GREEN ZONE (1-35), risk is rated as low. If the total risk value falls in the AMBER ZONE (36-60), risk is moderate and you should consider adopting procedures to minimize the risk. If the total value falls in the RED ZONE (61-80), you should implement measures to reduce the risk prior to starting the activity.

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The ability to assign numerical values or “color codes” to hazards using the GAR Model is not the most important part of risk assessment. What is critical to this step are team discussions leading to an understanding of the risks and how they will be managed.

Table S1.B.1. APPA Plot-Based Forest Monitoring Protocol assigned risk codes of 0 (For No Risk) through 10 (For Maximum Risk) to each of the eight Green-Amber-Red Risk Assessment elements.

Element	Rating
Supervision	6
Planning	6
Communication	6
Contingency Resources	7
Team Selection	6
Team Fitness	6
Environment	6
Event/Evolution Complexity	7
Total Risk Score	50

Step 4: Identify Risk Control Options

Supervision

The APPA Plot-Based Forest Monitoring Protocol will likely be implemented by individuals working for organizations other than NPS, NETN, or APPA. The Project Leader (who may not be an NPS or ATC employee) will be responsible for training and supervising all field monitors. Field monitors will be required to check in periodically with a Designated Office Staff (DOS; likely the Project Leader) who will be responsible for communicating with NPS and ATC staff, if needed. While the protocol identifies personnel, roles and responsibilities, and a chain of command, the entity conducting the work will have control over its implementation. NPS, NETN, and APPA highly recommend that field staff follow check-in and check-out procedures and carry multiple forms of communication, but will not necessarily be in a position to enforce supervisory controls or safety procedures. A score of 6 was assigned because of the potential inability to ensure an adequate amount of supervision.

Planning

The NETN Plot-Based Forest Monitoring Protocol includes numerous SOPs that explain training, personal safety, emergency communication (equipment and contacts), and appropriate field activities. Monitoring staff are asked to review these SOPs. Whenever work is performed under this protocol by NPS staff, they will be required to sign an acknowledgement that they have reviewed the JSA. However, when this methodology is used by someone working on the APPA, but not for NPS we can only encourage that the JSA be reviewed and signed. Monitoring staff are highly encouraged to have first aid and CPR training. The advance planning, written documentation, and training procedures promote a safe working environment and suggest a low score (4), but the inability of NPS to enforce these steps when the protocol is implemented by another entity demands a moderate score (6).

Communication

Routine and emergency communication procedures are explained in the relevant SOPs, and field monitors are encouraged to coordinate with the nearest ATC regional office. The procedures include a regular check-in/check-out procedure for field monitors to ensure that a responsible party knows if someone has not returned from the field activity in a timely manner. However, there are many places along the APPA where radio and cell phone communication is not possible. For this reason, field monitors must carry a Personal Locator Beacon for use in life-

SOP 1 - Safety

threatening emergencies. Despite the advance planning, written documentation, and training procedures, a moderate score (6) was assigned because of the known communication problems.

Contingency Resources

Contingency resources include communication equipment and procedures that explicitly involve park rangers, park dispatch, and 9-1-1. Field monitors are required to carry a Personal Locator Beacon and a second form of communication like a cell phone, but coverage is not available in many locations. SPOT GPS messengers may alleviate some issues and facilitate regular check-ins, but are not currently required equipment. In the worst case scenario, an incident involving one or two field monitors in an area with no cell phone coverage could result in a long delay before emergency services are alerted. However, monitors use marked sites and routes that are generally on or near established trails. They also set up explicit check-in times, so if a search is initiated after a missed check-in the individual should be located within a few hours of starting a search. A score of 7 was assigned for this worst-case scenario.

Team Selection

The monitoring protocol identifies the essential skills and abilities required to execute this protocol in a competent manner, but one of the features of this protocol is that significant experience is not required. Field monitors may have limited experience with research and field work, and some may be retirees. There is also variation in their orienteering and hiking experience. Field monitors are strongly encouraged to obtain basic first aid and CPR certification, and must work with a partner. A score of 6 was assigned because some monitoring staff may have limited experience with off-trail hiking and navigating.

Team Fitness

The nature of the APPA Plot-Based Forest Health Monitoring Protocol should ensure an overall high level of team fitness. The monitoring itself is not difficult, although significant travel/hiking time may be needed for some sites. A score of 6 was assigned because the monitoring does require long hikes that may be strenuous, and may require extended stays in the back-country. Field monitors must be diligent about adequate rest and nourishment to ensure that fatigue does not become a factor.

Environment

Environment was assigned a moderate score (6) because the work may involve some travel off of established trails, on uneven terrain. Activities may occur during a variety of weather conditions, although field monitors are told not to monitor if the weather forecast calls for severe weather.

Incident Complexity

Incident complexity was also assigned a medium score (7) because much of the APPA is relatively remote, field conditions change due to weather, and emergency evacuation logistics could be complicated. Individual field monitors must use judgment and experience to respond appropriately.

Step 5: Evaluate Risk vs. Gain

The scores for this assessment fall in the mid-to-upper range of the “amber” zone, indicating a moderate risk activity. While it is theoretically possible to make changes to reduce risk even further, the risks associated with monitoring along the ANST tend to be higher due to the remote setting and reliance on cooperators and volunteers to conduct many activities. Planning and preparation are the keys to minimizing risk. The APPA Environmental Monitoring Coordinator

SOP 1 - Safety

feels that the current procedures provide a good balance that encourages field monitors to be safe, but also acknowledges that APPA, NETN and NPS may have limited control over those utilizing this protocol and that monitoring may occur with disregard for many of the considerations outlined in this SOP. Regardless, the APPA Environmental Monitoring Coordinator and NETN feel that this monitoring activity, if carried out in accordance with all SOPs, has a manageable level of risk.

Step 6: Execute Decision

The decision made by the APPA Environmental Monitoring Coordinator is to promote the use of the APPA Forest Health Monitoring Protocol Standard Operating Procedures (SOPs).

Step 7: Supervise – Watch for Change

The APPA Environmental Monitoring Coordinator will encourage feedback from those who implement this protocol contractor on safe execution of the protocol including risk control options not considered thus far.

References and Additional Information

Acadia National Park. 2008. Acadia National Park Health and Safety Program Plan. Internal Document # A7619(ACAD-PB). U.S. Department of Interior, National Park Service, Acadia National Park, Bar Harbor, Maine.

American Lyme Disease Foundation. 2000. Tick ID Card. Tim Peters and Company Inc., Peapack, New Jersey.

Cass, W. 2007. Shenandoah National Park Long Term Ecological Monitoring System. SOP #2, version 1.2. U.S. Department of Interior, National Park Service, Shenandoah National Park, Luray, Virginia.

Sonoran Desert Network, National Park Service. 2008. SODN Field Safety Plan. Version 6.00. U.S. Department of Interior, National Park Service, Sonoran Desert Network Office, Tucson, Arizona.

Tierney, G., B. Mitchell, K. Miller, J. Comiskey, A. Kozlowski, and D. Faber-Langendoen. 2011. Northeast Temperate Network long-term forest monitoring protocol: 2011 revision. Natural Resource Report NPS/NETN/NRR—2010/195. National Park Service, Fort Collins, Colorado.

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Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	December 2011	Fred Dieffenbach	Modified from MIDN/NETN SOP	Specific needs of APPA
1.01	May 2012	Fred Dieffenbach	Revised to conform with Operational Leadership Training	Improved
1.02	September 2012	Brian Mitchell and Fred Dieffenbach	Require a PLB, edits for consistency of terminology, update forms, GAR, and JSA	Internal review

SOP 2 - Preparation and Equipment List

APPA

Version 1.04

Procedures follow the MIDN/NETN Preparation and Equipment List SOP except for the following differences:

- A botanist is not needed for APPA plots, but crews need to be trained to identify understory indicator plants listed in the APPA Quadrat SOP as well as common shrubs.
- No tree tags are used in APPA plots.
- Training for APPA crew includes tree marking and measuring horizontal distance on sloped ground.
- No soil samples are collected from APPA plots, so no soil training or equipment is needed.
- Prior to conducting field operations, field staff examine aerial photography in order to exclude any GRTS location which appears not to be forested (< 60% closed canopy), to lie on extreme slopes (> 30 degrees), which cannot safely be accessed, or which lies within 15 m of the boundary of APPA lands, a road, perennial stream with consistent break in canopy overhead, a perennial water body, or a mowed area. This is a critical step; careful pre-field analysis will save the crew significant time and energy visiting unsuitable locations.

The equipment and supplies needed for APPA Plot-Based forest monitoring are listed herein. This list differs from the MIDN/NETN equipment list as follows:

- APPA crews do not use a field computer, laser rangefinder, tree tags, or soil sampling equipment.
- Green or black forestry spray paint is needed for marking trees.
- APPA plots are marked with a single permanent marker – a capped rebar at plot center. Shorter lengths of rebar are included on the equipment list for installation in shallow soils.
- APPA crews need measuring tapes for plot setup.

The NETN Forest Health Monitoring Protocol and associated SOP's can be downloaded at the NETN Long-term Forest Health Monitoring page

<http://science.nature.nps.gov/im/units/netn/monitor/programs/ForestHealth/forestHealth.cfm>.

SOP 2 - Preparation and Equipment List

General Field Equipment

Park topo maps showing plot locations
Protocols with slope conversion table
Park permit
Tree and shrub lists
Indicator species list and field guide
Field notes and Early Detection ID cards
Datasheets (on Rite-in-the-Rain paper)
Enclosed clipboard
GPS unit
Sighting compass (3)
Clinometer (2)
Walkie-Talkies or cell phone
Batteries for GPS (AA), camera (AA), calipers
Flagging and survey flags
Sharpened pencils and permanent markers
Daypacks
First aid kit
Insect repellent
Water
Briar-proof chaps and field vests (optional)
Raingear
Lens tissues
10x hand lens (2)
Peterson's Eastern Trees Field Guide
The Shrub Identification Book - Symonds
Personal Locator Beacon

Plot Establishment

45-cm rebar stakes (1/2 in dia) and labeled cap
(1 per plot)
30-cm rebar (1/2 in dia) stakes (20)
Mini-sledge hammer
Chisel

Plot Measurements

Digital camera
Sonin electronic distance measurer
Work belt
30-m tape (1)
15-m tape (2)
Line level
Loggers tape (1)
DBH tape (2)
Forestry spray paint, green or black (several)
PVC pole cut to breast height (1.37 m)
Compact, waterproof binoculars (8x power)
Sturdy ruler (30 cm)
Digital calipers
Quadrat frame: 1x1 m
Clippers
Watch with timer
Sealable plastic bags (both small and large)
Octagonal camera guide (flat)
Camera tripod
Bubble level for photo-monitoring
Site ID cards for photo-monitoring

Back in Field Vehicle

Full-size plant press
Backup GPS Unit

SOP 2 - Preparation and Equipment List

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	March 2010	Geri Tierney	Refers to MIDN/NETN SOP ver. 2.07. Removed some heavy equipment. Adjusted plot and tree markers.	Needed lighter packs and minimal marking.
1.01	May 2010	Geri Tierney	Added photomonitoring equipment.	
1.02	May 2010	Brian Mitchell	Remove tree scribes, replace with forestry spray paint.	Paint less damaging to trees.
1.03	December 2011	Fred Dieffenbach	Subtle changes in wording to make SOP more broadly applicable.	
1.04	August 2012	Brian Mitchell	Added PLB	Internal review

SOP 3 - Using the Global Positioning System (GPS)

APPA

Version 1.01

Overview

This Standard Operating Procedure was adapted from a SOP written by Shenandoah National Park. It explains the methods that all observers should follow to learn to use Global Positioning System (GPS) with the Garmin 76CS unit. Forest monitoring crews use GPS to help navigate to and locate pre-existing plots as well as document the location of new plots.

Suggested Reading

Garmin GPSMAP 76S Owner's Manual and Quick Reference Guide (select 'Manuals' at <https://buy.garmin.com/shop/shop.do?cID=167&pID=183>)

Setting Up and Using the GPS Unit in the Field

Global positioning system equipment is used in the field to navigate to the predetermined location of new plots and to aid in the relocation of existing plots. The location of the plot center is also marked and recorded as a waypoint. Detailed steps for setting up and using the GPS unit are presented below.

Setting up the GPS Unit

1. Make sure the GPS is set to decimal degrees WGS84. Under the main menu, select 'Setup', then toggle to 'Location' and set the 'Location Format' to hddd.ddddd°, the 'Map Datum' to WGS84. Hit the 'Quit' button to return to the 'Setup' menu.
2. Make sure the GPS is set to True North. Toggle to 'Heading' on the Setup menu and set the 'North Reference' to True.

Note: These settings will be saved on the GPS and should not have to be re-entered each time the unit is turned on.

3. Be sure to carry at least one full replacement of batteries for the GPS receiver.
4. As soon as you turn the unit on, it starts to look for satellites. You can track the status of the satellites on the GPS information page. The GPS is most accurate when it has at least four satellites and a 3D position. The location of satellites in the sky changes from day to day and thus sometimes satellite reception is more difficult to achieve. Openings in the canopy of the forest can increase the strength of satellite signals reaching the GPS unit.
5. The current estimated accuracy of the receiver is also displayed on this Page. The accuracy fluctuates as satellite signals are gained and lost. An accuracy of + or – 10 m (30 ft) or better is desirable to precisely document location.

Navigating to a Site

1. After the receiver is turned on and has adequate reception, press the 'FIND' button, highlight 'Waypoints' and press 'ENTR'.
2. Press 'Menu' then 'Find by Name' or 'Find by Nearest' to find the appropriate waypoint name and press 'Enter'. Type in the name of the desired point, or press 'Page' to scroll through all the options. The waypoint screen will give you detailed information about the waypoint including distance to the point. Select 'Go To'.
3. At the top of the Map Page, the distance and bearing to the waypoint will be displayed. The Map Page, Compass Page or Highway Page can be used to navigate to the waypoint. As the distance to the waypoint decreases, the bearing and distance numbers will begin to jump around as the accuracy varies. As the waypoint nears, the use of a hand compass and measurement by pacing will help locate the point.

Marking a Waypoint

1. Hold down the Enter button until the 'Mark Waypoint' Screen appears. Note: If the Enter button or toggle button are held down too long, a MOB (man overboard) point will be collected. If this happens, just ignore it and start again.
2. The default name of a waypoint is a sequential number. To change the default name toggle to the number and press 'ENTR'.
3. Toggle up and down through the numbers and letters and left and right between characters. Once the last letter or digit has been selected, press 'ENTR' to save the name and highlight the whole name field. For APPA, you should enter the plot number as a three-number code (i.e., Plot 21 = 021).
4. The most accurate way to document a location is to collect a waypoint position that averages at least 100 points. To do this select 'Menu' and then choose 'Average Location'.
5. The 'Average Location' screen appears and measurement counts automatically begin. After the 'Measurement Count' reaches 100, press enter to save. Press 'OK' on the Mark Waypoint screen to return to the Map Page.
6. Before leaving the point, make sure that it has been recorded. Press 'FIND' and toggle to 'Waypoints' and press 'ENTR'. Does the new waypoint appear on the list?

Navigating

You can navigate using the Map Page, Compass Page or Highway Page but remember that the fastest, and safest way to a plot may not be a straight line. Crews should navigate along the A.T. and side trails to get close to site, then follow contours over to plot. Maps should be consulted to aide in finding a safe route. When navigating using the GPS, remember that directional signals you receive from GPS are only valid while you are moving. Unlike a compass, if you stop and turn to face a different direction, the GPS will not reposition until you move again. A compass

SOP 3 - Using the Global Positioning System (GPS)

must be used to determine the correct direction to continue after stopping, and care must be taken to hold the compass sufficiently far from the GPS handheld unit to avoid influencing the compass needle.

Connecting to a Computer

1. Connect the Garmin unit to a computer using a USB cable.
2. Turn the unit on.
3. Two ways to open DNR Garmin. You should be using version 5.3.2 or higher.
 - a. Open DNR Garmin from the Start menu or
 - b. Open DNR Garmin from the DNR Garmin toolbar in ArcMap. If the toolbar is not loaded, select View > Toolbars > DNR Garmin Toolbar from the ArcMap menu.
4. Confirm that DNR Garmin recognizes the unit.
 - a. If the unit is not recognized, 'Not Connected' will appear in the lower left corner (Figure S3.1).
 - b. If the unit is recognized, 'Connected' will appear in the lower left corner and the GPS unit information should appear on the screen (Figure S3.2).
5. If the unit is not recognized, make sure the Port is set to USB by selecting GPS > Set Port > USB. To refresh the connection, select GPS > Open. Note: this will only work if the GPS is not connected.

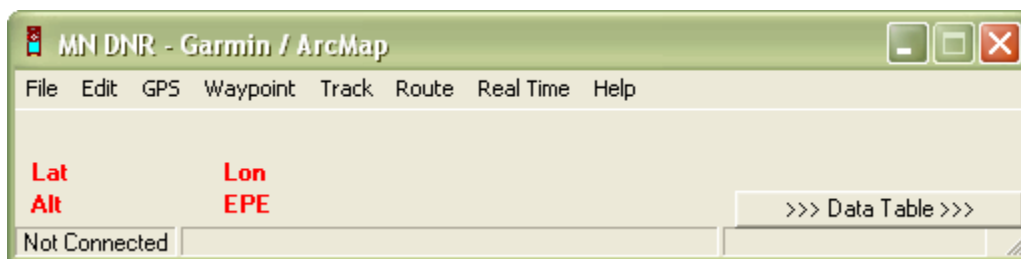


Figure S3.1. MN DNR—Garmin/ArcMap with GPS not connected.

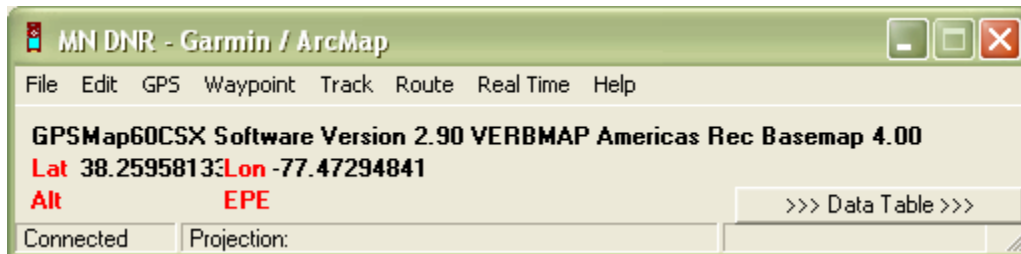


Figure S3.2. MN DNR—Garmin/ArcMap with Garmin unit connected.

6. Set the default projection to WGS84, and decimal degrees (hddd.ddddd°). To open the DNR Garmin Properties window (Figure S3.3); select File > Set Projection. You will need to set the projection three times.

Note: Use the correct datum for each watershed (ie, 18N or 19N for northern watersheds).

SOP 3 - Using the Global Positioning System (GPS)

- Select EPSG on the Projection tab and select 'WGS_1984' from the Datums drop-down box. You may want to type some of it in to narrow the options.
- Select 'No Projection' from the Projections drop down box.
- On the bottom of the same tab, click the 'Load PRJ' button and navigate through 'Geographic Coordinate Systems', 'World', 'WGS 1984', and then select 'WGS 1984'.
- At the top of the same tab, select ArcMap, click the 'Load PRJ' and navigate to the same projection file as in the last step. Click 'Ok'.

The Projection will now appear at the bottom center of the main MN DNR—Garmin/ArcMap screen (Figure S3.4).

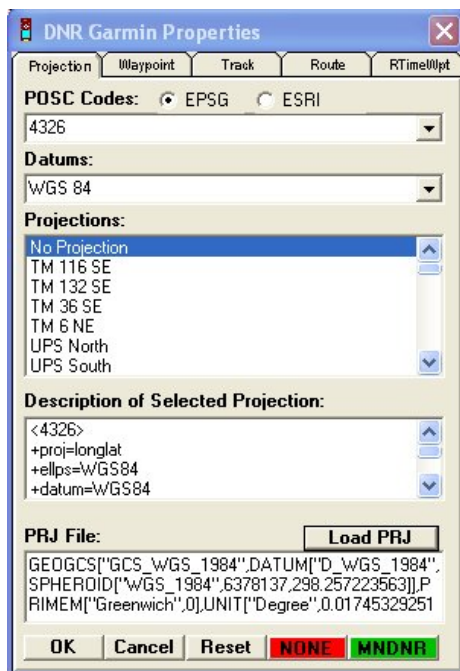


Figure S3.3. DNR Garmin Properties window with projection set to WGS 1984.

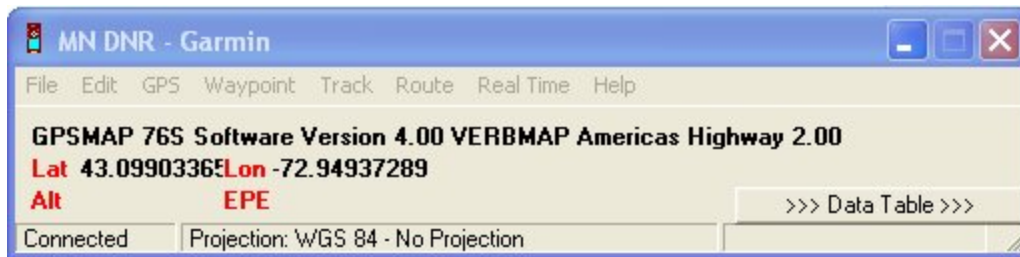


Figure S3.4. MN DNR—Garmin with Garmin unit connected and projection set to WGS 1984.

Uploading Waypoints to the Garmin Unit

In order to navigate to existing plot locations, waypoints with plot decimal degree (hddd.ddddd°) coordinates must be uploaded from a GIS layer to the GPS receiver. The steps for this procedure are as follows:

1. Turn on the computer and open the current ArcGIS map document with the GIS layer loaded. Make sure the GIS layer you want to upload is active. It should be highlighted (Figure S3.5).
2. Connect the GPS unit to the computer using the USB cable and turn the unit on.
3. Open MN DNR Garmin.

Select File > Load From > ArcMap > Layer. The Identify Fields dialog box will appear and you will need to select an Ident and Comment field. For the forest monitoring protocol, the Ident field will be the park GRTS number field (i.e. where the field is “11_FRSP_FRED”) and the Comment field should be the local name as classified by the vegetation map.

Note: If the shapefile already has a comment field, MN DNR Garmin will default to the existing comment field and ignore the field selected. You will need to either copy the field you want to use into the existing comment field or delete it.

4. To upload the waypoints to the GPS unit. Select Waypoint > Upload.
5. The GPS will beep when the upload is complete and a small box on the computer screen will read ‘Transfer Complete. Waypoints uploaded.’ Click OK. Now, you are ready to take the GPS into the field.
6. Note that the default symbol for uploaded waypoints is a blue flag. Press ‘FIND’ on the Garmin unit and select ‘Waypoints’ and then press ‘ENTR’ to see the waypoints that you just uploaded.

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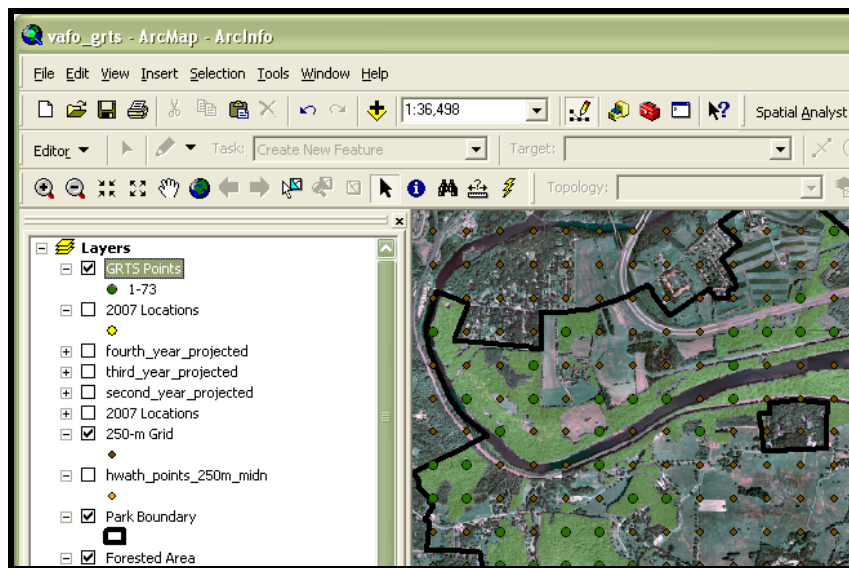


Figure S3.5. The GRTS Points layer is active in the Table of Contents of ArcMap.

Downloading Waypoints

Waypoints for newly established plots as well as updated waypoints for plots with inaccurate GPS locations need to be downloaded onto the computer upon return to the office from the field.

1. Open the ArcGIS map document with the relevant files.
2. Connect the GPS unit to the computer with a USB cable and turn it on.
3. Open DNR Garmin and verify that the GPS is acknowledged and that the projection is set to WGS 1984, and the location format is set to hddd.ddddd°. If you need help, see the section above on setting up DNR Garmin.
4. To download waypoints, select Waypoint > Download. The saved waypoints from the GPS will now appear in the table.
5. Note that all the waypoints on the GPS are downloaded (Figure S3.6). You can sort through these by clicking on any of the column headings. For example, click on 'symbol' to sort the waypoints by their symbol.
6. You can either save all the waypoints or select specific waypoints to save. What you choose to do may depend on the project you are working on. If you do not highlight any of the waypoints, they will all be saved. To highlight waypoints, click on the row identifier. In the above image, clicking on '2' highlighted the row which is Plot 0121.

SOP 3 - Using the Global Positioning System (GPS)

GPSMap60CSX Software Version 2.90 VERBMAP Americas Rec Basemap 4.00
 Lat 38.25966421 Lon -77.47298074
 Alt EPE

Waypoint Table

type	ident	lat	long	x_proj	y_proj	comment	display	symbol	unused1	dist	prox
WAYPOINT	47 FRSP FRED	38.2573958	-77.45891668	4237043.15757946	284850.172031333	15.36 20-FEB-08	0	159	0	0	0
WAYPOINT	0121	38.25959391	-77.47303457	4237509.86020268	283626.146299799	20-FEB-08 15:54:16	0	159	0	0	0
WAYPOINT	28 FRSP FRED	38.25739062	-77.45893254	4237293.15671332	284850.176389038	15.36 20-FEB-08	0	10	0	0	0
WAYPOINT	19 FRSP FRED	38.25561971	-77.46462618	4237043.15468852	284350.175889553	15.36 20-FEB-08	0	170	0	0	0
WAYPOINT	18 FRSP FRED	38.28026083	-77.47117504	4239739.15410799	283850.175931932	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	41 FRSP FRED	38.25585910	-77.45320709	4237043.15228029	285350.172272886	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	10 FRSP FRED	38.24430136	-77.43855562	4235739.14907159	285600.174924977	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	11 FRSP FRED	38.25141669	-77.45020101	4236549.15621623	285600.173647771	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	20 FRSP FRED	38.24721183	-77.43577743	4236043.15706995	286850.170711288	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	1 FRSP FRED	38.24721100	-77.43292289	4236043.14872314	287100.17386223	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	22 FRSP FRED	38.25366774	-77.45027661	4236793.15468247	285600.176298579	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	14 FRSP FRED	38.25805038	-77.45613766	4237293.14968346	285100.176757245	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	15 FRSP FRED	38.25396504	-77.43600290	4236793.15090571	286850.177075664	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	17 FRSP FRED	38.27131684	-77.46801431	4238793.14921438	284100.178032844	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	12 FRSP FRED	38.25549960	-77.47033568	4237043.15603449	283850.177086345	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	73 FRSP FRED	38.25609740	-77.44178784	4237043.15204298	286350.171732018	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	16 FRSP FRED	38.25378684	-77.44456720	4236793.15017232	286100.172259491	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	43 FRSP FRED	38.25123740	-77.45876488	4236543.14823932	284850.172254682	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	23 FRSP FRED	38.24898636	-77.45888894	4236293.14325032	284850.177130149	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	13 FRSP FRED	38.27350779	-77.47094605	4239043.15589373	283850.173712723	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	21 FRSP FRED	38.25147629	-77.44734638	4236549.1561496	285850.173301565	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	38 FRSP FRED	38.25336867	-77.46455016	4236793.15461442	284350.170963753	15.36 20-FEB-08	0	8284	0	0	0
WAYPOINT	30 FRSP FRED	38.25105761	-77.46732867	4236549.15415648	284100.171445826	15.36 20-FEB-08	0	8284	0	0	0

Figure S3.6. Data table displaying downloaded waypoints.

7. These waypoints need to be saved twice, once as a text file and once as a shapefile.

- To save as a text file, select File > Save To > File...

For forest monitoring plots, the text file should be saved in the 'backup_gps_text_files' folder. The naming convention should include the date the file was downloaded, the GPS brand and model number, and the type of data following the format "20080220_Garmin_76CSX_waypoints.txt".

- To save as a shapefile, select File > Save To > ArcMap > Shapefile Layer...

For forest monitoring plots, the shapefile should be saved in the 'backup_gps_shapefiles' folder. The naming convention should include the date the file was downloaded, the GPS brand and model number, and the type of data following the format "20080220_Garmin_CSX_waypoints.shp".

This file will automatically appear in the Table of Contents of the ArcGIS Map Document that you have open.

8. Close DNR Garmin and verify the contents of the new shapefile in the map document to ensure that your data were properly transferred.

Deleting Waypoints from the GPS Unit

The GPS receiver can hold up to 500 waypoints, but you may need to delete the downloaded waypoints from the GPS periodically to keep it from becoming full while in the field. Waypoints can either be deleted individually or the entire table can be deleted at once.

- Deleting a single waypoint:
 - From the 'Main Menu' screen, press 'Find' to open the Find screen.
 - Select 'Waypoints' to open the Waypoints screen.

SOP 3 - Using the Global Positioning System (GPS)

- c. Toggle to highlight the waypoint you would like to delete and Press 'ENTR' to open the Waypoint screen.
 - d. Toggle to highlight 'Delete' in the lower left corner and press 'ENTR'
 - e. When prompted 'Do you really want to delete waypoint xxx?' highlight 'Yes' and press 'ENTR'
2. Deleting all waypoints:
- a. Press 'Find' to open the Find screen.
 - b. Select 'Waypoints' to open the Waypoints screen.
 - c. Press 'MENU' to open the Menu screen.
 - d. Select 'Delete All' to delete all of the saved waypoints from the GPS Unit. Be sure that all of the waypoints have been downloaded and backed up before doing this!

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	April 2010	Geri Tierney	Adapted from SHEN LTEM GPS SOP ver. 1.2 and MIDN/NETN GPS SOP ver.2.01	
1.01	December 2011	Fred Dieffenbach	Revised spatial references from NAD 1983 UTM to WGS 1984 Decidegrees	WGS 1984 and decidegrees are more amenable to the A.T.

SOP 4 - Data Management & Quality Assurance/Quality Control

APPA

Version 1.02

Procedures follow the MIDN/NETN Data Management & Quality Assurance/Quality Control SOP except for the following differences:

- The APPA crew records data on Rite-in-Rain datasheets, rather than a field computer.
- Datasheets are copied and originals mailed to the project leader as soon as feasible after data collection, and after being reviewed by the crew leader for completeness and accuracy. Within one week of receipt by the project leader the field forms should be scanned and archived digitally.
- APPA datasheets are transcribed into the MS Access database by the project leader at the end of the field season.
- QA/QC on APPA plots requires staff who can identify shrubs and plants on the APPA indicator plant list (see APPA Quadrat SOP), or alternatively, a botanist.

The NETN Forest Health Monitoring Protocol and associated SOP's can be downloaded at the NETN Long-term Forest Health Monitoring page (<http://science.nature.nps.gov/im/units/netn/monitor/programs/ForestHealth/forestHealth.cfm>).

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version	Date	Revised By	Changes	Justification
1.00	April 2010	Geri Tierney	Refers to MIDN/NETN SOP ver. 2.10	
1.01	December 2011	Fred Dieffenbach	Removed URI references to make the protocol slightly more generic	Broaden potential application
1.02	February 2012	Fred Dieffenbach	Added scanning of field forms per discussion with Adam Kozlowski	

SOP 5 - Segment Selection

APPA

Version 1.03

Background

The segment based approach to monitoring forest resources was initially developed as a component of a NASA-funded project to enhance the Decision Support System (DSS) for the Appalachian Trail corridor. Sampling occurs at randomly placed points that are distributed throughout a series of watershed-based sampling segments.

We chose a two-stage sampling design that enabled us to select a representative set of trail segments, each with a cluster of forest plots. This approach considerably simplifies logistics and provides a natural stratification within which plots are likely to be similar in physical setting and habitat type. Watershed-based segments were selected because watershed boundaries are natural in origin and the scale chosen (HUC10) was selected because that level of division offers a balance between larger regional “sub-basins” (HUC08) and smaller “sub-watershed” (HUC12) areas (Figure S5.1). We determined that HUC08 “sub-basins” consolidated too much area while the smaller HUC12 “sub-watersheds” fragmented the landscape excessively. Other options for creating segments were considered but few were “natural” in origin. For example, segments based on arbitrary lengths were considered, but this approach was not based on ecological criteria. Likewise, politically based segments were also dismissed. Trail segments and plot locations for the first and second stage, respectively, of the sampling design were determined by randomly placing points using the Generalized Random Tessellation Stratified (GRTS) algorithm (see Sampling Design).

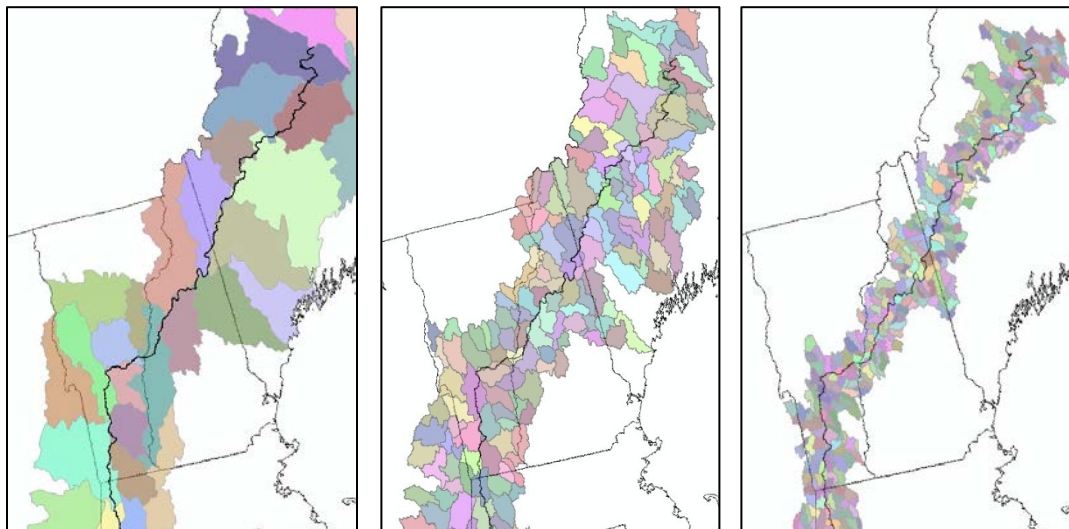


Figure S5.1. HUC08 “sub-basins” (left), HUC10 “watersheds” (center), and HUC 12 “sub-watersheds” (right).

Segment Selection Process

Segments were established by intersecting HUC10 watersheds with the APPA land area (i.e., corridor). Because the Appalachian Trail follows ridgelines for a large portion of its length, the watershed lines break the corridor transversely as well as longitudinally (Figure S5.2). The outcome of the HUC10 segmentation process was 177 segments ranging in size from approximately 4 ha to 2,185 ha. We determined¹⁰ that at least 5 plots at a plot density of 1 plot per 50 ha would be needed to characterize the forest resources within a segment. Based on these determinations, segments less than 250 ha were eliminated from consideration.

Each sampling segment was associated with 10-m DEM data to determine minimum segment elevation. To be included, an entire segment needed to satisfy the minimum elevation criterion. The purpose for associating elevation data with each segment was to identify mid-elevation segments. In the north (i.e., New England) mid-elevation is defined as > 450 m and in the south mid-elevation is defined as > 600 m.

We also considered whether a segment was within a mountain ecoregion as defined by the Bailey Ecoregion system used by the U.S. Forest Service. In practice, this criterion was of little value because all segments that satisfied the mid-elevation criteria were within mountain ecoregions.

A single GRTS point was assigned to each watershed segment. From the list of segments that met the above criteria, 10 segments¹¹ were selected using the randomly assigned GRTS point ID. Four segments were selected in the northern region (Figure S5.4) and 6 segments were selected in the south (Figure S5.5).

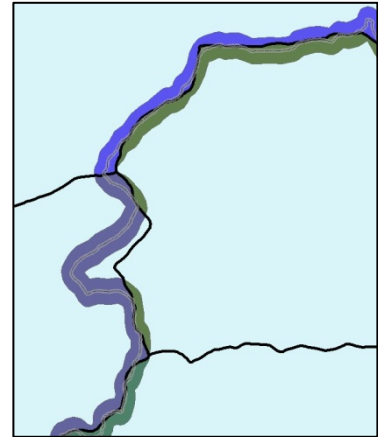


Figure S5.2. Watershed and corridor intersection.

¹⁰ Plot density, the minimum size of segments and the number of plots within a segment were set based on professional judgment and the limited amount of funding available for a pilot study. A density of 1 plot per 50 ha was deemed adequate but at least 5 plots would be needed to characterize a segment and estimate variability between plots. Based on these two judgment based criteria, segments needed to be at least 250 ha in size.

¹¹ The number of segments selected was based on professional judgment given a limited budget for a pilot study. Additional segments could be selected if desired, and if funding is available.

Point Selection Process

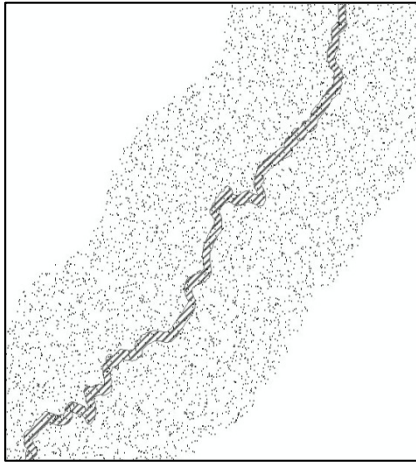


Figure S5.3. Sampling point density around APPA.

We began the point selection process by creating a point file that contains 800,000 randomly distributed GRTS points in an area that contains the APPA corridor plus a 2-mi buffer on each side¹². We opted to expand beyond the existing trail buffer (500 ft on each side of the trail) to accommodate any trail relocations that might happen in the foreseeable future (most trail relocations are no further than 2 mi from the existing Appalachian Trail location). Of the 800,000 points, approximately 47,000 are within the existing APPA corridor, yielding a density of approximately 200 points per HUC10 segment. The actual density of GRTS points per selected segment varies widely due to the range in size of the segments. Figure S5.3 shows all the GRTS sampling points within and around the APPA corridor for a section that is approximately 8.5 mi long.

Points falling within one of the 10 selected segments were further filtered by distance from the APPA corridor boundary. Any point within 15 m of the APPA corridor boundary was excluded to ensure that no part of the forest monitoring plot whose center is identified by the point coordinates would extend onto private lands.

While there is no budget currently allocated for forest sampling, a target sample size of approximately 100 plots should adequately balance between cost and data value. Based on professional judgment we determined that a plot density of 1 plot per 50 ha was desirable. Using this density as a guide, we divided the area of each segment by 50 to determine the number of plots to sample in a given segment. This ensured that sampling intensity among segments was consistent. At the end of this process, we selected 105 sampling points, with no segment having fewer than 5 plots.

Figure S5.6 shows a portion of a segment in Maine with all possible GRTS points displayed. In contrast, Figure S5.7 shows GRTS points that were selected for sampling during pilot monitoring.

¹² The GRTS point file extends out 2 mi from the AT corridor to ensure that points are available for future trail relocations, and to equip potential future projects with random sampling points.

SOP 5 - Segment Selection

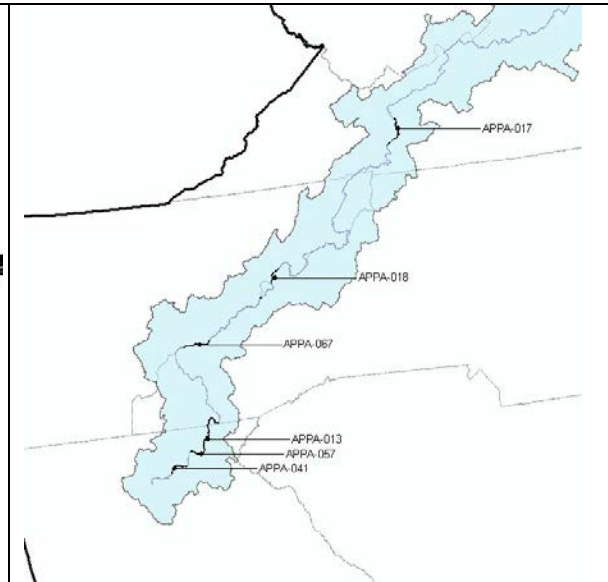
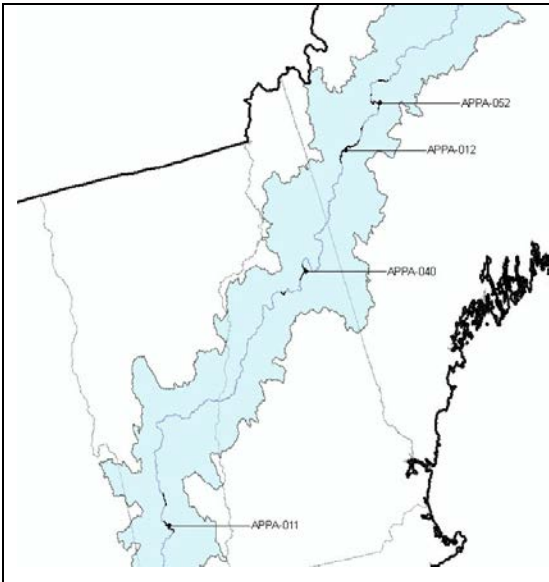


Figure S5.4. Selected segments in the north. **Figure S5.5.** Selected segments in the south.

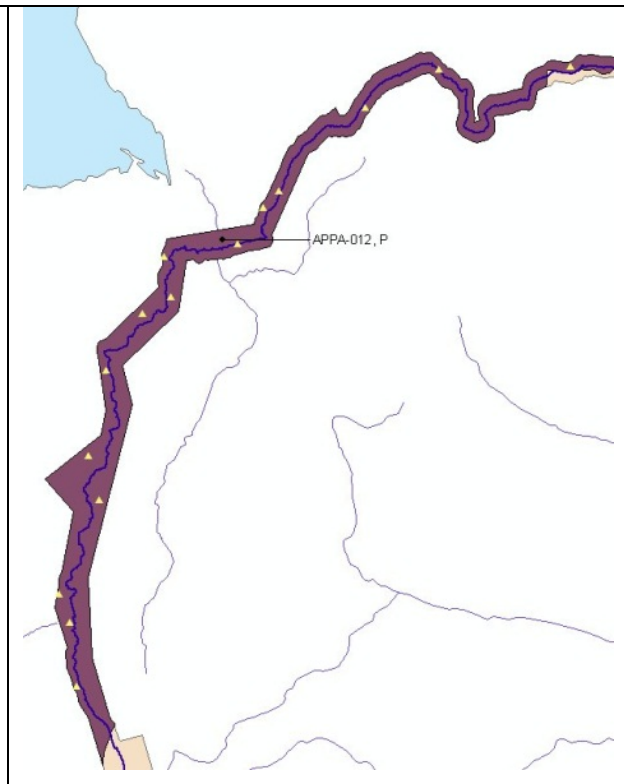
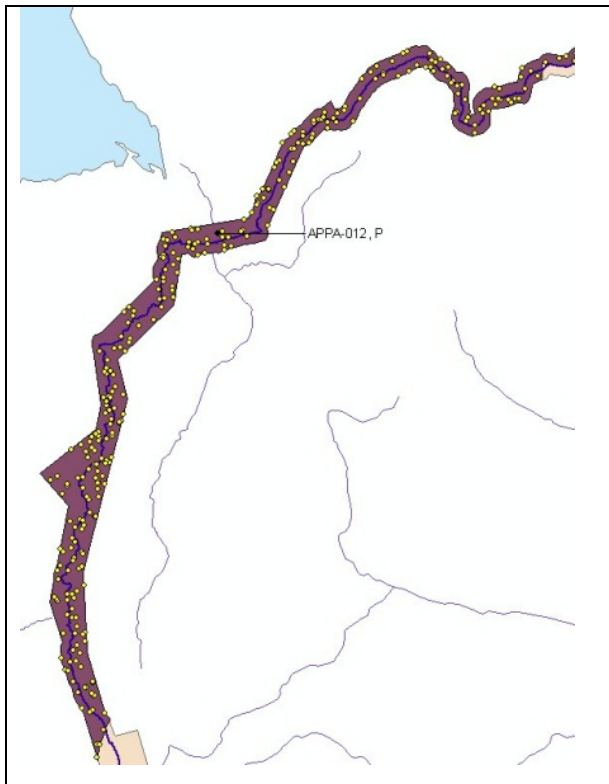


Figure S5.6. Potential points in a selected segment. **Figure S5.7.** Selected points in the segment shown in Figure S5.6.

SOP 5 - Segment Selection

Revision History

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Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	April 2010	Fred Dieffenbach		
1.01	February 2012	Fred Dieffenbach	Reconciled review edits and comments.	Revised diagrams for clarity.
1.02	September 2012	Brian Mitchell	Minor edits, clarified that minimum elevation was used for segment selection.	Internal review.
1.03	October 2012	Fred Dieffenbach	Clarifications based on John Karish review.	Internal review.

SOP 6 - Site Selection and Plot Establishment

APPA

Version 1.02

Follow the MIDN/NETN Site Selection and Plot Establishment SOP, with the following differences:

- Obtain current declination for each watershed from your supervisor.
- The Appalachian Trail footpath is included within our sampling frame, and the presence of that footpath or any hiking trail in the plot is not a reason for exclusion.
- Only mid-elevation upland forested sites are included within the APPA sampling frame. Upon arrival at a GRTS location, visually examine the location to ensure that soil is not seasonally saturated and that the location is primarily forested (> 60 % closed canopy overhead) or succeeding to forest.
- If the plot center is < 15 m from any of the unsuitable features listed in the MIDN/NETN SOP (such as a road, or perennial stream with consistent break in canopy above), or if the plot presents a safety hazard as described in the MIDN/NETN SOP, attempt to move the plot center 20 m horizontal distance perpendicular to the feature in either direction. Before doing so, check field maps to ensure the boundary of APPA land is not within about 35 m in that direction, to avoid setting up a plot which extends beyond APPA land. If multiple features (roads, fields, streams) or hazards are present and there is insufficient space (<40 m between features or too close to APPA boundary) to establish a plot, discard the plot and record the reason. Then add the next backup location to the list of plot locations for establishment, and proceed to the next nearest pre-selected location currently included in the annual sample.
- The APPA plot layout differs substantially from the NETN plot layout. APPA plots are 11-m radius circular plots, oriented to true north (see Figure S6.1).
- Only a single permanent marker is installed at APPA plots. Use the Plot Establishment procedure described below to install this capped rebar.
- Temporary markers are used to delineate microplots, CWD transects, and quadrats during measurement, as described below. It is very important that these flags be collected and removed from the site after measurement.

Plot Establishment

Install a permanent marker at plot center. Using a mini-sledge hammer, set a rebar¹³ firmly into the ground. The rebar should extend above ground to facilitate relocation. Cap the rebar with an appropriately labeled survey cap. Do not omit the cap; it is an important safety feature which protects hikers from injury on the sharp metal end.

¹³ See SOP 2 - Preparation and Equipment List for specific rebar length recommendations

SOP 6 - Site Selection and Plot Establishment

If plot center is within view of the AT footpath or any hiking trail, shelter or campsite, the center marker will need to be less visible. In this case, sink rebar flush to the ground, and cap. Where soil is shallow to bedrock it may be necessary to use a shorter rebar.

If the rebar cannot be set exactly at plot center due to a rock, an intermittent streambed, or some other obstacle, temporarily mark plot center and look for a suitable location to secure the rebar within a 1-m radius of the current position. If no suitable location exists within a 1-m radius, expand the search to a 2-m radius. If a suitable location is found, this becomes the new plot center. If no suitable location exists within a 2-m radius, return to the original position, and find the 60° (UR) microplot center as described below. Install the permanent rebar marker at this location. If this microplot center is not suitable, continue on to the 180° (BL) microplot location, or if necessary, the 300° (UL) microplot location. Be sure to record in Plot Notes if the permanent rebar is set at a microplot center, and identify which microplot is marked with rebar.

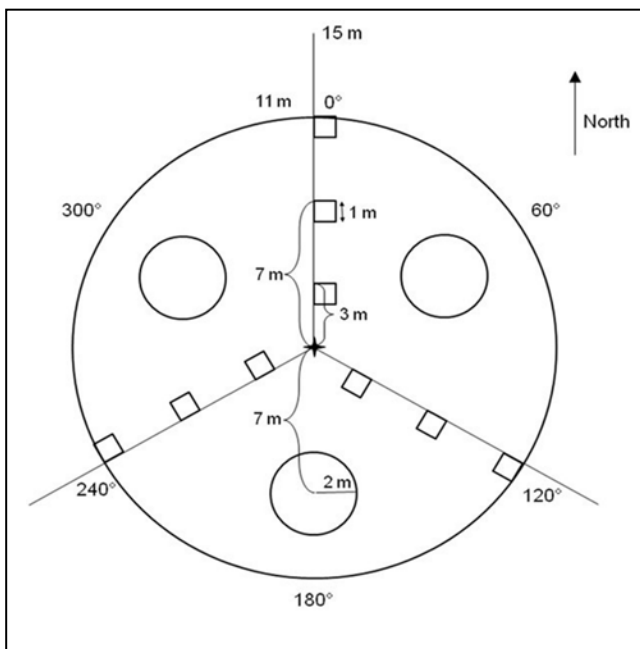


Figure S6.1. APPA plot layout showing 11-m radius circular tree plot with three nested 2-m radius regeneration microplots, nine 1-m² vegetation quadrats, and three 15-m CWD transects.

Select two witness trees near plot center that are at least 10 cm dbh, and as close to 90 degrees apart as possible. On each witness tree, paint a 5 cm by 5 cm square on the side of the tree facing plot center at 10 cm below dbh, using green forestry marking paint. This is in addition to the horizontal line at dbh. When the tree is measured (see the Tree Measurements SOP), make sure to record that the trees are witness trees in the appropriate column.

If no suitable rebar marker location is found after checking all three microplot centers, return to the original position, and select two witness trees near plot center, as described above.

If no suitable witness trees are available near plot center, double-check to ensure the location is forested ($\geq 60\%$ closed canopy overhead). If it is, and exposed bedrock is available within a 2-m radius of plot center, select a new plot center location as close to the original plot center location as possible. Use the mini-sledge hammer and a chisel to make a small (3-cm) dimple into the exposed bedrock. Record in Plot Notes that plot center is marked on bedrock.

Next, install brightly colored survey flags to temporarily mark microplot centers, CWD transects, and quadrats, as follows. Note that APPA plots are oriented to true north, not upslope like MIDN/NETN plots.

SOP 6 - Site Selection and Plot Establishment

Establish three microplots at 60, 180, and 300 degrees using a compass and measuring tape. The center of each microplot should be 7 m slope distance from plot center. At the center of the microplot, set a brightly colored survey flag in the ground.

Next, establish three transects emanating from plot center at 0, 120, and 240 degrees using a compass and measuring tape. The length of each transect is 15 m slope distance. At 3, 7, 11 and 15 m slope distance from plot center along each transect, set a brightly colored survey flag into the ground. The 15-m flag marks the end of the transect, and the others mark the far end of respective quadrats. Leave the measuring tapes in place along the three transects to help delineate the plot during measurement.

The crew must be exact about sighting and distance measurements, so that the same locations can be found during any remeasurement. Distances should be measured to within 0.1 m error, and bearings should be sighted to within 2 degrees error.

When sighting compass bearings, crew members must take care that metal objects do not affect the compass needle, and that the compass is held level (flat) at all times. The compass needle will not show small shifts in azimuth when the compass is tilted. When sighting up or down slope, remember to hold the compass level—do not tilt it relative to the slope.

To measure slope distance, pull the tape taught parallel to the ground surface, ensuring that it is not caught on vegetation. Both ends of the tape must be held at the same height above the ground to keep it parallel to the ground.

It is essential that all survey flags be collected and removed after measurement. Only a single capped rebar marker should remain at the monitoring plot.

Data Collection

Follow the MIDN/NETN Site Selection and Plot Establishment SOP for collection of site information, with the following differences:

- For Park, record APPA.
- For coordinates, record latitude and longitude in decimal degrees rather than UTM coordinates. Use WGS 1984 as the datum.
- For orientation, record the bearing along the line where the plot is steepest, aiming towards the high end of the plot from plot center.
- For slope, measure along the orientation bearing using a clinometer. Measure the slope to the nearest degree (not %) from plot center to the high point on the plot boundary along the orientation bearing. This slope should always be positive or zero, unless the plot is on a mound. Then measure the slope to the nearest degree (not %) from plot center to the low point on the plot boundary in the opposite direction (180 degrees apart) from the orientation bearing. This slope should always be negative or zero, unless the plot is in a bowl. To measure slope, Observer 1 must sight Observer 2 at a height equivalent to the eye-level of Observer 1.

SOP 6 - Site Selection and Plot Establishment

The NETN Forest Health Monitoring Protocol and associated SOP's can be downloaded at the NETN Long-term Forest Health Monitoring page

(<http://science.nature.nps.gov/im/units/netn/monitor/programs/ForestHealth/forestHealth.cfm>).

Revision History

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Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	March 2010	Geri Tierney	Refers to MIDN/NETN SOP ver. 3.05, Some parts of plot setup adapted from ERMN SOP ver. 3.0. Changed plot layout. Used ERMN procedure for moving plot center if needed. Use clinometer for slope.	Need lighter packs, minimal markings, and back-country procedures.
1.01	May 2010	Brian Mitchell	Use decimal degrees rather than UTM, and record plot orientation as the upslope bearing along the steepest part of the plot. High and Low plot slopes are now more similar to NETN; two measurements from plot center. Always mark two witness trees, and record witness tree ID's on the Tree Measurements form.	UTM are not appropriate for the trail, and orientation allows determination of local lay of the plot. No scribing of trees due to potential for damaging trees; use paint instead.
1.02	January 2012	Fred Dieffenbach	Remove specific reference to 2010 declination and replaced it with 'current' declination to broaden application. Removed reference to NAD 1983 and inserted WGS 1984	2010 declination will become antiquated; WGS 1984 is better suited to A.T.

SOP 7 - Photopoint Procedures

APPA

Version 1.03

Procedures follow the DRAFT APPA Repeat Panorama Monitoring SOP which is available on request from the Appalachian National Scenic Trail Environmental Monitoring Coordinator, with the following specifications:

- The panoramic series will be taken from plot center. If a tripod is available, it should be placed (a bubble level is highly recommended) at plot center, and select an appropriate height for the tripod that will allow a relatively unobstructed view in most directions (e.g., above the lower understory).
- Camera settings are not specified in the Repeat Panorama Monitoring SOP. The resolution should be at least 4 MP per photo, with JPG compression. Do not use a flash for panoramic or canopy photos, and use a normal zoom (e.g., 50 mm equivalent rather than telephoto or wide angle; the camera should start in this mode). Do not use any special filter settings (e.g. “sunset” or “sports”). Take care to avoid photographing crew members.
- Information described in sections 3.1, 3.2, and 3.5 of the Repeat Panorama Monitoring SOP may be supplanted by similar site documentation steps contained in the APPA Plot-Based Forest Monitoring protocol. In other words, you do not need to document the photos as well as the forest plot itself by following two sets of nearly identical procedures. The site ID card in section 3.3 is needed, and the scale bar can be a dbh pole or quadrat side with marks every 10 cm.
- In addition to the panoramic series and canopy photo, two additional scenes will be taken. The first scene is photographed from plot center, facing north and holding the camera vertically (portrait). The second photograph is a close-up of the UR microplot ground cover, taken from a position standing over that microplot and holding the camera in a horizontal position (landscape). Place a ruler in the microplot photograph for a scale. A flash can be used for this final photo, if needed.
- On the data sheet, record the initials of the photographer, the height of the tripod, and the numbers of the a) first photo of the panoramic series; b) last photo of the panoramic series; c) the canopy photo; d) the vertical photo, and e) the microplot close-up photo.
- Photos should be downloaded to a computer as soon as is realistically possible.

SOP 7 - Photopoint Procedures

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	April 2010	Geri Tierney	Initial version adapted from MIDN/NETN SOP ver. 2.03	
1.01	May 2010	Geri Tierney	Added specifications for use of new APPA Repeat Panorama Monitoring SOP.	
1.02	May 2010	Brian Mitchell	Use the full octagonal guide, for 27 total photos (8 horizontal, 8 up, 8 down, 1 canopy, 1 portrait north, on microplot). Noted some sections of panorama SOP that could be excluded, and documented camera settings.	Should be sufficient memory and battery for full protocol.
1.03	December 2011	Fred Dieffenbach	Removed reference to 'octa-guide' and made tripod optional	Octa-guide and tripod use is replaced by freehand approach

SOP 8 - Stand and Site Measurements

APPA

Version 1.01

Procedures follow the MIDN/NETN Stand and Site Measurements SOP except for the following differences:

- For stand height, vertical angle should be measured using a clinometer.
- Earthworms: Visually assess and record the presence (1) or absence (0) of earthworm casts and burrows in the vicinity of the plot. To do so, examine up to three locations just outside the perimeter of the forest plot (in order to avoid disturbing the plot itself). Gently brush aside unconsolidated litter to view casts and burrows at the soil surface. Earthworm burrows are temporary or permanent soil channels made by earthworms for living space and during travel. Burrows can be observed as circular openings in the soil surface. Sometimes burrows are covered by, or surrounded by, casts, litter or organic matter. Earthworm casts are excreted by earthworms after feeding, and are composed of soil mixed with digested plant residues. Casts appear as distinctive, moist aggregates of rich soil. Cast production is highest during moist spring and fall seasons, but should be visible throughout the summer in areas with established earthworm populations. If examination is inconclusive, record 9.

The NETN Forest Health Monitoring Protocol and associated SOP's can be downloaded at the NETN Long-term Forest Health Monitoring page

<http://science.nature.nps.gov/im/units/netn/monitor/programs/ForestHealth/forestHealth.cfm>.

Revision History

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Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	March 2010	Geri Tierney	Refers to MIDN/NETN SOP	
1.01	May 2010	Geri Tierney	Added visual assessment of earthworm presence from NETN soil sampling SOP.	

SOP 9 - Tree Measurements

APPA

Version 1.03

Procedures follow the MIDN/NETN Tree Measurements SOP except for the following differences:

- Begin tallying trees from the 0° transect and continue clockwise through the plot.
- Trees in APPA plots are not tagged but instead are marked with forestry paint in the following way: Use the mark on the DBH pole to identify the location of the paint mark (at DBH), and create a horizontal line on the bark of the tree, using green forestry paint. The mark should be 5–7 cm in length and perpendicular to the tree axis. The mark should always be located where the diameter was measured. If the diameter was measured in an unusual place, the paint mark must be placed at the location of the diameter measurement. This allows accurate remeasurement of DBH during return visits. The paint mark should face plot center. If there is a trail close to the plot, paint marks should be placed on the far side of the tree, away from the trail, so that the marks are not seen from the trail. If the paint mark is not facing plot center, or is unusual in any way, write a description of the irregularity in the Tree Notes section of the data form.
- Paint snags unless they are unstable or in an advanced stage of decay. Do not paint snags that sway when touched to ensure that no snags are knocked down. If the wood of the snag is decayed around DBH such that paint marks will quickly erode, do not mark the snag. Note in the Tree Notes section of the data form that the snag was not marked, and proceed to record data as usual.
- Mark and measure all trees ≥ 10 cm dbh that fall within the 11 m tree plot. That is, include all trees that lie within 11 m horizontal distance of plot center. A tree which occurs on the plot perimeter is included if the center of the stem base lies directly on or within the perimeter.
- For Azimuth, use a compass to measure azimuth from plot center to each tree. Record to the nearest degree.
- For Distance, use the Sonin electronic distance measurer to measure horizontal distance to the nearest 0.1 m. Use the attached bubble level to ensure the Sonin is held level. If line of sight is obstructed, you can measure horizontal distance using a tape and line level, if necessary, to ensure the tape is held level.
- On some slopes it will not be possible to measure horizontal distance directly. In that case, measure slope distance using either the Sonin or tape, and then convert to horizontal distance using the Slope Conversion Table (Appendix B). To do so, measure the slope (in degrees) between the tree and plot center using a clinometer. On the slope table, find the column corresponding to the measured slope (read column headers at top of chart) and the row corresponding to the measured slope distance (read row headers at left of chart); then, horizontal slope is found in the chart at the intersection of that row and column. For

SOP 9 - Tree Measurements

example, if the slope between plot center and the measured tree is 20 degrees, and the slope distance between tree and plot center is 10 m, the horizontal distance is recorded as 9.4 m. Note that horizontal distance is equivalent to slope distance on slope ≤ 5 degrees, so no conversion is necessary.

- Make sure to include all trees within 11 m horizontal distance of plot center. On moderate to steep slopes there will likely be trees that lie > 11 m slope distance, but < 11 m horizontal distance; these trees must be included. The slope conversion table shows the maximum slope distance a tree may lie from plot center to be included (ranging from 11.1 m at 6° slope to 12.7 m at 30° slope).
- If the tree is a witness tree for the plot, mark “Yes” in the “Witness?” column of the tree data form.

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(<http://science.nature.nps.gov/im/units/netn/monitor/programs/ForestHealth/forestHealth.cfm>).

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	March 2010	Geri Tierney	Refers to MIDN/NETN SOP ver. 3.09 Parts are adapted from ERMN SOP ver 3.0. Trees will be scribed, not tagged. Crew will not have LAR.	Minimize markings.
1.01	May 2010	Geri Tierney	Improved procedures for measuring slope distance.	
1.02	May 2010	Brian Mitchell	Trees will be marked with paint rather than scribing. Witness trees need to be recorded on the data form.	Reduce damage to trees.
1.03	December 2011	Fred Dieffenbach	Minor grammar changes	

SOP 10 - Microplot Measurements

APPA

Version 1.01

Follow the NETN procedures within the MIDN/NETN Microplot SOP except for the following differences:

- Microplot centers are located at 7 m slope distance from the full plot center, in the direction of 60, 180 and 300 degrees, respectively. APPA microplot codes match MIDN/NETN codes (UR for 60°, BC for 180°, and UL for 300°).
- Saplings in APPA plots are marked with forestry paint. Use the top of the DBH pole to identify the location of the paint mark (at DBH), and create a horizontal mark on the bark of the tree, using green forestry paint. Paint marks are 5–7 cm in length (or the width of the sapling if smaller) and are perpendicular to the tree axis. The paint mark should always be located where the diameter was measured. If the diameter was measured in an unusual place, the paint mark must be placed at the location of the diameter measurement. This will allow accurate remeasurement of DBH during return visits. The paint mark should face plot center. If there is a trail close to the plot, paint marks should be placed on the far side of the tree, away from the trail, so that the marks are not seen from the trail. If the paint mark is not facing plot center, or is unusual in any way, write a description of the irregularity in the Sapling Notes section of the data form.
- If a shrub species cannot be identified in the field, tally the unknown shrub and collect a twig sample or photograph as described in the MIDN/NETN Microplot SOP. Collected unknown specimens should be transported from the field in zip-lock bags. Bag must be labeled with day of collection, plot, and specimen number. Upon return to camp, promptly identify collected plants, or press specimens for later identification.

The NETN Long-term Forest Health Monitoring Protocol and associated SOP's can be downloaded at the NETN website (<http://science.nature.nps.gov/im/units/netn/monitor/programs/ForestHealth/forestHealth.cfm>).

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

SOP 10 - Microplot Measurements

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	April 2010	Geri Tierney	Refers to MIDN/NETN SOP ver. 4.03. Large saplings are scribed to facilitate microplot relocation.	
1.01	May 2010	Brian Mitchell	Saplings will be painted with forestry paint rather than scribed. All saplings will be marked.	Reduce damage to trees caused by scribing.

SOP 11 - Coarse Woody Debris Measurements

APPA

Version 1.00

Procedures follow the MIDN/NETN Coarse Woody Debris SOP except for the following differences:

- In APPA plots, coarse woody debris transects extend 15 m slope distance from plot center in the following directions: 0°, 120°, and 240°. The codes for these transects match MIDN/NETN codes (UP for 0°, BR for 120°, and BL for 240°).
- Slope is measured using a clinometer (in degrees), rather than a laser rangefinder.

The NETN Forest Health Monitoring Protocol and associated SOP's can be downloaded at the NETN Long-term Forest Health Monitoring page

<http://science.nature.nps.gov/im/units/netn/monitor/programs/ForestHealth/forestHealth.cfm>.

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version	Date	Revised By	Changes	Justification
1.00	March 2010	Geri Tierney	Refers to most recent MIDN/NETN SOP	

SOP 12 - Quadrat Measurements

APPA

Version 1.01

Procedures follow the NETN procedures in the MIDN/NETN Quadrat Measurements SOP except for the following differences:

- In APPA plots, species percent cover data are collected for indicator plants listed in Appendix C for northern and southern segments, respectively. These species were selected for their invasiveness, sensitivity to anthropogenic stressors, or for special interest. Cover data are also collected for all non-indicator herbaceous species (combined), trees and shrubs less than 15 cm in height (combined), and all trees and shrubs greater than 15 cm (individually).
- APPA plots do not require a botanist, but do require staff to be trained to recognize indicator species.
- Three quadrats are located along each of three transects for a total of nine quadrats per plot. Quadrats are located at 2-3 m, 6-7 m, and 10-11 m slope distance, respectively along the three CWD transects (extending from plot center at 0°, 120°, and 240°. Quadrats are not permanently marked. Quadrats are always placed to the RIGHT of the transect meter tape, as one looks along the transect from plot center (i.e., the quadrats are placed on the clockwise side of the transect tape).
- Quadrat codes correspond to the transect and distance as follows: UP-3, UP-7, UP-11, BR-3, BR-7, BR-11, BL-3, BL-7 or BL-11, where UP refers to the transect at 0°, BR refers to the bottom right transect at 120°, and BL refers to the bottom left transect at 240°.
- During the plot search for additional species, only search for indicator species. Record any indicator species found on the plot that were not recorded in the quadrats.

The NETN Forest Health Monitoring Protocol and associated SOP's can be downloaded at the NETN Long-term Forest Health Monitoring page

<http://science.nature.nps.gov/im/units/netn/monitor/programs/ForestHealth/forestHealth.cfm>.

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	April 2010	Geri Tierney	Refers to MIDN/NETN SOP ver. 4.04	
1.01	May 2010	Brian Mitchell	In addition to cover of indicators, combined cover of all non-indicator herbs will be collected, as well as combined cover of all trees and shrubs less than 15 cm in height. In addition, all trees and shrubs > 15 cm in height will have cover estimated by species.	Crew will be able to identify non-germinant trees and shrubs, and estimating smaller herb and woody cover will provide information about overall vegetation cover.

SOP 13 - Landscape Context

APPA

Version 1.00

Procedures follow the MIDN/NETN Landscape Context SOP except for the following differences:

- APPA will use existing data sources for this landscape context analysis. Digital Orthophoto Quarter-Quadrangles (DOQQs) may be available from U.S. Department of Agriculture (USDA) National Agricultural Imagery Program (NAIP; <http://165.221.201.14/NAIP.html>) or the National Digital Orthophoto Program (NDOP; <http://www.ndop.gov/>). Alternatively, APPA may use the USGS National Land Cover Database (NLCD) for this analysis.
- Forest patch size analysis is performed at the scale of the HUC-10 watershed.
- For Neighborhood Anthropogenic Land Use, calculate using these two neighborhood sizes: a 400 m radius circle around each plot (i.e., a 50 ha local neighborhood, just as in the MIDN/NETN SOP); and also a 4 km radius circle (i.e., a 5,000 ha larger neighborhood, Heinz Center 2002).

Literature Cited

Heinz Center. 2002. The State of the Nation's Ecosystems: Measuring the Lands, Waters and Living Resources of the United States. The Heinz Center for Science, Economics and the Environment. Cambridge University Press, New York, New York.

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	February 2012	Geri Tierney	Adapted from MIDN/NETN Forest Protocol.	

SOP 14 - Analyzing and Reporting Ecological Integrity

APPA

Version 1.01

Procedures follow the MIDN/NETN SOP, “Analyzing and Reporting Ecological Integrity” except for the following differences:

Metrics and Ratings

Metrics and ratings are similar to those reported for MIDN/NETN, except that soils data are not collected under the APPA protocol so measures of forest function related to soil have been eliminated from Table S14.1. In addition, the APPA quadrat measurements assess only indicator species, rather than all species present.

Table S14.1. Metrics and ratings for evaluating the ecological integrity of forest ecosystems.

Metric type	Metric	Metric Ranking		
		Good	Caution	Significant Concern
Landscape structure	Forest patch size	> 50 ha	10-50 ha	< 10 ha
	Anthropogenic land use	< 10% for both neighborhood sizes	≤ 40% for both neighborhood sizes, and at least one neighborhood size ≥ 10%	>40% for one or both neighborhood sizes
Structure	Structural stage (3 northern provinces ¹)	≥ 70% late-successional	< 70% late-successional	< 70% combined mature and late-successional
	Structural stage (5 mid & southern provinces ²)	≥ 25% late-successional	< 25% late-successional	< 25% combined mature and late-successional
	Snag abundance	≥ 10% standing trees are snags and ≥10% med-lg trees are snags ³	< 10% standing trees are snags or <10% med-lg trees are snags	< 5 med-lg snags/ha
	Coarse woody debris volume	> 15% live tree volume	5- 15% live tree volume	< 5% live tree volume
Composition	Tree regeneration	Seedling ratio ≥ 0	Seedling ratio < 0	Stocking index outside acceptable range ⁴
	Tree condition	Foliage problem < 10% and no priority 1 or 2 pests ⁵ and BBD ≤ 2	Foliage problem 10-50% or priority 2 pest or BBD > 2	Foliage problem >50% or priority 1 pest
	Indicator species: invasive exotic plants	< 0.5 key species per plot	0.5 to < 3.5 key species per plot	3.5 or more key species per plot
	Indicator species: deer browse	No decrease in frequency of most browse-sensitive species	Decrease in frequency of most browsed species or increase in frequency of browse-avoided species	

SOP 14 - Analyzing and Reporting Ecological Integrity

Table S14.1. Metrics and ratings for evaluating the ecological integrity of forest ecosystems (continued).

Metric type	Metric	Metric Ranking		
		Good	Caution	Significant Concern
	Tree mortality rates	Mort ≤ 1.6%	Mort > 1.6%	Decrease in frequency of most browsed species <i>and</i> increase in frequency of browse-avoided species

¹ Three northern provinces include: White Mountain, New England Piedmont, Green-Taconic-Berkshire Mountains

² Five mid and southern provinces include: Hudson Valley, Lower New England, Northern Appalachian Piedmont, Northern Ridge and Valley, Blue Ridge Mountains.

³ Med-lg trees are ≥ 30 cm diameter-at-breast-height.

⁴ Tree regeneration stocking index varies by ecoregion section.

⁵ Priority 1 pests are Asian longhorned beetle, emerald ash borer and sudden oak death. Priority 2 pests are hemlock woolly adelgid, balsam woolly adelgid, butternut canker, and beach bark disease (BBD).

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Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.3 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	December 2011	Fred Dieffenbach	Initial revision, excerpted from NETN/MIDN analysis and reporting SOP	
1.01	September 2012	Brian Mitchell and Geri Tierney	Minor edits, clarify anthropogenic land use metric	Internal review

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National Park Service
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