Inventory & Monitoring Division

National Park Service

Northeast Temperate Network– Forest Health Monitoring Standard Operating Procedures

Please cite this as:

Tierney, G., B. Mitchell, K. Miller, J. Comiskey, A. Kozlowski, and D. Faber-Langendoen. 2017. Northeast Temperate Network Forest Health Monitoring Standard Operating Procedures. Natural Resource Report NPS/NETN/SOP—2017. National Park Service.

Summary

This document delineates the safety and standard operating procedures used to collect data by the NETN forest health monitoring crew.

Contents

Page

Summary 1

Figures 9

Tables 13

Safety Procedures 14

Definitions (alphabetical) 14

Overview 14

Responding to an Incident 15

Field Preparation 15

Job Safety 15

Field Safety 18

Vehicle Safety 26

Contact Information 27

References and Additional Information 27

Appendix S1. A. Job Safety Analysis for the long-term forest monitoring protocol. 30

Appendix S1.B. Green-Amber-Red Risk Assessment. 38

Step 1: Define the Mission or Task 38

Step 2: Define the Threats 38

Step 3: Assess Risk and Assign a Numerical Value 38

Step 4: Identify Risk Control Options 39

Step 5: Evaluate Risk vs. Gain 41

Step 6: Execute Decision 41

Step 7: Supervise – Watch for Change 41

Appendix S1.C. Directions to nearest hospital from each park, separated by network. 42

Northeast Temperate Network 42

Acadia National Park– Headquarters 42

Acadia National Park– Seawall 43

Acadia National Park– Schoodic 44

Marsh-Billings-Rockefeller National Historical Park 45

Minute Man National Historical Park 46

Morristown National Historical Park 47

Roosevelt-Vanderbilt National Historic Sites (ELRO, HOFR, VAMA) 48

Saint-Gaudens National Historic Site (Option 1) 49
Saint-Gaudens National Historic Site (Option B) 50
Saratoga National Historical Park 51
Weir Farm National Historic Site 52
Mid-atlantic Network 53
Appomattox Court House National Historical Park 53
Colonial National Historical Park 55
Chancellorsville Unit—Fredericksburg & Spotsylvania National Military Park 56
Fredericksburg Unit—Fredericksburg & Spotsylvania National Military Park 57
Spotsylvania Unit—Fredericksburg & Spotsylvania National Military Park 58
Spotsylvania Unit—Fredericksburg & Spotsylvania National Military Park 59
Wilderness Unit—Fredericksburg & Spotsylvania National Military Park 60
Wilderness Unit—Fredericksburg & Spotsylvania National Military Park 61
Gettysburg National Military Park/Eisenhower National Historic Site 63
Gettysburg National Military Park/Eisenhower National Historic Site (continued) 64
George Washington Birthplace National Monument 65
Hopewell Furnace National Historic Site 67
Petersburg National Battlefield 68
Chickahominy Bluff Battlefield Unit—Richmond National Battlefield Park 69
Turkey Hill Unit—Richmond National Battlefield Park 70
Cold Harbor Unit—Richmond National Battlefield Park 71
Sagamore Hill National Historic Site 75
Thomas Stone National Historic Site 76
Valley Forge National Historical Park 77
Appendix S1.D. Emergency contacts/procedures for each park 78
Northeast Temperate Network 78
Mid-Atlantic Network 80
Appendix S1.E. Workers compensation procedures for each park, Version 1.1. 82
Appendix S1.F. Procedures and guidance for proper use of park radios 88
Overview 88
Radio procedures during normal operating conditions 88
Radio procedures during an emergency 89
Appendix S1.H. Instructions for responding to an automobile accident in an NPS-owned vehicle. 95

Accident/collision reports should be filed for: 96
Appendix S1.I. Northeast Region accident/incident reporting process. 97
Northeast Region 97
TORT Claims – Accident/Incident Reporting Process 97
Appendix S1.J. SF-91 Motor Vehicle Accident Report 99
Appendix S1.K. SF-94 Statement of Witness. 103
Revision History 104
Revision History Log 104
SOP 2 - Preparation and Equipment List 105
Overview 105
Staff 105
Planning and Coordination 106
Maps 106
Schedule 106
Logistics 107
Training 107
Communication and Crew Oversight 111
Equipment 111
General Field Equipment 112
Plot Measurements 112
Back in Field Office 112
Plot Establishment 112
Revision History 113
Revision History Log 113
SOP 3 - Using the Global Positioning System (GPS) 117
Overview 117
Setting Up and Using the GPS Unit in the Field 117
Connecting the Garmin 60CSX Unit to a Computer 121
Uploading Waypoints to the Garmin Unit 123
Downloading Waypoints 124
Deleting Waypoints from the GPS Unit 126
Revision History 127
Revision History Log 127

SOP 4 - Using the LTI TruPulse 360ºR 129
Overview 129
Suggested Reading 129
General Use 129
Getting Started 130
Setup 131
Taking Measurements 135
Troubleshooting 136
Revision History 137
Revision History Log 137
SOP 5 - Data Management & Quality Assurance/Quality Control 139
Acknowledgements 139
Overview 139
Field Procedures 139
Field Computer 140
Datasheets 140
Data Verification 140
Database Merge Tool 142
Schedule of Data Management Duties 142
Data Validation 143
Field QA/QC 144
Importing Soil Data from the Lab into the Database 145
Appendix S5.A. QA/QC steps quick-reference. 149
Revision History 152
Revision History Log 152
Revision History Log (continued) 153
SOP 6 - Site Selection, Plot Establishment and Remeasurement 155
Overview 155
Definitions 155
Procedure 157
Data Collection 163
Revision History 165
Revision History Log 165
Revision History Log (continued) 166

SOP 7 - Photopoint 169
Overview 169
Data Collection 169
Camera 170
Photographer 170
Weather 170
Data Management 170
Figure S7.1. Bulk File Rename Utility screen 172
Revision History 174
Revision History Log 174
SOP 8 - Stand and Site Measurements 175
Overview 175
Data Collection 175
Disturbance Code 179
Revision History 182
Revision History Log 182
Revision History Log (continued) 183
SOP 9 - Tree Measurements 185
Overview 185
Caution 185
Definitions 185
Procedure 186
Data Collection 187
Revision History 194
Revision History Log 194
Revision History Log (continued) 195
SOP 10 - Microplot 197
Overview 197
Definitions 197
Data Collection 197
Microplot Code 199
Revision History 201
Revision History Log 201

Revision History Log (continued) 202
SOP 11 - Coarse Woody Debris 204
Overview 204
Definitions 204
Data Collection 204
Tally Rules for CWD 204
Revision History 207
Revision History Log 207
Revision History Log (continued) 208
SOP 12 - Soil Measurements and Sampling 210
Overview 210
Regulations Governing Sample Collection 210
Data Collection 211
Unconsolidated Litter Thickness 215
Forest Floor Depth 215
Total Depth Collected 215
A Thickness 215
Soil Notes 216
Sample Drying 216
Sample Analysis 216
Soil Archiving 217
Original Sample Type 217
Sieved/Pulverized Sample Type 217
Soil that has been sorted with larger particle sizes removed, or pulverized to create uniform soil particle size. The analytical lab encloses these samples in small Whirl-Paks. 217
Revision History 217
Revision History Log 217
Revision History Log (continued) 218
SOP 13 - Quadrat Measurements 220
Overview 220
Data Collection 220
Revision History 226
Revision History Log 226
Revision History Log (continued) 227

SOP 14 – Collecting and Aging Tree Cores 228
Overview 228
Definitions 228
Procedure 228
References 232
Revision History 232
Revision History Log 232
SOP 15 – Limiting Exotic Species Transport (LEST) 234
Overview 234
When to Implement LEST 234
Materials Needed 234
Removing Exotic Species 234
Revision History 235
Revision History Log 235
SOP 16 - Landscape Context 236
Overview 236
Sources of Spatial Data 236
Spatial Analysis 237
Forest Patch Size 237
Neighborhood Anthropogenic Land Use 238
Revision History 238
Revision History Log 239
SOP 17 - Analyzing and Reporting Ecological Integrity 240
Overview 240
Ecological Integrity 240
Selecting Metrics 241
Rating Metrics 241
Scorecard 242
Metrics and Ratings 242
Forest Patch Size 244
Anthropogenic Land Use 244
Confidence 245
Structural Stage Distribution 245
Snags and Coarse Woody Debris 248

Tree Regeneration 251
Tree Condition 254
Biotic Homogenization 256
Indicator Species—Invasive Exotic Plants 257
Indicator Species—Deer Browse 258
Tree Growth and Mortality Rates 260
Soil Chemistry—Acid Stress 262
Soil Chemistry—Nitrogen Saturation 263
Revision History 274
Revision History Log 274
Revision History Log (continued) 275
SOP 18 - Deviations, Differences, and Summary of Major Changes 278
Overview 278
Differences between MIDN and NETN Methods 278
Known Deviations and Major Changes 280
Revision History 288
Revision History Log 289
SOP 19 - Protocol and Database Revision 292
Overview 292
Revision Timeframe 292
Database Tracker 292
Revision History 293
Revision History Log 293

Figures

Page

Figure S1.1. Tick species found in the eastern US. 21

Figure S1.2. Centers for Disease Control recommended procedures for tick removal. 21

Figure S1.C.1. The route from Acadia NP Headquarters to the Mount Desert Island Hospital in Bar Harbor, Maine 42

Figure S1.C.4. Route from Marsh-Billings-Rockefeller NHP in Woodstock, Vermont to Dartmouth Hitchcock Hospital in Lebanon, New Hampshire. 45

Figure S1.C.5. Route from Minute Man NHP Brooks Village parking lot in Concord, Massachusetts to Emerson Hospital, also in Concord. 46

Figure S1.C.6. Route from Morristorn NHP Jockey Hollow Visitor Center to the Morristown Memorial Hospital, both in Morristown, New Jersey. 47

Figure S1.C.9. The entire route. 48

Figure S1.C.8. End point at St. Francis Hospital. 48

Figure S1.C.7. Start point at Home of FDR NHS Visitor Center parking lot. 48

Figure S1.C.10. Option 1 route from Saint-Gaudens NHS Visitor Center parking lot to Mount Ascutney Hospital. 49

Figure S1.C.11. Option 2 route from Saint-Gaudens NHS to Dartmouth Hitchcock Medical Center. 50

Figure S1.C.12. Route from Saratoga NHP entrance on NY-32 to Saratoga Hospital. 51

Figure S1.C.13. Route from Weir Farm NHS to Danbury Hospital. 52

Figure S1.C.14. End point at Danbury Hospital 52

Figure S1.C.15. Route from Appomattox Court House NHP to Lynchburg General Hospital. 53

Figure S1.C.16. End of Route from Booker T. Washington NM to Carilion Franklin Memorial Hospital. 54

Figure S1.C.17. Route to Mary Immaculate Hospital from Colonial National Historical Park. 55

Figure S1.C.18. Route from Chancellorsville Unit to Mary Washington Hospital. 56

Figure S1.C.19. Route from Chancellorsville Unit to NextCare Urgent Care. 56

Figure S1.C.20. Route from Chancellorsville Unit to Mary Washington Hospital. 57

Figure S1.C.21. Route from Spotsylvania Unit to Mary Washington Hospital. 58

Figure S1.C.22. Route from Spotsylvania Unit to Prime Care Urgent & Family Care. 59

Figure S1.C.23. Route from Wilderness Unit to Mary Washington Hospital. 60

Figure S1.C.24. Route from Wilderness Unit to Rapidan Medical Center. 62

Figure S1.C.25. Map of Gettysburg NMP and Eisenhower NHP with Gettysburg Hospital marked at center. 63

Figure S1.C.26. Map of Gettysburg downtown with Gettysburg Hospital marked near center. 64

Figure S1.C.27. Route from George Washington NM to Riverside Tappahannock Hospital. 66

Figure S1.C.28. Route from Hopewell Furnace NHS to Pottstown Memorial Medical Center. 67

Figure S1.C.29. Route from Petersburg NB to Southside Regional Medical Center. 68

Figure S1.C.30. Route from Chichahominy Battelfield Unit—Richmond NBP *to Bon Secours Memorial Regional Medical Center*. 69

Figure S1.C.31. Route from Turkey Hill Unit—Richmond NBP to Bon Secours Memorial Regional Medical Center. 70

Figure S1.C.32. Route from Cold Harbor Unit—Richmond NBP to Bon Secours Memorial Regional Medical Center. 71

Figure S1.C.33. Route from Fort Harrison Unit—Richmond NBP to Memorial Regional Hospital. 72

Figure S1.C.34. Route from Malvern Hill Unit—Richmond NBP to Memorial Regional Hospital. 73

Figure S1.C.35. Route from Rural Point Unit—Richmond NBP to Bon Secours Memorial Regional Medical Center. 74

Figure S1.C.36. Route from Sagamore Hill NHS to Syosset Hospital. 75

Figure S1.C.37. Route from Thomas Stone NHS to Civista MedicalCenter. 76

Figure S1.C.38. Route from Valley Forge NHP to Civista MedicalCenter. 77

Figure S7.2. MN DNR—Garmin/ArcMap with Garmin unit GPSmap 60CSX connected. 122

Figure S7.3. DNR Garmin Properties window with projection set to NAD 1983, UTM Zone 18N. 123

Figure S7.4. MN DNR—Garmin/ArcMap with Garmin unit GPSmap 60CSX connected and projection set to NAD 1983, UTM Zone 18N. 123

Figure S7.5. ArcMap screenshot, showing that the GRTS Points layer is active in the Table of Contents. 124

Figure S7.6. Data table in the MN DNR – Garmin/ArcMap application displaying downloaded waypoints. 125

Figure S4.1 TruPulse 360ºR features (© LTI). 130

Figure S4.2. TruPulse 360ºR setup mounted on an LTI non-ferrous tripod with L-bracket mount and bubble level. 130

Figure S4.5. Measurement modes used in forest health monitoring; a) SD - slope distance, b) HD – horizontal distance, c) HD (flashing) + HT – tree height routine, d) AZ – horizontal azimuth, e) INC – inclination (slope angle). 132

Figure S4.6. Tilt Sensor Calibration Routine, steps 1-8. Press "Fire" button at every step, with 1 second pauses between steps. Hold the TruPulse 360ºR on a flat, relatively level surface (+/-15 degrees of level) (© LTI)..... 133

Figure S4.7. Compass Calibration Routine, steps 1-8. Press "Fire" button at every step, with 1 second pauses between steps. Hold the TruPulse 360ºR close to magnetic North (+/- 15 degrees towards North) during the compass calibration routine (© LTI). 134

Figure S4.8. Measurements required for the Tree height routine (© LTI). 136

Figure S6.2. The MIDN plot layout showing square tree plot with three nested 3-m radius microplots, 12 one-m^2 vegetation quadrats, and three 15-m coarse woody debris (CWD) transects..... 157

Figure S6.3. Sequential steps in setting up a forest vegetation monitoring plot in NETN parks. Step number is followed by the distance and azimuth for NHPs in NETN. Distances for ACAD are shown on the second line. Distance measurements are in a horizontal plane, except that steps 2, 6, and 10 are 4 meters slope distance. Bent rebar stakes are installed at plot corners ( ). A rebar stake with a pre-marked survey cap is installed as plot center ( ). Plot midpoints and microplot centers are each marked with a fiberglass stake ( ). Azimuths are relative to the orientation of the plot. 160

Figure S6.4. Sequential steps in setting up a forest vegetation monitoring plot in MIDN parks. Step number is followed by the distance and azimuth for all parks in MIDN. Distance measurements are in a horizontal plane. Azimuths are relative to the orientation of the plot..... 161

Figure S7.2. Bulk File Rename Utility screen 173

Figure S9.2. Measuring DBH on a leaning tree..... 188

Figure S9.3. Measuring DBH on a live windthrown tree. 188

Figure S9.1. Measuring DBH on tree with a curved bole..... 188

Figure S9.4. Measuring DBH on a tree that A) forks above breast-height, and B) measuring DBH on a tree that forks below breast-height..... 189

Figure S9.5. Measuring DBH on A) a tree with a fork that originates below 0.3 m, based on the intersection of the pith, and second fork that originates between 0.3 and 1.37m, B) a tree with a fork that originates above 0.3 m, with a secondary fork that isn't tallied and C) a tree with three forks that intersect at roughly the same place on the stem..... 190

Figure S9.8. Illustration of crown classes in a forest canopy. 192

Figure S11.1. Diagram showing the point of intersection along the transect where diameter of the coarse woody debris is measured. 205

Figure S11.2. Diagram showing how to estimate the longest and shortest axis of the cross-section of coarse woody debris. 207

Figure S12.1. Soil sampling location relative to plot. S1 shows location of soil sample during first visit, S2 shows location of soil sample during second visit, etc. (added the alternate soil sample sites to figure on a trial basis). 212

Figure S13.1. Layout and naming of quadrats in A) NETN parks, and B) MIDN parks. 221

Figure S14.1. Parts of the increment borer. 228

Figure S14.2. Cross section of tree bole to show arrangement of borer along the longest axis (red line). 229

Figure S14.2. Example of a pith locator from Applequist 1958. 232

Tables

Table S1.1. Designated office staff for each network. The forest crew will all be supplied with office staff home and/or cell phone numbers during training. 17

Table S1.B.1. MIDN/NETN Long-term 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. 39

Table S8.1. Preferred browse regeneration species. 177

Table S8.2. Preferred browse herbaceous plant species. 177

Table S10.1. Area in square meters for each microplot cover class breakpoint. 201

Table S13.1. List of targeted herbaceous species measured in the quadrats in MIDN parks. The list is consistent with protocols used by the National Capital Region Network. 224

Table S13.1. List of targeted herbaceous species measured in the quadrats in MIDN parks. The list is consistent with protocols used by the National Capital Region Network (continued). 225

Table S16.1. Buffer radius for neighborhood anthropogenic land use calculations for each park. 238

Table S17.1. Metrics and ratings for evaluating the ecological integrity of forest ecosystems. 243

Table S17.3. Key invasive exotic species of forest, woodland and successional ecosystems in the northeastern U.S. 258

Table S18.1. History of tree condition codes. 287

SOP-1 Safety Procedures

Mid-Atlantic Network/Northeast Temperate Network

Version 1.08

Definitions (alphabetical)

Designated office staff (DOS): Refers to the Inventory and Monitoring (I&M) staff member who is designated to remain in the office and available to provide daily field work plans and emergency response services for the Forest Crew. The default DOS is the protocol lead.

Field team: Refers to the 2-3 person group of forest crew members and other monitoring staff who are working together at a sampling plot. A typical field day consists of 2 field teams who are working at separate forest plot locations.

Forest crew: Refers to the collective team of 3-4 NPS seasonal employees and 1 forest crew leader who conduct the majority of the field work for the forest protocol.

Forest crew leader: Refers to the field team leader for the forest crew. The forest crew leader is responsible for planning and making changes to the daily field work plans, communicating those changes to the DOS and other field team, following daily check-in procedures, and acting as alternative DOS when appropriate (see Daily Communication and Planning).

Monitoring staff: Refers to all personnel engaged in field activities related to this protocol. This includes National Park Service (NPS) employees, contractors, and volunteers either actively participating in or observing monitoring activities. Volunteers are required to have read and signed a Volunteer Agreement and all monitoring staff must read and sign the Job Safety Analysis form before participating in any surveys.

Protocol lead: Refers to the individual responsible for coordinating implementation of the forest protocol (plant ecologist in NETN, and MIDN program manager in MIDN). The protocol lead is the default DOS, unless he/she will be in the field or otherwise unavailable. The protocol lead is responsible for ensuring the forest crew is properly trained in NPS Safety procedures.

Overview

The Northeast Temperate Network (NETN) and the Mid-Atlantic Network (MIDN) consider the occupational health and safety of their employees, cooperators, and volunteers to be of utmost importance, and are committed to ensuring that all monitoring staff receive adequate training on National Park Service (NPS) safety procedures, incident reporting, and emergency response prior to field work. This SOP and supporting appendices were designed to provide a summary of safety issues that should be covered during the pre-season training on long-term forest monitoring protocol, and to serve as a first reference in case of an incident. Topics covered include emergency procedures

and contacts, incident reporting, field preparation, safe field procedures, vehicle safety, and workers compensation procedures. A Job Safety Analysis (JSA), which documents hazards associated with this protocol and recommends approaches to mitigate these hazards, is included as an appendix (Appendix A) to this SOP. The JSA must be read and signed by all monitoring staff who conduct field work for this protocol. In addition to the JSA, members of the forest crew must read the entire Safety SOP, including all appendices. A Green-Amber-Red assessment of risk is included in Appendix B. This SOP does not cover first aid.

Responding to an Incident

Life-Threatening Medical Emergency

1. **Call 9-1-1 or park emergency number. If in an NETN park, use park radios to contact dispatch.** Uninjured, assisting personnel: Administer first aid to the best of your knowledge, ability and training. If appropriate, transport to emergency room. Directions to the nearest hospital from each park are in Appendix C and emergency numbers are in Appendix D. Locations of the nearest hospital to each park have also been programmed into the GPS navigation units that are provided to the forest crew.

2. Uninjured, assisting personnel: As soon as it is practical to do so, inform the protocol lead and the park's emergency contact of the incident (Appendix D).

3. For injured NPS employees and NPS volunteers, complete Worker's Compensation paperwork within 48 hours of incident (Appendix E). For other, non-NPS monitoring staff (i.e., contractors and cooperators), follow your organization's procedures for documenting accidents.

Non-Emergency Incidents

1. For a non-emergency incident that may require medical attention, injured monitoring staff must contact the protocol lead immediately after incident.

2. For injured NPS staff and NPS volunteers, complete Worker's Compensation paperwork (must be done within 48 hours of incident, Appendix E). For contractors and cooperators, follow your organization's procedures for documenting accidents.

3. Injured monitoring staff should seek medical attention, if needed.

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

Field Preparation

All monitoring staff are responsible for maintaining a safe work environment for themselves and their coworkers.

Job Safety

An important tool used to promote safe conduct is the Job Safety Analysis (JSA; sometimes called a Job Hazard Analysis or JHA). This approach is consistent with NPS Directors Order 50 and

Reference Manual 50B for Occupational Health and Safety. The JSA process is to (1) identify hazards associated with field and laboratory settings, as appropriate, and (2) develop approaches to mitigate those hazards. All monitoring staff who conduct field work for this protocol must read and sign the JSA in Appendix A. In addition to the JSA, members of the forest crew must read the entire Safety SOP, including all appendices.

First Aid Kits and Training

Every NETN and MIDN vehicle must have a first aid kit that is to remain with the vehicle at all times. In addition to the vehicle first aid kit, a backpacking first aid kit should be with each field team at all times while in the field. An inventory of first aid kits must be performed prior to each field season by the forest crew leader to ensure that all medical supplies are in sufficient quantity and haven't expired. Each first aid kit will have an inventory list of the supplies it must contain. Items in first aid kits that are used must be promptly replaced.

At the beginning of every field season the forest crew will receive basic first aid and CPR training, if they do not already have current certifications. In addition, permanent I&M staff, including the NETN protocol lead and forest crew leader, who work closely with the forest crew will be certified in Wilderness First Aid.

Daily Communication and Planning

Field teams are expected to carry three modes of communication at all times while in the field. In all parks except ACAD, cell phones are the primary mode of communication. In ACAD, park radios are the primary mode of communication. Procedures for proper use of park radios are detailed in Appendix F. The secondary mode of communication can be a park radio (when not the primary). The third backup mode of communication is a personal locator beacon (PLB) to be used only for emergency situations. All modes of communication must be fully charged and tested at the beginning of each day. For directions on proper use of park radios during normal communications and during emergency situations, refer to Appendix F. To use the PLB, follow the directions on the beacon. For information on routine PLB maintenance, refer to Appendix G.

The forest crew leader must check in with a designated office staff (DOS) at the end of each field day, and forest crew members cannot leave lodging until everyone is accounted for at the end of the day. When the forest crew leader is safely out of the field, but other crew members are not, the crew leader will contact and relieve the DOS of his/her responsibilities. In this case, the crew leader assumes the role of the DOS until all crew members are out of the field. If the crew leader is not able to reach crew members by the 6:30 pm deadline (or other mutually agreed-upon time), the crew leader should contact the program lead and local emergency response personnel. In the event that the forest crew leader is not in the field with the forest crew, then another member of the forest crew must be assigned check-in responsibilities for each day the forest crew leader is absent. The default DOS will be the protocol lead for each network, unless this person is in the field or unavailable (Table S1.1). Backup DOS will be appointed in the order listed in Table S1.1, and should be notified at least 24 hours in advance of when they will be needed. Additional contact information for potential DOS will be provided to the forest crew during the first week of training. All potential DOS will be

provided with a full set of field maps and plot GPS coordinates, forest crew and personal cell numbers, and GSA vehicle information prior to the start of the field season.

If plans for the next field day were not finalized in time for the evening check-in, monitoring staff must check-in with the DOS the next morning. The morning check-in must include which plots each team is visiting and possible backup locations. If plans change, teams must contact each other, and let the DOS know of the change. Evening check-in must occur before 6:00 pm. It is recommended that crew members set an alarm for 5:30 pm to remind them to contact the DOS; likewise, it is also recommended that DOS set an alarm for 6:00 pm as a reminder that a call should be received from the field crew members. If one or more of the field teams are going to be in the field past 6:00 pm, they must contact each other, and the DOS at least 20 minutes before 6:00 pm to set a later check-in time. The preferred method of check-in is by cell phone.

If the forest crew leader does not contact the DOS by 6:00 pm, or one of the field teams has been unaccounted for, the DOS should attempt to contact forest crew members using all possible modes of communication (e.g., forest crew and personal cell phones). If no contact is made by 6:30 pm, the DOS should contact park or local emergency response personnel to inform them of the situation and provide emergency response with the unaccounted for field team's last known location, a vehicle description, and names of monitoring staff involved.

Table S1.1. Designated office staff for each network. The forest crew will all be supplied with office staff home and/or cell phone numbers during training.

Network	Contact	Office	E-mail
NETN	1. Kate Miller	207-288-8736	kathryn_miller@nps.gov
NETN	2. Jim Comiskey	703-258-2145	jim_comiskey@nps.gov
NETN	3. Aaron Weed	802-359-3896	aaron_weed@nps.gov
NETN	4. Adam Kozlowski	802-457-3368 x240	adam_kozlowski@nps.gov
MIDN	1. Jim Comiskey	703-258-2145	jim_comiskey@nps.gov
MIDN	2. Kate Miller	207-288-8736	kathryn_miller@nps.gov
MIDN	3. Nathan Dammeyer	202-380-8370	nathan_dammeyer@nps.gov

Personal Gear

Monitoring staff are responsible for ensuring they are wearing 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 it is recommended that an extra set of clothing be kept in the vehicle. Monitoring staff avoid over-exposure to the sun by wearing sunscreen and/or protective clothing. Monitoring staff should always carry ample water (2-3 liters) and food when working in the field. Dehydration is a serious condition that can lead to more serious conditions if untreated, and must be avoided. It is important to drink liquid frequently to maintain hydration on a warm day, even if you don't feel thirsty.

Field Safety

Slip, Trip, Fall Prevention

Uneven terrain, slippery rocks, dense brush, and fatigue are all hazards that could result in a slip, trip, or fall. The following guidelines must be obeyed by monitoring staff to avoid injury from slips, trips, or falls:

- Always wear appropriate footwear such as sturdy hiking boots
- Pay attention to where you are going, and remain alert of potential hazards
- Walk at an appropriate pace 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 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.

Proper use of Backpacks

Forest crew members are expected to carry ≥ 35-40 pound packs over uneven terrain on a daily basis, and it is important for everyone to understand appropriate ways to pack, lift, and carry a heavy backpack to avoid serious back, neck and shoulder injuries. Monitoring staff must follow these guidelines:

- Use a sturdy field pack with padded and adjustable hip and shoulder straps. Packs will be provided for forest crew members.
- Pack heavy items in the center of the pack and close to your back.
- Make sure weight is evenly distributed from side to side.
- Once equipment is packed, tighten the compression straps to minimize movement inside the pack during travel.
- When picking up a heavy pack, use your legs to do the lifting, 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, and do not swing the pack quickly over one shoulder.
- Always carry a pack with both shoulder straps and with the hip belt and chest straps secured.
- 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.

Weather

Weather conditions in the eastern U.S. can be hazardous and can change quickly. The forest crew leader is responsible for planning their day according to the local weather forecast. Individual field teams are responsible for being aware of their surroundings and changing conditions, and for consulting with the forest crew leader if plans need to change.

Thunderstorms

Storms that produce strong winds and lightning are dangerous and should be avoided in the field. If caught in a lightning storm, seek shelter in a building or car as soon as possible. If no shelter is available, spread out and move to an open space. Squat low to the ground on the balls of your feet with your hands on your knees (do NOT lie flat on the ground). Avoid high elevations, conductive materials, and tall structures such as trees or telephone poles. If you are in the open and feel your hair stand on end (indicating lightning is about to strike), immediately make yourself the smallest target possible and minimize contact with the ground.

NOTE: A person struck by lightning can often be revived by prompt administration of CPR and oxygen.

Excessive Heat and Sun

Over-exposure to heat and sun can cause dehydration, heat exhaustion, or heat stroke. All are serious conditions that can be life threatening, and must be avoided. When working in hot weather, be sure to drink plenty of water and eat foods that can replace electrolytes. Wear loose and light colored clothing, including a hat to block the sun's rays. It may help to shift the field schedule to avoid working outside during the hottest part of the day.

WARNING: Signs of heat stroke include hot, red or spotted (usually dry) skin, and the sufferer may be mentally confused, delirious, having convulsions, or unconscious. If heat stroke is suspected, seek immediate medical attention!

Poor Air Quality

Summer ozone and particulate matter levels occasionally exceed federal health standards. 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 minimal for healthy individuals.

When poor air quality warnings occur, it is advisable for the field teams to avoid overly strenuous activity 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/.

Deer ticks and Lyme Disease

Several species of ticks are commonly encountered in eastern U.S. parks while working in the field (Figure S1.1). This includes the deer tick (*Ixodes scapularis*), which is a known vector of Lyme disease and Ehrlichiosis. Monitoring staff must take the precautions outlined below to help minimize the chances of having an embedded tick that could lead to illness:

- Clothes treated with tick and insect repellents have been found to be fairly effective tick repellant. Therefore monitoring staff will be provided with deet and permethrin and encouraged to treat their clothing with permethrin periodically throughout the summer. Monitoring staff should carefully follow the application instructions on the spray bottles to ensure their safety. Permethrin will remain active for several weeks and through several washings.

- Monitoring staff should take additional precautions to protect themselves from ticks, including tucking pants in socks and tucking in shirts. Long sleeves and gaiters (especially when treated with permethrin) have been found to help. Monitoring staff may consider other barrier devises such as RynoSkin™, Under Armor®, elastic bands, and duct tape, when they are an option.

- Check clothes and skin for ticks regularly throughout the day. Ticks typically need to be embedded for at least 24 hours for disease transmission to occur; therefore, the earlier ticks are found and removed, the lower your chances are of acquiring a tick-borne illness.

- At the end of each field day, remove your clothes and inspect your ENTIRE body thoroughly for ticks. Have a co-worker inspect your back. Place your work clothing in a cloth laundry bag that has been treated with permethrin to keep ticks from escaping into your living quarters or vehicle.

- If you find a tick that is already embedded, use fine-tipped tweezers or a spoon-shaped tick remover to firmly grasp the tick close to your skin (Figure S1.2). Slowly and steadily pull the tick's body away from your skin. Do not twist or jerk the tick, as it may break off the head and leave it embedded. 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. Do not use heat or harsh fluids to get ticks to back out of skin.

- Consider saving the tick for later identification in a small plastic bag or firmly stuck to transparent tape. Tick ID can help in disease diagnosis.

- NPS staff or NPS volunteers who receive a deer tick bite, should fill out a complete record on the tick log. If this is the first tick bite, file a worker's compensation CA-1 claim to get a CA-16. Keep an eye out for any early symptoms of tick-borne diseases, If you start to notice symptoms, use the CA-16 to get medical treatment.

- Be sure to tell the doctor that you had an embedded tick, and that you regularly come in contact with ticks at work. Show the tick, if you saved it.

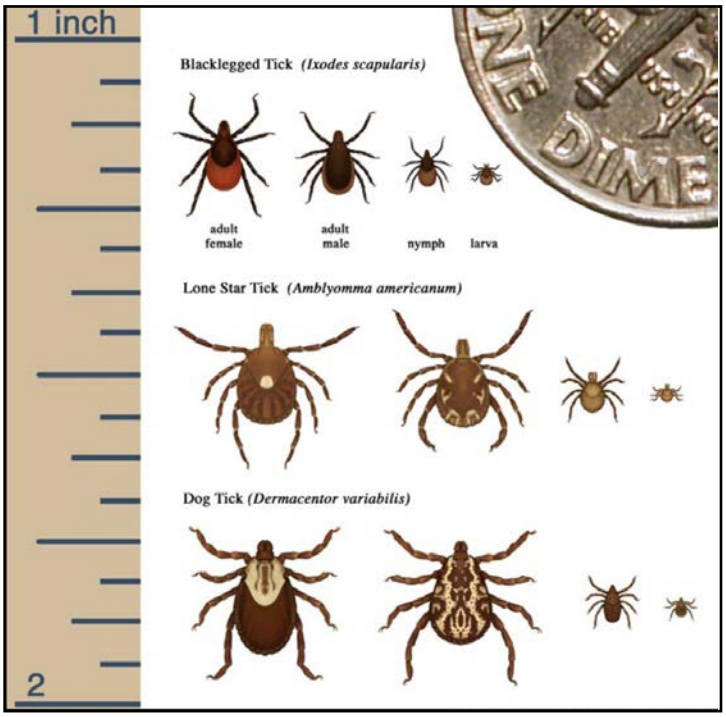


Figure S1.1. Tick species found in the eastern US.

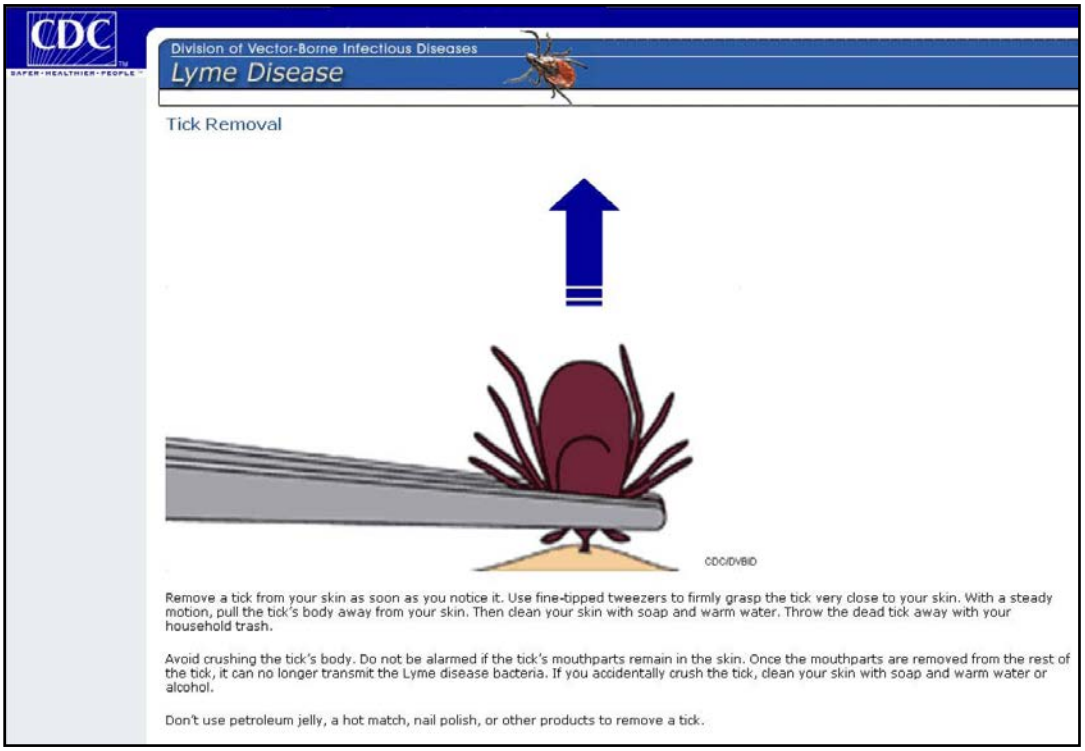


Figure S1.2. Centers for Disease Control recommended procedures for tick removal.

Signs and symptoms of tick-borne diseases:

1. **Lyme disease** symptoms may include a characteristic "bull's-eye" rash that develops a few days or weeks after the tick bite. At the same time, flu-like symptoms such as fever, malaise, fatigue, headache, muscle and joint aches appear. Other symptoms may include tingling or numbness in extremities, a spotted rash on extremities, bad headaches, high fever, joint aches, stiff neck, fatigue, or swollen glands. *Ixodes* ticks are most likely to transmit infection after feeding in skin for two or more days.

2. **Rocky Mountain. Spotted Fever** symptoms include sudden onset of fever, headache, and muscle pain, followed by development of spotted rash at wrists or ankles.

3. **Ehrlichiosis s**ymptoms are similar to Lyme disease, but differ with a rapid on-set of fever and severe headache and the absence of the rash around the tick bite.

4. **Babesiosis:** Most infected people have no symptoms. For those that do, there is a gradual on-set of not feeling well and loss of appetite and fatigue.

5. **Red Meat Allergy** symptoms may include an initial painful, itchy lesion greater than 50mm that lasts at least a week after the tick bite. Within 6 months a severe anaphylactic reaction may occur as much as 3-6 hours after eating beef, pork, or lamb.

Considerations for using repellents containing DEET:

- DEET products have been widely used for many years; these products have occasionally been associated with some adverse reactions. Frequently, reported reactions are about skin or eye irritation. There have been reports of central nervous system problems.

- By using products with lower concentrations of DEET and by applying as little of the product as needed for your outdoor work, you can reduce your expose to DEET.

- Products with about 20 – 30% DEET are considered effective for most insects, but do not seem to be effective against the black-legged or deer tick (*Ixodes scapularis*)

- Generally, products with about 20 – 30% DEET are considered safe for adults (except for those with allergies to DEET products) when applied as directed.

Considerations for using repellents containing permethrin:

- Products containing permethrin are for use on **clothing only – not for use on skin**. If permethrin is used improperly (e.g., sprayed directly on the skin), it can have negative health effects.

- Permethrin kills ticks that come in contact with treated clothing and one application lasts two weeks or more. Do not treat the clothing more than once every two weeks.

- Carefully read and follow manufacturer's instructions for application, and refer to the Material Safety Data Sheet (MSDS) if you have questions.

- Do not apply while clothing is being worn.
- Apply to clothing item in a well-ventilated outdoor area, protected from wind.
- Lightly moisten the fabric with permethrin – do not saturate the fabric.
- Allow clothing item to dry outdoors for at least two hours before wearing (4 hours in humid conditions).
- Keep treated clothes in a separate bag for storage and transport.
- Launder treated clothing separately from other clothing.

More information on Permethrin:
http://www.epa.gov/oppsrrd1/REDs/factsheets/permethrin_fs.htm
http://drugsafetysite.com/permethrin/

Prophylactic (preventative) use of antibiotics:
In addition to treating early stages of Lyme and other tick borne diseases, a new approach involves administering antibiotics to prevent Lyme disease transmission from the deer tick. While evidence is still preliminary, a single dose of antibiotics may reduce chances of Lyme transmission following a deer tick bite if 1) the tick was attached for 24 or more hours, 2) the bite occurred in an area where Lyme disease is common, AND 3) antibiotics can be started with 72 hours (3 days) of the time the tick was removed. It is only after symptoms of Lyme develop that a longer duration of antibiotics should be administered.

A few things to keep in mind about antibiotic therapy:
According to the US Public Health Service, Centers for Disease Control:

1. Every time a person takes antibiotics, sensitive bacteria are killed, but resistant germs may be left to grow and multiply. Repeated and improper uses of antibiotics are primary causes of the increase in drug-resistant bacteria.
2. Misuse of antibiotics jeopardizes the usefulness of essential drugs. Decreasing inappropriate antibiotic use is the best way to control resistance.
3. Antibiotic resistance can cause significant danger and suffering for people who have common infections that once were easily treatable with antibiotics. When antibiotics fail to work, the consequences are longer-lasting illnesses; more doctor visits or extended hospital stays; and the need for more expensive and toxic medications.

More information on Lyme Disease and Ticks:
Center for Disease Control:
http://www.cdc.gov/lyme/ (also a free webinar on tickborne diseases)

American Lyme Disease Foundation:
http://www.aldf.com/

Tick Management Handbook:
http://www.ct.gov/caes/lib/caes/documents/publications/bulletins/b1010.pdf

Poisonous Plants and Animals

Both for safety and protection of park resources, it is never advisable for monitoring staff to eat wild plants while working in a National Park, regardless of their confidence in plant identification. Keep a safe distance from wildlife.

Poison Ivy

Poison ivy (*Toxicodendron* spp.) is present in most NETN and MIDN parks, and can be very abundant in localized areas. Abundance of poison ivy is not a justification for excluding a plot. However, if anyone of the monitoring staff is susceptible to extreme allergic reactions to poison ivy, this person should avoid working in areas infested with poison ivy, and all gear that has been near poison ivy needs to be carefully cleaned. When working in areas with poison ivy, it is advisable that monitoring staff take precautions to 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 amount of skin contact with the plant, and if needed, use poison ivy wipes after contact. Monitoring staff should be careful not to rub their faces when working around poison ivy. After working in an area with abundant poison ivy, monitoring staff should gently wash exposed skin in cool water with the specially provided poison ivy soap, and should change into fresh field clothes. At the end of a field day, the forest crew should also wash potentially contaminated equipment (e.g., quadrat, DBH tape, etc). If anyone has a minor allergic reaction, use the provided cream. If a severe allergic reaction occurs, the affected individual should seek medical attention, notify the protocol lead as soon as possible, and if an NPS employee or NPS Volunteer, file a workers compensation claim.

Venomous Snakes

The following species of venomous snakes may occur in some NETN and most MIDN parks: 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, pay attention to where you put your hands and feet, and be aware around rock piles and bedrock outcrops. Note that many snake bites are purely defensive, and contain no venom. Bites from immature snakes are much more likely to contain a more dangerous amount of venom than bites from adult snakes. Should you receive a snake bite from a potentially poisonous snake, follow the procedure below:

- Treat all bites as if envenomation has occurred.
    - Time is of the essence
    - The field team should assign one person to use the radio or cell phone to call for assistance. This person should identify the call 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.
    - Immobilize the bitten limb firmly with a splinted elastic (Ace) bandage and get the victim out of the woods and to a hospital as quickly as possible.
    - **Do not** use thin circulation restrictive cords, pack with ice for long periods (more than five minutes) or attempt to cut open or otherwise enlarge the fang punctures.
- Reassure the victim that they will be OK and otherwise attempt to maintain the calm both for the victim and for all others involved.
    - In a field team situation, begin leading the victim slowly out of the woods as soon as the bitten limb has been immobilized. **Move as slow as necessary to maintain a normal heart rate for the victim.** Waiting for assistance will only prolong the process of getting proper medical treatment.
    - In a solitary situation, establish radio contact and relay the necessary information as you walk slowly out of the woods. Focus on remaining calm and maintaining a normal heart rate.
    - It is better to spend your available time getting to proper medical treatment facilities than it is to fumble with field therapy and wait for assistance to reach you.

The range of the copperhead covers all MIDN parks, and the following NETN parks: Morristown NHP (MORR), Roosevelt Vanderbilt NHS (ROVA), Saratoga NHP (SARA) and Weir Farm NHS (WEFA). The likelihood of encountering a copperhead is low in NETN parks, but higher in MIDN parks, where the species is listed by NatureServe as “apparently secure” across the MIDN. Copperhead bites are not typically considered life threatening, and in most cases antivenin is not administered.

The range of the cottonmouth only covers the Southeastern corner of Virginia, and is listed by NatureServe as “vulnerable” (S3). Parks where this species may occur include Richmond NBP (RICH) and Petersburg NB (PETE). Cottonmouth bites that are defensive typically do not contain venom. However, cottonmouth bites are capable of delivering a lethal dose.

The range of the timber rattlesnake covers all MIDN and NETN parks except Acadia NP (ACAD). This species is listed by NatureServe as “critically imperiled” (S1: New Hampshire, Vermont, Massachusetts, and Connecticut) or “vulnerable” (S3: New York, Pennsylvania) throughout NETN, and the likelihood of encountering a timber rattlesnake in NETN parks is very low. The timber rattlesnake is more likely to occur in the MIDN parks located in Virginia such as, Appomattox Courthouse NHP (APPO), Booker T. Washington NM (BOWA), Fredericksburg and Spotsylvania NMP (FRSP), PETE, and RICH, where the species is listed as “apparently secure” (S4). Adult timber rattlesnakes are capable of delivering a lethal dose of venom.

Bees, Wasps, and Yellow Jackets

If any monitoring staff are allergic to bee stings, they should alert the forest crew leader and protocol lead and make sure to carry appropriate medications. If they carry an epinephrine injector, they should make sure all members of their field team know where it is carried and how to administer it. 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 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.

Black Bears

Black bears range throughout the Northeast and Mid-Atlantic states, but an encounter with a bear in the field is not likely since bears generally avoid people. 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 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 bear begins to attack, fight back aggressively.

Vehicle Safety

Responsibilities of NPS Vehicle Operators

Field teams are responsible for inspecting their vehicles before every use to ensure the vehicles are in safe working condition. This includes visually checking tire pressure, adjusting mirrors, and making sure equipment is secure. Field teams must perform preventative maintenance in a timely manner (e.g., having oil changed by a qualified mechanic), and report any potential hazards or needed repairs to the protocol lead.

Rules that must be followed when operating an NPS vehicle:

- Everyone in a government vehicle is required to wear a seat belt.
- Use of cell phone (both talking and texting) is strictly prohibited while driving.
- Only NPS employees or authorized volunteers, cooperators and contractors are allowed to operate a government vehicle.
- Passengers who are not NPS employees or authorized volunteers, cooperators and contractors are forbidden from riding in a government vehicle.
- Drivers must adhere to all federal and state vehicle regulations, including all posted speed limits.

Because government vehicles are self-insured, damage resulting from government vehicle accidents are generally paid by the driver's program (e.g., NETN or MIDN). However, in cases of severe negligence, the driver found at fault for the accident may be personally liable.

GSA Rental Information

Preventative maintenance records are monitored by GSA Fleet. When a service is required, the contact person for the rental (likely the protocol lead) will receive an e-mail that identifies the maintenance service required and when the vehicle is due for that service. Field teams must have requested services performed promptly after the notification.

If the GSA rental breaks down or requires immediate maintenance, consult the information on GSA roadside assistance (GSA Quick Facts) in the glove compartment of the vehicle on how to proceed.

Procedures for reporting a motor vehicle accident

In the event of an automobile accident, a copy of this SOP (including all appendices) must be in every NPS and GSA vehicle at all times. Note that some procedures are different if vehicles are National Park Service (NPS) owned versus Government Services Administration (GSA) owned. Therefore GSA vehicles must also have a GSA Motor Vehicle Accident Reporting Kit (GSA Form 1627) in the glove compartment.

In case of an automobile accident in a **GSA-owned vehicle**, locate the GSA Motor Vehicle Accident Reporting Kit (GSA Form 1627) in the glove compartment, and follow the instructions therein. Also contact Duane Vallee at 603-666-7955 for NETN rental vehicles, and Darrell Thompson at 804-279-6800 for MIDN rental vehicles.

In the event of an automobile accident in an **NPS-owned** vehicle, follow the procedures listed in **Appendix H** to respond to the accident, follow the NER guidelines for reporting an accident (Appendix I), and complete the corresponding forms (SF-91 and SF-94) in Appendix J. Note that this SOP and corresponding appendices address Federal guidelines and requirements for accident reporting only. Cooperators and contractors may have additional reporting requirements.

Contact Information

Northeast Temperate Network:
Kate Miller
Acadia National Park
PO Box 177 Eagle Lake Road
Bar Harbor, ME 04605
work: (207) 288-8736
e-mail: kathryn_miller@nps.gov

Mid-Atlantic Network:
Jim Comiskey
Fredericksburg & Spotsylvania NMP
120 Chatham Lane
Fredericksburg, VA 22405
work: (703) 258-2145
e-mail: jim_comiskey@nps.gov

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.

Appendix S1. A. Job Safety Analysis for the long-term forest monitoring protocol.

JOB SAFETY ANALYSIS: General Field Work Travel to, from, and within parks	**JOB TITLE:** Field Crew Members **DEPARTMENT:** Northeast Temperate Network and Mid-Atlantic Network **ANALYSIS BY:** Kate M. Miller, NETN Plant Ecologist	☒ **NEW** ☐ **REVISED** ☒ **REVIEWED** Brian R Mitchell, NETN Program Manager

Required and/or Recommended Personal Protective Equipment:

Required: Two modes of communication (e.g., radio and cell phone), first aid kit, driver's license, and poison ivy soil (e.g., tecnu).

Recommended as appropriate: rain gear, condition-appropriate footwear and clothing (preferably treated with permethrin), hat, safety glasses, and sufficient food and water.

Tasks	Potential Hazards	Recommended Action or Procedure
Planning and Communication	Not being prepared and following plan/itinerary. Communication breakdowns.	• Plan ahead. Know where you and each crew member will be going, particular hazards associated with travel routes, and sites to be visited that day. Check expected weather and stream conditions for day and sites to be visited. • Understand itinerary of planned trip and follow carefully. Coordinate drop-off and pick-up times (or return times) and locations precisely. • Check in with Designated Office Staff (DOS) prior to field work with a trip plan, and after field work to confirm crew safety. If return will be delayed, contact DOS before agreed-upon check-in time to establish a new check-in time. Always carry two methods of communication with full charges. • Inform park staff when you are working in their park.
Emergency Preparedness	Not knowing emergency procedures. Not having emergency supplies.	• Know who to contact and how to reach them in the event of a life-threatening or non-life-threatening emergency. • Have current CPR and first aid certification, and know the certification status of co-workers. • Keep a well-maintained first aid kit in each vehicle and with each field team.

Appendix S1. A. Job Safety Analysis for the long-term forest monitoring protocol (continued).

Tasks	Potential Hazards	Recommended Action or Procedure
General foot travel	Falling or tripping due to stream crossings, wading, 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 especially stream wading. Stay aware of your feet. Address blisters and hot spots promptly. • Avoid carrying excessive weight loads or unbalanced loads. • When walking on a steep slope, lean upslope. Ensure that stems and vines are alive and can support your weight before relying on them. • Use extreme caution traversing wet rocks, streams, steep slopes or blowdown areas. If crossing a stream, proceed cautiously, testing footing carefully and using a sturdy pole or walking stick for balance.
Working outdoors during	Being struck by falling trees or branches	• Listen to the weather forecast each morning (park radio and/or internet). • Plan or adjust field work to avoid being out in thunderstorms. • 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. • If you can't get inside and if you feel your hair stand on end, lightning is about to strike. • Make yourself the smallest target possible and minimize contact with the ground. • Crouch down on your pack on the balls of your feet and keep your feet close together. Place your hands on your knees and lower your head. • During a thunderstorm members of the crew should stay separated by at least ten 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 after working in areas with poison ivy.

Appendix S1. A. Job Safety Analysis for the long-term forest monitoring protocol (continued).

Tasks	Potential Hazards	Recommended Action or Procedure
Working in bear territory	Black bear encounter	• Avoid working solo, if possible. • 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 but do not make eye contact, continually make noise – do not freeze or remain silent. • Appear larger by standing tall, waving arms or jacket over your head. • Slowly back away – don't approach a bear. • Never run from a bear. • If bear charges, throw things and shout loudly. • If bear attacks, 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 or anyone you are working with is known to have allergic reactions to be stings, tell the rest of the crew and your supervisor. Make sure you carry emergency medication with you at all times, and that your co-workers know where you keep it. • Wear long sleeve shirts and pants, tuck in shirt. Bright colors and metal objects may attract bees or wasps. • If you are stung, a cold compress may bring relief. • If stinger is left behind, scrape it off of skin. Do not use tweezer 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, no-see-ums, and chiggers	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. Do not apply Permethrin, Permanone, or greater than 30% DEET directly to skin, only to clothing. • Carry after-bite medication to reduce skin irritation.

Appendix S1. A. Job Safety Analysis for the long-term forest monitoring protocol (continued).

Tasks	Potential Hazards	Recommended Action or Procedure
Poisonous snakes	Being bitten by a poisonous snake	• Wear snake gaiters when in known snake territories. • 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 evonomation has occurred. • Immobilize the bitten area and keep it lower than the heart. • Apply a bandage, wrapped two to four inches above the bite, to help slow the venom. This should **not** cut off the flow of blood from a vein or artery – the band should be loose enough to slip a finger under it. • Remove rings, watches, shoes, etc. before swelling begins in earnest. • Seek medical attention immediately and/or call for help. Remain calm. • Rattlesnake bites are more likely to be life-threatening.
Ticks	Contracting diseases transmitted from ticks	• Use tick avoidance precautions, including pre-treating clothing with permethrin, tucking pants into socks and shirt into pants. Avoid sitting directly on the ground, especially in leaf litter, and check packs for ticks before putting them on. • Wear clothes (including pants and long-sleeved shirts) that are l light colored and check for ticks on clothing periodically throughout the day. • 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.
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 at you.
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.

Appendix S1. A. Job Safety Analysis for the long-term forest monitoring protocol (continued).

Tasks	Potential Hazards	Recommended Action or Procedure
Hazard trees	Being struck by falling trees or branches.	1. Take adequate garments for all possible weather conditions. Choose clothing that will keep you warm even if it gets wet. 2. Look up. Be alert for widow-makers, storm damaged trees with large broken limbs, and unstable standing dead trees. 3. Do not spend extended time in an area with hazard trees. 4. Do not attempt to tag or measure unstable snags.
High water stream crossings	Injuries from falling and/or drowning	1. Thoroughly investigate area to find safest crossings 2. Wear appropriate foot gear for stream crossings. 3. It is safer to wade through high water, rather than rock hop across a stream trying to keep your boots dry. 1. Unbuckle your pack and be prepared to jettison gear should you lose your balance or fall in. 2. Use a sturdy pole or walking stick for balance.
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.

Appendix S1. A. Job Safety Analysis for the long-term forest monitoring protocol (continued).

Tasks	Potential Hazards	Recommended Action or Procedure
General operation of a vehicle	Injuries from vehicle accident; Damage to vehicle	• Perform pre-operational check of vehicle (oil, tire pressure, tire condition, fluids, wipers, brakes, lights, gas, etc.). Report all needed repairs to the crew leader or supervisor promptly. • Do not use the vehicle if it is unsafe. • Wear seat belts with shoulder harnesses whenever vehicle is in motion. (E.O. 13043 4-16-97) • Do not use cell phones or text while driving. • Only NPS employees, volunteers, or authorized cooperators and contractors are allowed to operate or ride in a government vehicle. • Ensure full visibility from all windows and mirrors. Clean windshield regularly. • Always ride inside the vehicle. • Properly store and secure all tools, equipment, and cargo so that they will not shift during sudden starts or stops. • Plan your travel before you start. Know your route. • Practice defensive driving; be alert to potential hazards. • Obey all traffic laws and speed limits. • Adjust speed to changing weather or traffic conditions • Allow adequate following/stopping distance. • Avoid distractions such as eating or adjusting navigation/GPS units while driving. • Be alert for pedestrians or bicyclists using roadways. • Be watchful for wildlife crossing roads, especially at early morning, dusk, and after dark. • Do NOT drive if fatigued. Stay alert!
Driving on gravel, dirt, or un-maintained roads	Injuries from vehicle accident; Damage to vehicle	• Maintain a slow and safe speed for changing road conditions, such as loose gravel, large potholes, washed out road, fallen trees or rocks, etc. • Be alert on narrow roads for oncoming vehicles and log trucks. Be prepared to slow down, pull over, or stop with little notice. • Many roads require 4-wheel drive and/or high-clearance vehicles for safe passage. Use the appropriate vehicle for the terrain. • Do not exceed the capacity of your vehicle or driving ability. When in doubt, turn around or back out. Use spotters to assist in navigating obstacles and assessing water depth at stream crossings.

Mid-Atlantic Network /Northeast Temperate Network

Please sign your name below to certify that you have read the Job Hazard Analysis and fully understand the Safety Standard Operating Procedures for the MIDN/NETN long-term forest monitoring protocol.

Print Name:_____ Signature:_____ Date:_____

Print Name:_____ Signature:_____ Date:_____

Print Name:_____ Signature:_____ Date:_____

Print Name:_____ Signature:_____ Date:_____

Print Name:_____ Signature:_____ Date:_____

Print Name:_____ Signature:_____ Date:_____

Print Name:_____ Signature:_____ Date:_____

Print Name:_____ Signature:_____ Date:_____

Print Name:_____ Signature:_____ Date:_____

Appendix S1.B. Green-Amber-Red Risk Assessment.

This appendix 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 NETN Long-term Forest Monitoring Protocol. This GAR was adapted from the NETN Rocky Intertidal Monitoring Protocol by NETN Plant Ecologist (Kate Miller) on 21 March 2012, and approved by the NPS Northeast Region I&M Program Manager (John Karish) on 29 March 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 NETN Long-term 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.

The GAR is a seven step process. Each step is defined and explained in the context of the NETN Long-term Forest Monitoring Protocol below.

Step 1: Define the Mission or Task

The NETN Long-term Forest Monitoring Protocol includes a field-based monitoring activity: sampling permanent forest plots. Monitoring staff are part of a team, and may work in multiple pairs when conducting the monitoring activities. The activity is conducted away from roads and trails, has been limited to locations with lower slopes (<30%). Potential safety hazards (along with mitigation measures) have been identified in a Job Safety Analysis (JSA; Appendix C). Of specific concern is that monitoring staff will regularly be working in fairly remote areas with limited communication options in the event of an emergency. A serious injury due to walking through thick brush or a trip and fall while traversing uneven or steep terrain are both possible and are the most significant risks 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 (Appendix A).

Step 3: Assess Risk and Assign a Numerical Value

The numerical ranks (Table S1.B.1) were assigned by Kate Miller, the NETN Plant Ecologist, and the NPS project leader for the NETN Long-term Forest Monitoring Protocol. NETN and MIDN staff reviewed the ratings and analysis and their suggestions were incorporated. It should be noted that at the time numerical values were assigned (21 March, 2012) the protocol had been in operation for six years and considerable time and effort had already gone into evaluating and mitigating risks.

The GAR process is described in 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 event or evolution.

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 is team discussions leading to an understanding of the risks and how they will be managed.

Table S1.B.1. MIDN/NETN Long-term 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	3
Planning	2
Communication	2
Contingency Resources	3
Team Selection	2
Team Fitness	4
Environment	6
Event/Evolution Complexity	6
Total Risk Score	28

Step 4: Identify Risk Control Options

Supervision

The MIDN/NETN Long-term Forest Monitoring Protocol clearly identifies personnel, roles and responsibilities, and a chain of command. The NETN Plant Ecologist is the supervisor in NETN and the MIDN Program Manager is the supervisor in MIDN. The supervisor is either in the field with one of the teams or is available to answer questions from monitoring staff. The Forest Crew Leader is the field coordinator, and is in the field with one of the field teams at all times. Monitoring staff will always work in teams of 2 or more, and will never work alone. Monitoring staff are required to follow check-in and check-out procedures as stated in this SOP. A score of 3 was assigned because there is often one team working without a Forest Crew Leader or supervisor. However teams maintain strong lines of communication and are always aware of the locations each team is working.

Planning

The MIDN/NETN Long-term Forest Monitoring Protocol includes numerous SOPs that explain training, personal safety, emergency communication (equipment and contacts), and appropriate field activities. Monitoring staff are required to read the field SOPs during training week, and this includes a detailed Safety SOP, which they must sign in acknowledgement that they have read and understood the SOP. Monitoring staff receive first aid and CPR training during training week, if they are not already certified. In addition, permanent monitoring staff who work closely with the crew and the Forest Crew Leader receive more extensive first aid and safety training. Daily sampling plans are agreed upon by both field teams at the beginning of the day, and these plans are provided to a designated office staff member who has copies of field maps for each park. Due to this advance planning, written documentation, and training procedures, a low score (2) was assigned.

Communication

Routine and emergency communication procedures are explained in the relevant SOPs, and monitoring staff are provided with the full SOP and laminated field note cards that cover

procedures and list contact information specific to each park. The procedures include coordination with park natural resource managers and other designated park staff. The Safety SOP also includes a daily check-out/check-in procedure that is required for monitoring staff to follow to ensure that a responsible party knows if someone has not returned from the field activity in a timely manner. Each field team is provided multiple modes of communication to ensure good communication between field teams. Due to this advance planning, written documentation, training procedures and multiple forms of communication, a low score (2) was assigned.

Contingency Resources

Contingency resources include communication equipment and procedures that explicitly involve park rangers, park dispatch, and 9-1-1. Monitoring staff are required to carry at least 3 of the provided modes of communication: 1) NPS issue cell phone pre-programmed with emergency contacts for each park, 2) a park radio with park frequencies and a direct NETN radio frequency, 3) SPOT messenger and 4) a personal locator beacon (PLB). In parks with poor cell coverage (ACAD), a cell phone does not count as one of the 3 modes of communication. With the PLB and SPOT Messenger, notification of emergency services should happen within minutes of an incident, but emergency services may not be able to reach the crew quickly due to the remoteness of some sites. A score of 3 was assigned instead of a lower score because of the potential delay before emergency services could reach the crew.

Team Selection

The monitoring protocol clearly identifies the essential skills and abilities required to execute this protocol in a competent manner. Prior field experience is strongly preferred for team members. Team members also attend a week long training the covers sampling and safety procedures in detail, and is prior to sampling. All team members will have basic first aid and CPR skills, and will receive first aid and CPR training during the first week of forest crew training if they do not have these skills. Team members who are less experienced are paired with a more experienced team member until they are sufficiently trained. Due to the strong preference for hiring experienced team members, and extensive pre-season training, a score of 2 was assigned.

Team Fitness

Team selection should ensure an overall high level of initial team fitness. Monitoring staff are in the field for long hours (averaging 10 hour days) and may be required to hike several miles over rough terrain and work in harsh weather conditions (i.e., high heat/humidity, cool and rainy). Team members are instructed to carry sufficient food and water, rain gear, and to be aware of the weather forecast. Team members are also given the option to adjust their schedule during heat waves so they are not working during the hottest part of the day. A score of 4 was assigned because the field days are long and the work can be strenuous. Monitoring staff must be diligent about adequate rest and nourishment to ensure that fatigue does not become a factor.

Environment

Environment was assigned a medium score (6) primarily because the work often involves activities in dense foliage away from trails, on uneven and occasionally steep terrain, and unexpected

encounters with dangerous wildlife (e.g., black bears, venomous snakes, etc.) are possible. Activities occur during a variety of weather conditions, but are cancelled by thunderstorms and high winds.

Incident Complexity

Incident complexity was also assigned a medium score (6) because daily field conditions change due to weather, and terrain can be highly variable. Individual monitoring staff must use judgment and experience to respond appropriately, and should involve the NETN Forest Crew Leader or the NETN Plant Ecologist in any decision where there is uncertainty.

Step 5: Evaluate Risk vs. Gain

The NETN Program Manager has determined that the activity, if carried out in accordance with all SOPs, has an acceptable level of risk.

Step 6: Execute Decision

The decision made by the NETN Plant Ecologist is to conduct the activity in accordance with NETN Long-term Forest Monitoring Protocol Standard Operating Procedures (SOPs).

Step 7: Supervise – Watch for Change

The NETN Plant Ecologist continually solicits feedback from the contractor and NPS staff on safe execution of the protocol including risk control options not considered thus far.

Appendix S1.C. Directions to nearest hospital from each park, separated by network.

Northeast Temperate Network

Acadia National Park– Headquarters

Directions to nearest hospital start at the **Headquarters building** (A) in Acadia National Park and end at the **Mount Desert Island Hospital** (B) in Bar Harbor, Maine. Destination is 1.6 miles and **five minutes** away.

Phone Number: (207) 288-5081.

Location: 10 Wayman Lane, Bar Harbor, ME 04609

Directions:

1. Head East (turn right) on Eagle Lake Road/ ME- 233 toward Arata Drive. Continue to follow ME-233 for 1.3 miles

2. ME-233 turns right and becomes Main St./ ME -3. Continue for 0.2 miles.

3. Turn left at Wayman Ln. MDI Hospital will be on the left (115 ft).

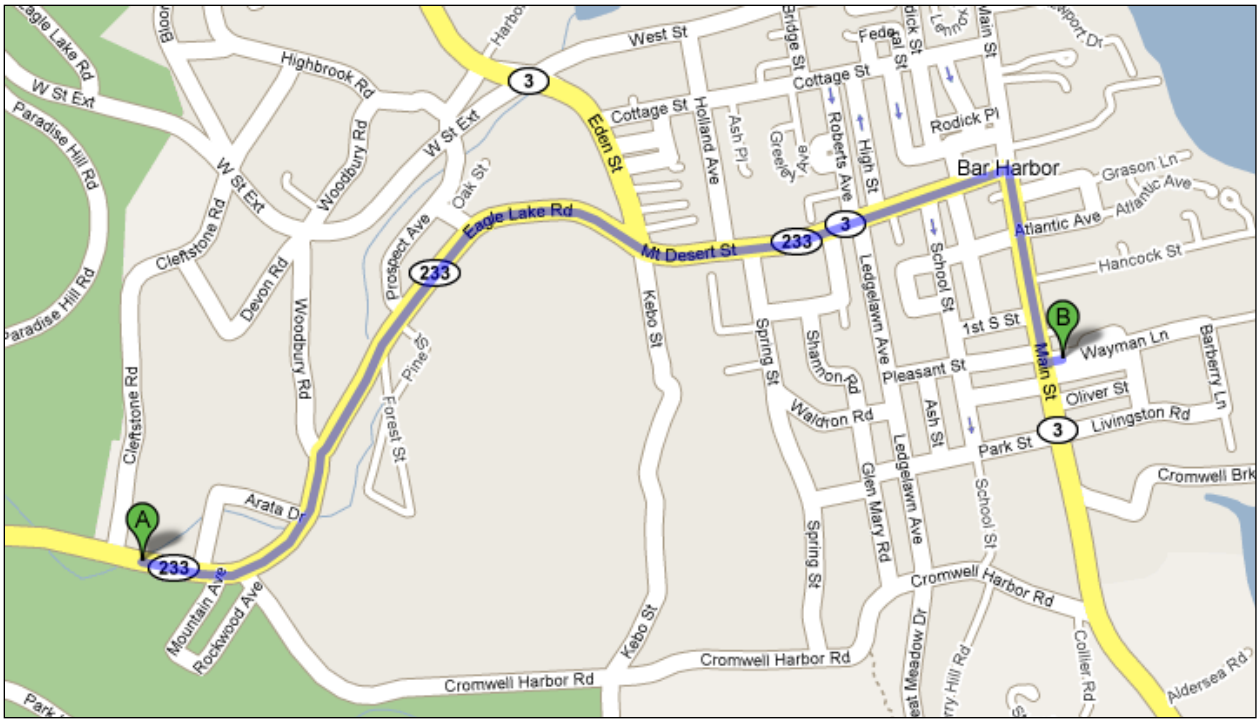


Figure S1.C.1. The route from Acadia NP Headquarters to the Mount Desert Island Hospital in Bar Harbor, Maine.

Acadia National Park– Seawall

Directions to nearest health clinic start at the **Seawall Park Housing** (A) in Acadia National Park and end at the **Community Health Center** (B) in Southwest Harbor, Maine. This clinic has been good for treating Lyme disease, but does not have emergency services. Destination is 2.3 miles and **four minutes** away.

Phone Number: (207) 244-5630.

Location: 9 Village Green Way, Southwest Harbor, ME 04679

Directions:

1. Head east on ME-102 Alt N/Seawall Road toward Seascape Ln for 2.2 miles.

2. Turn right onto ME-102 N/ Main St. and go 0.7 mi.

3. Turn left onto Village Green Way and go 0.1 mi. Community Health Clinic is at 9 Village Green Way.

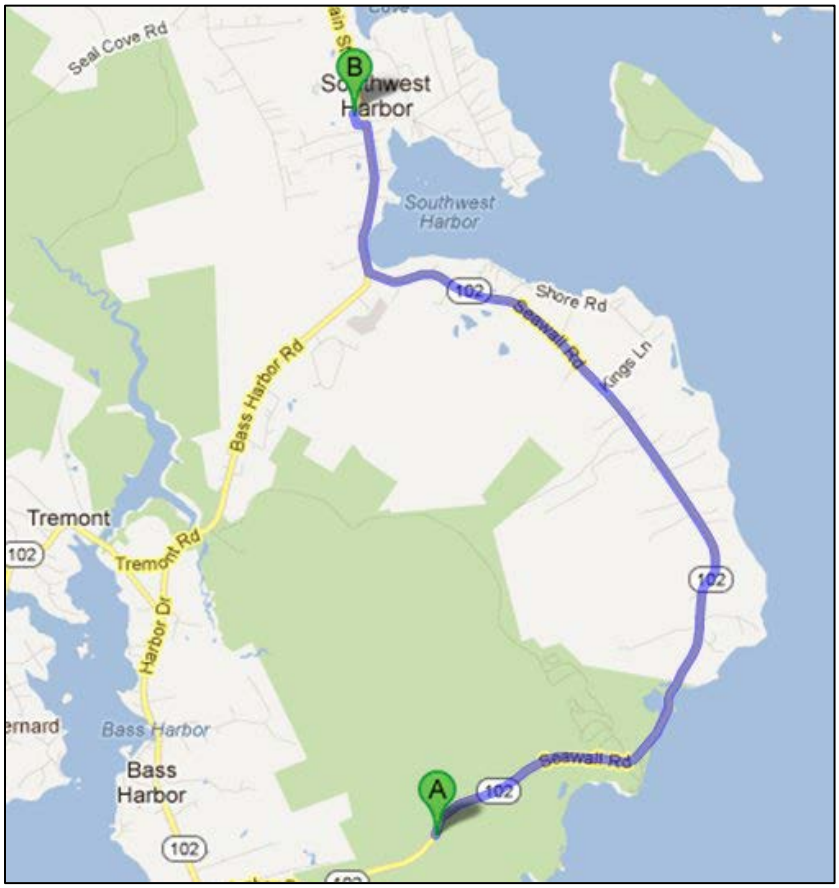


Figure S1.C.2. The route from Seawall Campground (A) to the Community Health Center (B) in Southwest Harbor, Maine.

Acadia National Park– Schoodic

Directions to nearest health clinic start at the **Schoodic Education and Research Center Entrance** (A) in Acadia National Park and end at the **Eleanor Eidener Dixon Memorial Clinic** (B) in Gouldsboro, Maine. Destination is 11.5 miles and **24 minutes** away.

Phone Number: (207) 963-4066.
Location: 37 Clinic Road, Gouldsboro, ME 04607
Directions:

1. Head south out of parking lot and go about 240 feet.

2. Take the 1st left and go 0.1 miles.

3. Turn left toward Moore Rd and follow 3.3 miles.

4. Continue straight onto Moore Rd for 1.5 miles.

5. Turn left onto ME-186 W/Main St and proceed 0.6 miles.

6. Turn right onto ME-186 W/Newman St and follow for 6.0 miles.

7. Continue onto Clinic Rd and go 0.1 miles. Clinic will be on the left.

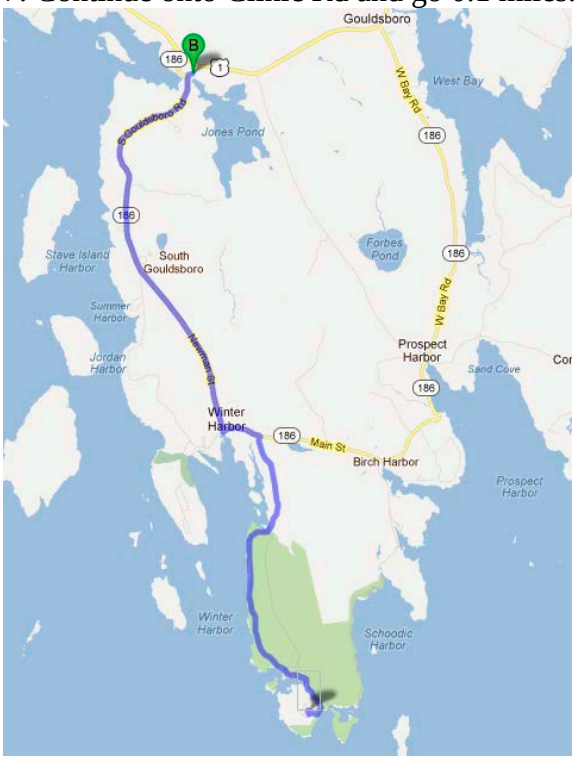


Figure S1.C.3. The route from Schoodic Education and Research Center (A) in Acadia National Park to Eleanor Widener Dixon Memorial Clinic (B) in Gouldsboro, Maine.

Marsh-Billings-Rockefeller National Historical Park

The nearest hospital to Woodstock, Vermont is Dartmouth Hitchcock Medical Center (DHMC) in Lebanon, New Hampshire, and is about 22 miles and **31 minutes away**. Directions to nearest hospital start at the **Billings Farm parking lot** (A) in Woodstock, Vermont and end at the **Dartmouth Hitchcock Medical Center** (B) in Lebanon, New Hampshire:

Phone Number: (603) 650-5000
Location: 1 Medical Center Drive, Lebanon, NH.

Directions:

1. From the Billings-Farm parking lot, turn left at the Y onto Elm Street/ VT-12. Continue for 0.4 miles.

2. Turn left at Pleasant St./ VT-12. Continue for 0.6 miles.

3. Turn left at US-4/VT-12/Woodstock Rd. Continue to follow US-4 for 9.4 miles.

4. Turn right and go 0.1 miles.

5. Take the ramp onto 1-89 South and go 8.1 miles.

6. Take exit 18 for NH-120 toward Hanover and go 0.2 miles.

7. Turn left at Centerra Pkwy/Lahaye Drive and continue on Lahaye Drive for 0.5 miles.

8. Turn right at the Hitchcock Loop Road/ Medical Center Drive and continue for 0.3 miles.

9. Turn left at DHMC East Entrance, and turn right to stay on DHMC East Entrance.

Figure S1.C.4. Route from Marsh-Billings-Rockefeller NHP in Woodstock, Vermont to Dartmouth Hitchcock Hospital in Lebanon, New Hampshire.

Minute Man National Historical Park

Directions to nearest hospital start at the **Brooks Village parking lot** (A) on 2A (N Great Road) in Minute Man National Historical Park, and end at **Emerson Hospital**. Destination is 3.9 miles and about **8 minutes** away:

Phone Number: (978) 369-1400
Location: 133 Old Road to 9 Acre Corner, Concord, MA 01742.
Directions:

1. Head west on Massachusetts 2A W/N Great Road/ Lexington Rd. toward Brooks Road. Continue for 3.8 miles.

2. Turn left onto Old Road to 9 Acre Corner. Destination will be on left side of road.

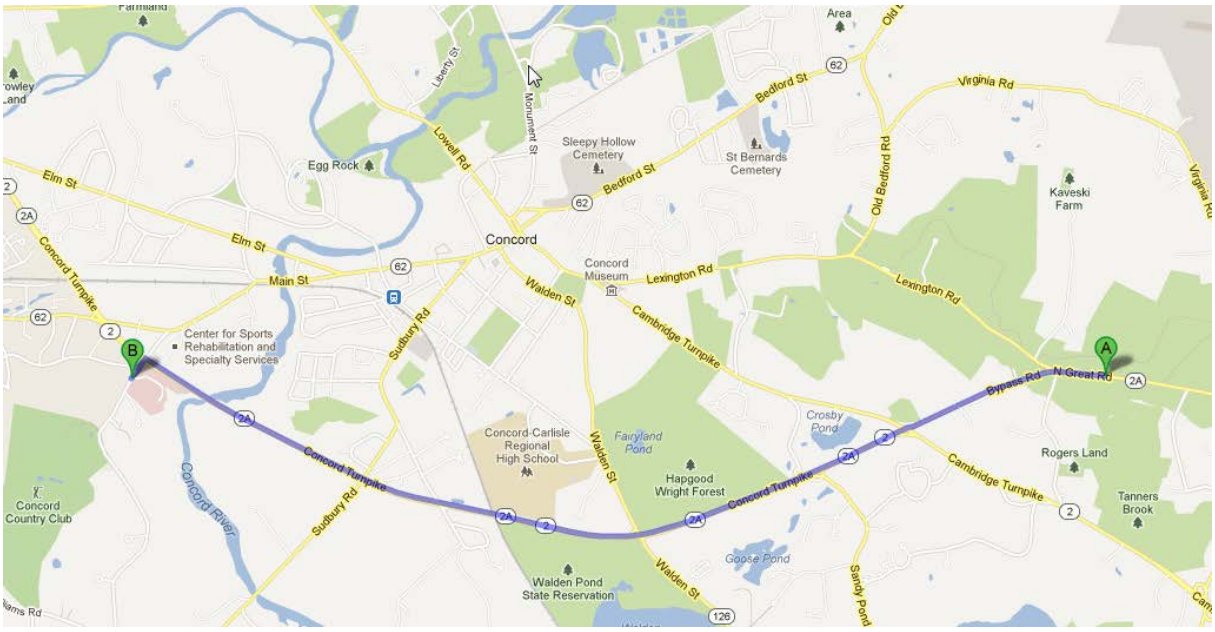


Figure S1.C.5. Route from Minute Man NHP Brooks Village parking lot in Concord, Massachusetts to Emerson Hospital, also in Concord.

Morristown National Historical Park

Directions to nearest hospital start at the **Jockey Hollow Visitor Center** (A) in Morristown National Historical Park, and end at **Morristown Memorial Hospital** (B). Destination is 6.5 miles and about **18 minutes** away:

Phone Number: (973) 971-5000.
Location: 100 Madison Ave, Morristown, NJ 07962.

Directions:

1. Head northwest on Cemetary Rd. toward Sugarloaf Rd. Continue 1.2 miles.

2. Turn left at Sugarloaf Rd. Continue 1.3 miles

3. Turn left on Jockey Hollow Rd. Continue 0.8 miles

4. Continue on Western Ave. Continue 1.9 miles.

5. Turn right on NJ-124/ Washington St. Continue 0.2 miles.

6. Continue on NJ-124/ South St. for 0.7 miles.

7. Turn slight left at Madison Ave/ NJ-53. Continue 0.5 miles. Destination is on the left.

Figure S1.C.6. Route from Morristorn NHP Jockey Hollow Visitor Center to the Morristown Memorial Hospital, both in Morristown, New Jersey.

Roosevelt-Vanderbilt National Historic Sites (ELRO, HOFR, VAMA)

Directions to nearest hospital start at the **Visitor Center parking lot** (A) at the Home of FDR National Historic Site**,** and end at **St. Francis Hospital** (B). Destination is 4.8 miles and about **9 minutes** away:

Phone Number: (845) 483-5000.
Location: 241 North Road, Poughkeepsie, NY 12601.

Directions:

1. Head south on Albany Post Rd./ Rte-9/ US-9 toward Kessler Dr. Continue for 3.7 miles.

2. Turn left onto Delafield St. Continue for 0.2 miles.

3. Turn left onto Spruce St. Continue for 308 ft.

4. Spruce St. turns right and becomes Talmadge St. Continue for 0.2 miles.

5. Turn left at NY-9G/ Washington St. Continue for 0.4 miles.

6. Destination is on the right side of Washington St.

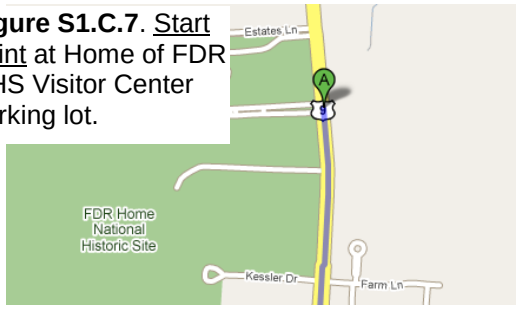


Figure S1.C.7. Start point at Home of FDR NHS Visitor Center parking lot.

Figure S1.C.8. End point at St. Francis Hospital.

Figure S1.C.9. The entire route.

Saint-Gaudens National Historic Site (Option 1)

Directions to nearest hospital start at the **Visitor Center parking lot** (A) at Saint-Gaudens National Historic Site**,** and end at **Mount Ascutney Hospital** (B). Destination is 3.8 miles and about **10 minutes** away:

Phone Number: (802) 674-6711.
Location: 289 County Road, Windsor, VT 05089.

Directions:

1. Head southwest on St. Gaudens Rd. toward NH-12A/ NH Rte 12A/ Wilson Rd. Continue for 0.6 miles.

2. Take a slight left at NH-12A/ NH Rte 12A/ Wilson Rd, and continue for 1.5 miles.

3. Turn right onto Bridge St. and continue for 0.3 miles.

4. Turn left on State St. and go 0.7 miles.

5. Turn right at County Rd. and go 0.3 miles.

6. Destination is on the left side of County Rd.

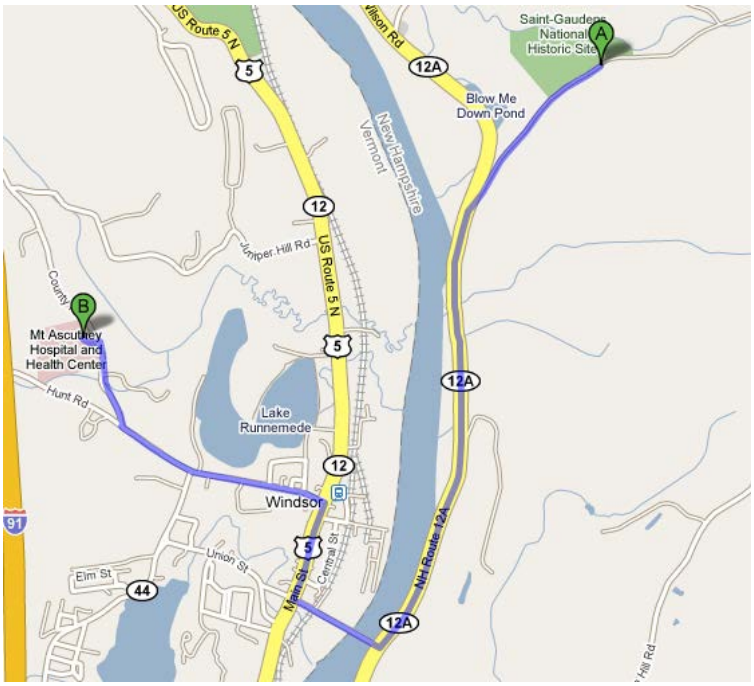


Figure S1.C.10. Option 1 route from Saint-Gaudens NHS Visitor Center parking lot to Mount Ascutney Hospital.

Saint-Gaudens National Historic Site (Option B)

An alternative to Mount Ascutney Hospital is the Dartmouth Hitchcock Medical Center in Lebanon, New Hampshire. For injuries that are not life-threatening, DHMC is the better option. Directions to DHMC start at the Visitor Center parking lot (A) at Saint-Gaudens National Historic Site**,** and end at Dartmouth Hitchcock Medical Center in Lebanon, NH (B). Destination is 19.5 miles and about **33 minutes** away:

Phone Number: (603) 650-5000
Location: 1 Medical Center Drive, Lebanon, NH.

Directions:

1. Head southwest on St. Gaudens Road toward NH-12A/NH Route 12A/ Wilson Rd. Continue for 1 mile.

2. Turn sharp right at NH-12A/NH Route 12A/ Wilson Road, and continue on NH-12A for 11.4 miles.

3. Merge onto I-89 S via the ramp to Concord/Lebabon and go 3.8 miles.

4. Take exit 18 for NH-129 toward Hanover and go 0.2 miles.
5. Turn left at Centerra Pkwy/Lahaye Drive and continue on Lahaye Drive for 0.5 miles.

6. Turn right at the Hitchcock Loop Road/ Medical Center Drive and continue for 0.3 miles.

7. Turn left at DHMC East Entrance, and turn right to stay on DHMC East Entrance.

Saratoga National Historical Park

Directions to nearest hospital start at the **Saratoga National Historical Park entrance on NY-32** (A)**,** and end at **Saratoga Hospital** (B). Destination is 11.6 miles and about **24 minutes** away.

Phone Number: (518) 587-3222
Location:.211 Church Street, Saratoga Springs, NY 12866

Directions:

1. Turn right onto NY-32 N and go 0.8 mi.

2. Turn left onto Co Rd 71 and go 1.5 mi.

3. Turn right onto Sweer Rd. and go 1.4 mi.

4. Continue on Nielson Road for 0.9 mi.

5. Turn right onto Chapman Hill Rd and go 0.5 mi.

6. Continue onto Fitch Rd.

7. Turn right onyo New York 9P N and continue 2.2 mi.

8. Turn right onto Gilbert Rd. and go 1.3 mi.

9. Turn left onto Lake Ave. and go 2.1 mi.

10 Continue onto Church Street. After 0.6 mi, destination will be on the right.

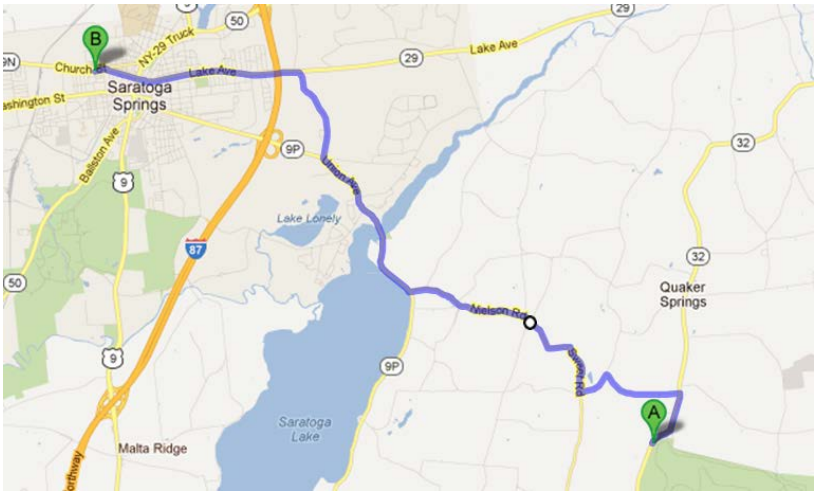


Figure S1.C.12. Route from Saratoga NHP entrance on NY-32 to Saratoga Hospital.

Weir Farm National Historic Site

Directions to nearest hospital start at **Weir Farm National Historic Site** on Nod Hill Road (A), and end at **Danbury Hospital** (B). Destination is 12.2 miles and about **22 minutes** away.

Phone Number: (203) 739-7000
Location: 24 Hospital Avenue, Danbury, CT 06810.

Figure S1.C.13. Route from Weir Farm NHS to Danbury Hospital.

Directions:

1. Exit park North onto Nod Hill Road. Head North on Nod Hill Road toward Pelham Ln. Continue for 0.7 miles.

2. Turn right at Old Branchville Rd, and continue 0.5 miles

3. Turn right at Branchville Rd/CT-102, and continue 0.3 miles.

4. Turn left at Danbury Norwalk Rd/US-7 Continue to follow US-7 for 8.6 miles

5. Take the exit onto 1-84 E/ US-7 N toward New Milford/Waterbury and continue for 1.7 miles.

6. Take exit 5 toward CT-37/Bethel/CT-39/CT-53. Go 0.2 miles.

7. Merge onto Downs St. and go 0.7 miles.

8. Continue on CT-37/North St. / Rte-37 for 0.7 miles

9. Turn right at Hayestown Avenue and go 0.3 miles.

10. Turn right at Tamarack Avenue and go 0.6 miles.

11. Turn left at Hospital Avenue.

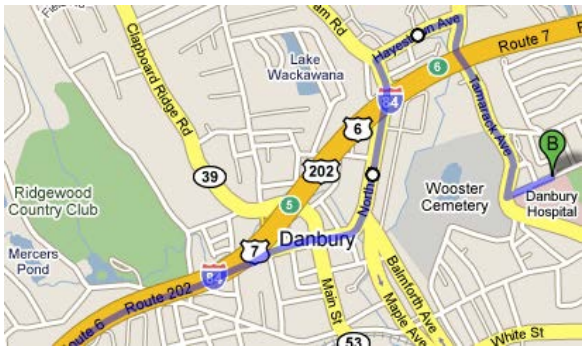


Figure S1.C.14. End point at Danbury Hospital

Mid-atlantic Network
Appomattox Court House National Historical Park

Lynchburg General Hospital
1901 Tate Springs Rd, Lynchburg, VA 24501-1167 – (434) 200-3000
25.3 mi – about **38 mins**

Figure S1.C.15. Route from Appomattox Court House NHP to Lynchburg General Hospital.

	1. Head **south** on **Appomattox Courthouse NHP** toward **VA-24** About 1 min	go 0.3 mi total 0.3 mi
24	2. Turn **right** at **VA-24** About 3 mins	go 1.6 mi total 1.9 mi
460	3. Turn **right** to merge onto **US-460 W/VA-24 W** toward **Lynchburg** Continue to follow US-460 W About 22 mins	go 18.2 mi total 20.1 mi
	4. Take the **Campbell Ave/US-460 Bus/US-501 Bus** exit toward **US-501/S Boston**	go 0.2 mi total 20.3 mi
460	5. Keep **right** at the fork, follow signs for **Campbell Ave** and merge onto **Campbell Ave/ US-460/US-501** Continue to follow US-460/US-501 About 4 mins	go 2.3 mi total 22.6 mi
	6. Continue on **Kemper St**	go 0.1 mi total 22.8 mi
↰	7. Turn **left** at **Fort Ave**	go 0.2 mi total 22.9 mi
501	8. Turn **right** at **Campbell Ave/US-501** Continue to follow US-501 About 3 mins	go 0.9 mi total 23.9 mi
↱	9. Turn **right** at **Atherholt Rd** About 1 min	go 0.3 mi total 24.2 mi
↱	10. Turn **right** at **Tate Springs Rd**	go 0.1 mi total 24.3 mi
	11. Continue on **Hillsdale Rd** About 1 min	go 0.5 mi total 24.7 mi
↶	12. Make a **U-turn** About 1 min	go 0.5 mi total 25.2 mi
↗	13. Slight **right** at **Tate Springs Rd**	go 361 ft total 25.3 mi

Booker T. Washington National Monument

Carilion Franklin Memorial Hospital
180 Floyd Ave, Rocky Mount, VA 24151-1389 – (540) 483-5277
15.5 mi – about **27 mins**

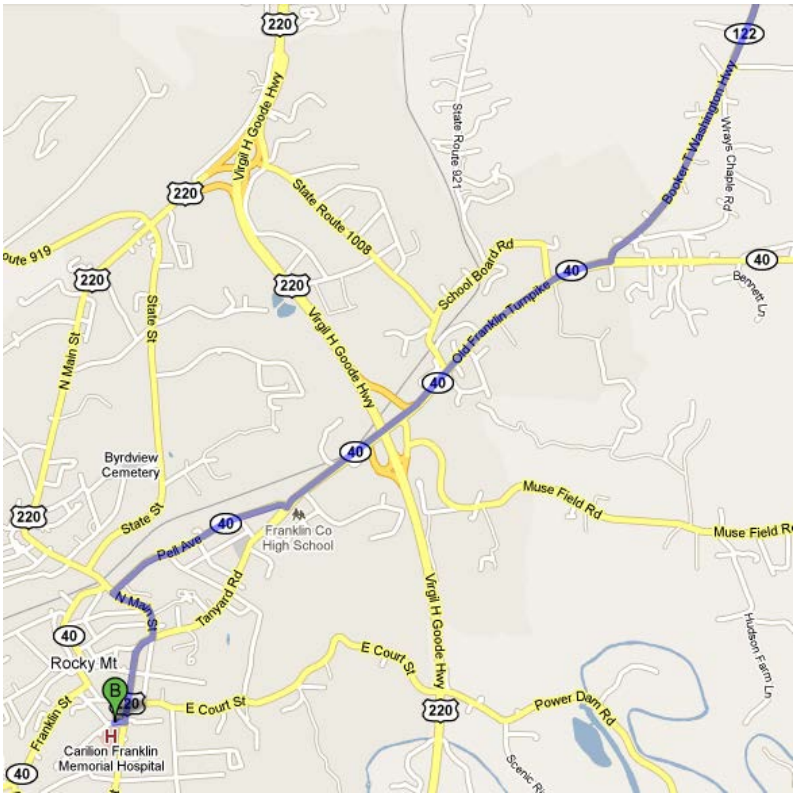


Figure S1.C.16. End of Route from Booker T. Washington NM to Carilion Franklin Memorial Hospital.

	1. Head **north** on **Booker T Wash National Monument** toward **Booker T Washington Hwy/VA-122**	go 0.3 mi total 0.3 mi
122	2. Turn **left** at **Booker T Washington Hwy/VA-122** About 20 mins	go 12.5 mi total 12.7 mi
40	3. Turn **right** at **Old Franklin Turnpike/VA-40** Continue to follow VA-40 About 3 mins	go 1.4 mi total 14.2 mi
40	4. Slight **right** at **Pell Ave/VA-40** About 1 min	go 0.7 mi total 14.9 mi
220	5. Turn **left** at **N Main St/US-220** About 1 min	go 0.2 mi total 15.1 mi
220	6. Turn **right** at **S Main St/US-220** About 1 min	go 0.3 mi total 15.4 mi
↱	7. Turn **right** at **Floyd Ave** Destination will be on the left	go 177 ft total 15.5 mi

Colonial National Historical Park

Mary Immaculate Hospital
2 Bernardine Dr., Newport News, VA 23602 – (757) 886-6000
8.8 mi – about **16 mins**

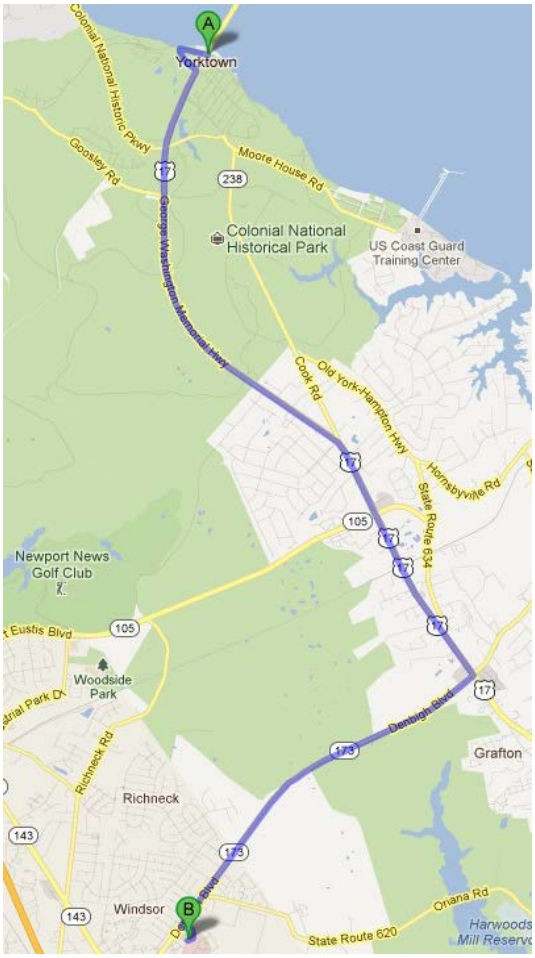


Figure S1.C.17. Route to Mary Immaculate Hospital from Colonial National Historical Park.

	1. Head **west** on **State Route 1020/Water St** toward **Mathews St**	go 0.2 mi total 0.2 mi
	2. Take the 1st left onto **Mathews St**	go 0.2 mi total 0.4 mi
17B	3. Slight right onto **U.S. 17B S/George Washington Memorial Hwy** About 8 mins	go 5.3 mi total 5.7 mi
173	4. Turn right onto **VA-173 W/Denbigh Blvd** About 5 mins	go 2.9 mi total 8.6 mi
	5. Turn left onto **Ridgewood Pkwy** About 1 min	go 404 ft total 8.6 mi
	6. Take the 1st right onto **Bernardine Dr** Destination will be on the left	go 0.1 mi total 8.8 mi

Chancellorsville Unit—Fredericksburg & Spotsylvania National Military Park

Life threatening emergencies:
Mary Washington Hospital
1001 Sam Perry Blvd, Fredericksburg, VA 22401 – (540) 741-1100
10.6 mi – about 17 mins

Figure S1.C.18. Route from Chancellorsville Unit to Mary Washington Hospital.

3	1. Head **east** on **Plank Rd/VA-3** toward **National Military Park** About 14 mins	go 9.1 mi total 9.1 mi
1	2. Take the ramp onto **Jefferson Davis Hwy/US-1/US-17** About 2 mins	go 1.3 mi total 10.3 mi
↰	3. Turn **left** at **Mary Washington Blvd** About 1 min	go 0.2 mi total 10.6 mi
	4. Continue on **Sam Perry Blvd** Destination will be on the right	go 20 ft total 10.6 mi

For minor/non-life threatening injuries:
NextCare Urgent Care
Ste 105, 5825 Plank Rd, Fredericksburg, VA 22407-5207 – (888) 563-8021
4.2 mi – about 7 mins

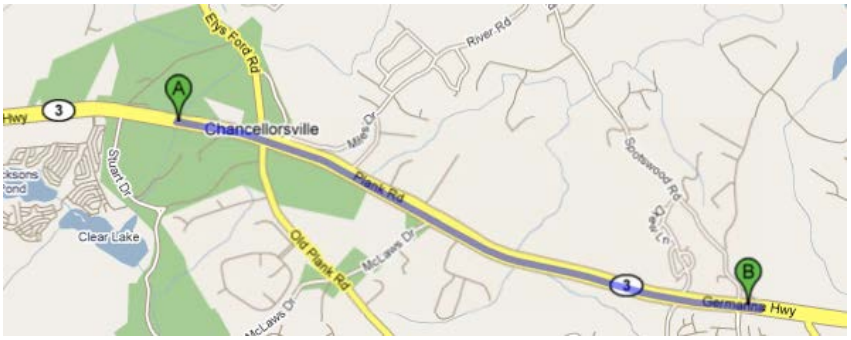


Figure S1.C.19. Route from Chancellorsville Unit to NextCare Urgent Care.

3	1. Head **east** on **Plank Rd/VA-3** toward **National Military Park** About 6 mins	go 4.1 mi total 4.1 mi
3	2. Make a **U-turn** About 1 min	go 0.1 mi total 4.2 mi

Fredericksburg Unit—Fredericksburg & Spotsylvania National Military Park

Mary Washington Hospital
1001 Sam Perry Blvd, Fredericksburg, VA 22401 – (540) 741-1100
3.8 mi – about **10 mins**

1. Head **northeast** on **Lee Dr** toward **Lloyd Ln**
   About 4 mins
2. Sharp **right** at **Lafayette Blvd/US-1**
   About 1 min
3. Slight **left** to stay on **Lafayette Blvd/US-1**
4. Turn **left** at **Blue and Gray Pkwy/VA-3**
   About 3 mins
5. Take the ramp onto **Jefferson Davis Hwy/US-1/US-17**
   About 2 mins
6. Turn **left** at **Mary Washington Blvd**
   About 1 min
7. Continue on **Sam Perry Blvd**
   Destination will be on the right

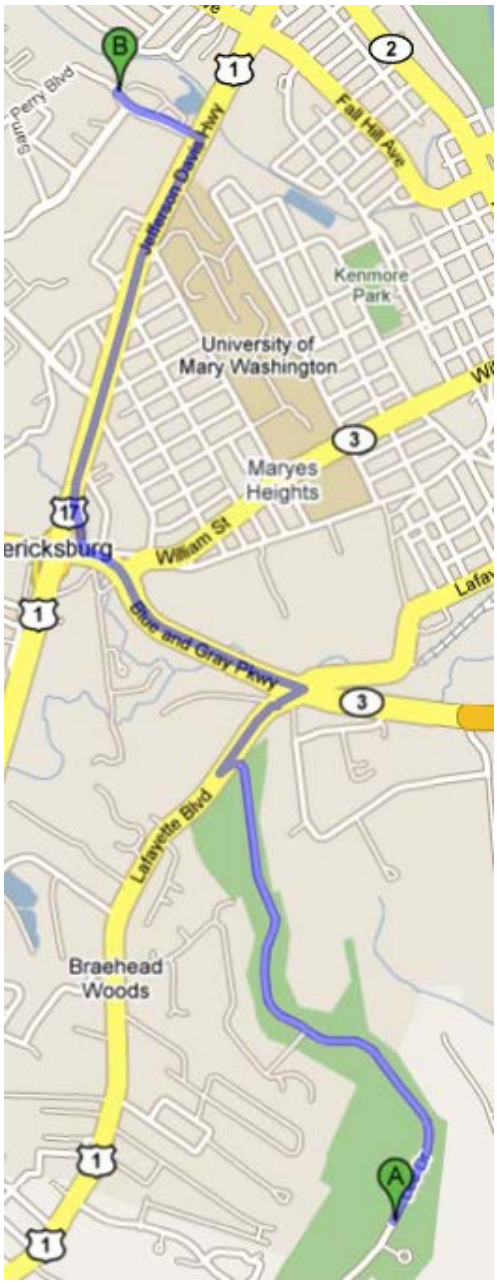


Figure S1.C.20. Route from Chancellorsville Unit to Mary Washington Hospital.

Spotsylvania Unit—Fredericksburg & Spotsylvania National Military Park

For life-threatening emergencies:

Mary Washington Hospital

1001 Sam Perry Blvd, Fredericksburg, VA 22401 – (540) 741-1100

12.4 mi – about 23 mins

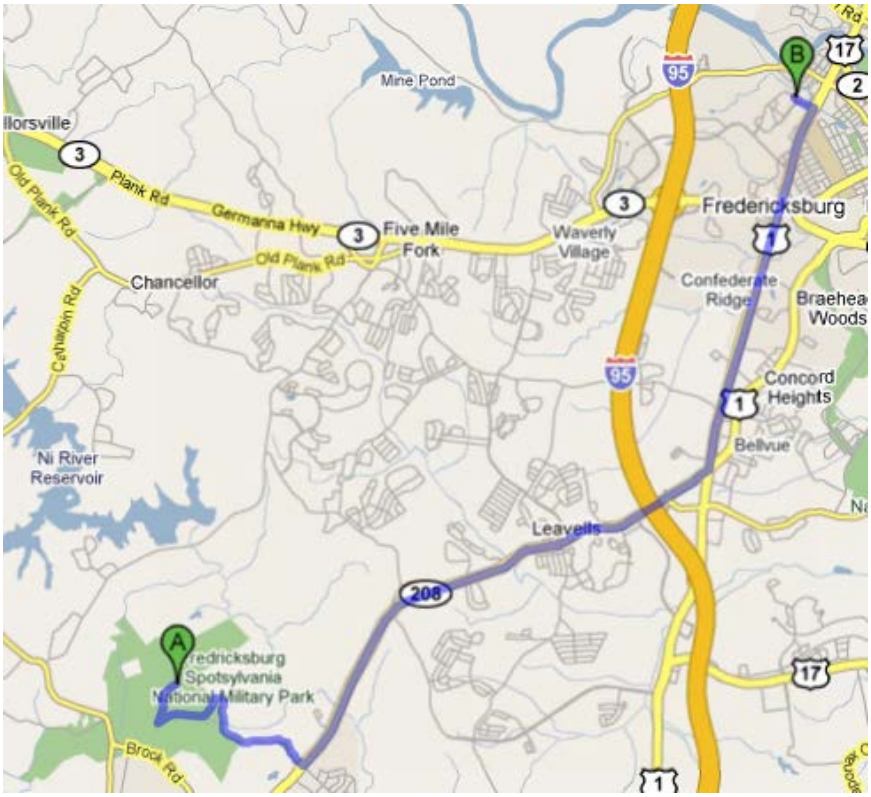


Figure S1.C.21. Route from Spotsylvania Unit to Mary Washington Hospital.

	1. Head **southwest** on **Anderson Dr** toward **Gordon Dr** About 1 min	go 0.5 mi total 0.5 mi
↰	2. Sharp **left** at **Gordon Dr** About 2 mins	go 0.7 mi total 1.2 mi
↱	3. Turn **right** at **Grant Dr E** About 4 mins	go 1.4 mi total 2.6 mi
208	4. Turn **left** at **Courthouse Rd/VA-208** About 9 mins	go 5.6 mi total 8.2 mi
1	5. Slight **left** at **Jefferson Davis Hwy/US-1/US-17** About 6 mins	go 4.0 mi total 12.2 mi
↰	6. Turn **left** at **Mary Washington Blvd** About 1 min	go 0.2 mi total 12.4 mi
	7. Continue on **Sam Perry Blvd** Destination will be on the right	go 20 ft total 12.4 mi

Spotsylvania Unit—Fredericksburg & Spotsylvania National Military Park

For minor/non-life threatening emergencies:
Prime Care Urgent & Family Care
9763 Courthouse Rd, Spotsylvania, VA 22553 – (540) 710-2751
4.2 mi – about 10 mins

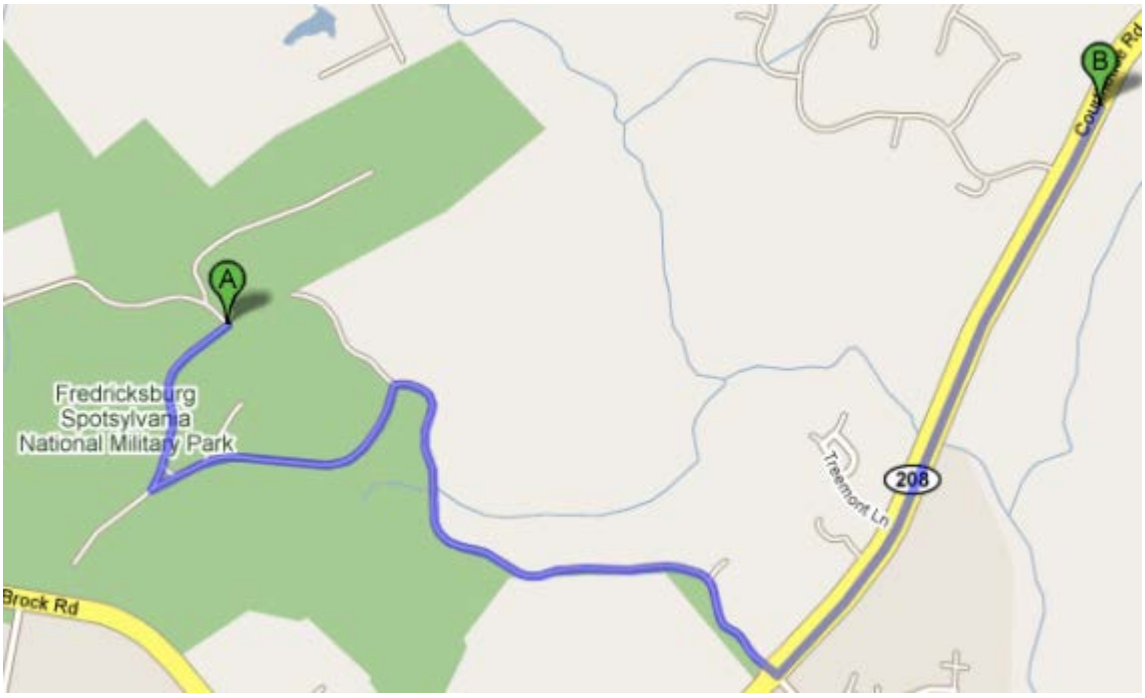


Figure S1.C.22. Route from Spotsylvania Unit to Prime Care Urgent & Family Care.

	1. Head **southwest** on **Anderson Dr** toward **Gordon Dr** About 1 min	go 0.5 mi total 0.5 mi
↰	2. Sharp **left** at **Gordon Dr** About 2 mins	go 0.7 mi total 1.2 mi
↱	3. Turn **right** at **Grant Dr E** About 4 mins	go 1.4 mi total 2.6 mi
208	4. Turn **left** at **Courthouse Rd/VA-208** About 4 mins	go 1.6 mi total 4.2 mi

Wilderness Unit—Fredericksburg & Spotsylvania National Military Park

For life-threatening emergencies:
Mary Washington Hospital
1001 Sam Perry Blvd, Fredericksburg, VA 22401 – (540) 741-1100
16.2 mi – about 31 mins

Figure S1.C.23. Route from Wilderness Unit to Mary Washington Hospital.

	1. Head **east** on **Hill Ewell Dr** toward **Quarter Charge Dr** About 3 mins	go 1.2 mi total 1.2 mi
↰	2. Turn **left** at **Orange Plank Rd** About 8 mins	go 2.9 mi total 4.1 mi
3	3. Turn **right** at **Plank Rd/VA-3** About 17 mins	go 10.6 mi total 14.7 mi
1	4. Take the ramp onto **Jefferson Davis Hwy/US-1/US-17** About 2 mins	go 1.3 mi total 15.9 mi
↰	5. Turn **left** at **Mary Washington Blvd** About 1 min	go 0.2 mi total 16.2 mi
	6. Continue on **Sam Perry Blvd** Destination will be on the right	go 20 ft total 16.2 mi

Wilderness Unit—Fredericksburg & Spotsylvania National Military Park

For minor/non-life threatening emergencies:
Rapidan Medical Center
4444 Germanna Hwy # 310, Locust Grove, VA 22508-2039 – (540) 972-6222
7.5 mi – about 15 mins

1. Head **west** on **Hill Ewell Dr** toward **Grant Ct**
   About 5 mins
2. Turn **right** at **Constitution Hwy/VA-20**
   About 3 mins
3. Turn **left** at **Germanna Hwy/VA-3**
   About 4 mins
4. Make a **U-turn**
   About 2 mins

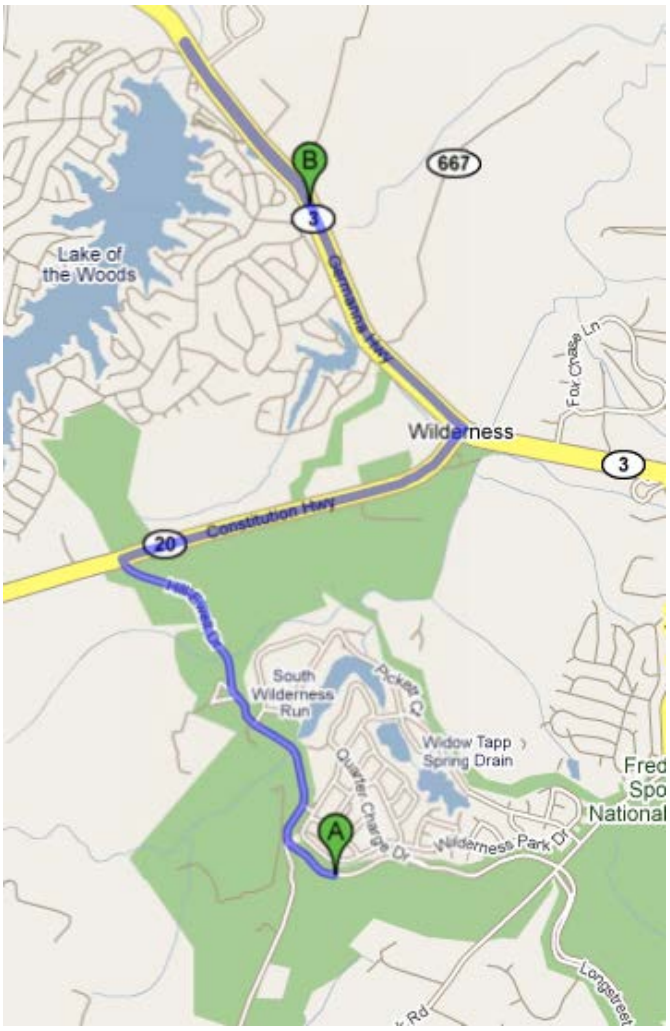


Figure S1.C.24. Route from Wilderness Unit to Rapidan Medical Center.

Gettysburg National Military Park/Eisenhower National Historic Site

Gettysburg Hospital
147 Gettys St, Gettysburg, PA 17325-2536 – (717) 334-2121

Due to the location of Gettysburg Hospital, directions will vary widely depending on location on the park. Refer to maps below. A20 shows most of Gettysburg NMP and A21 shows a close up of Gettysburg town center.

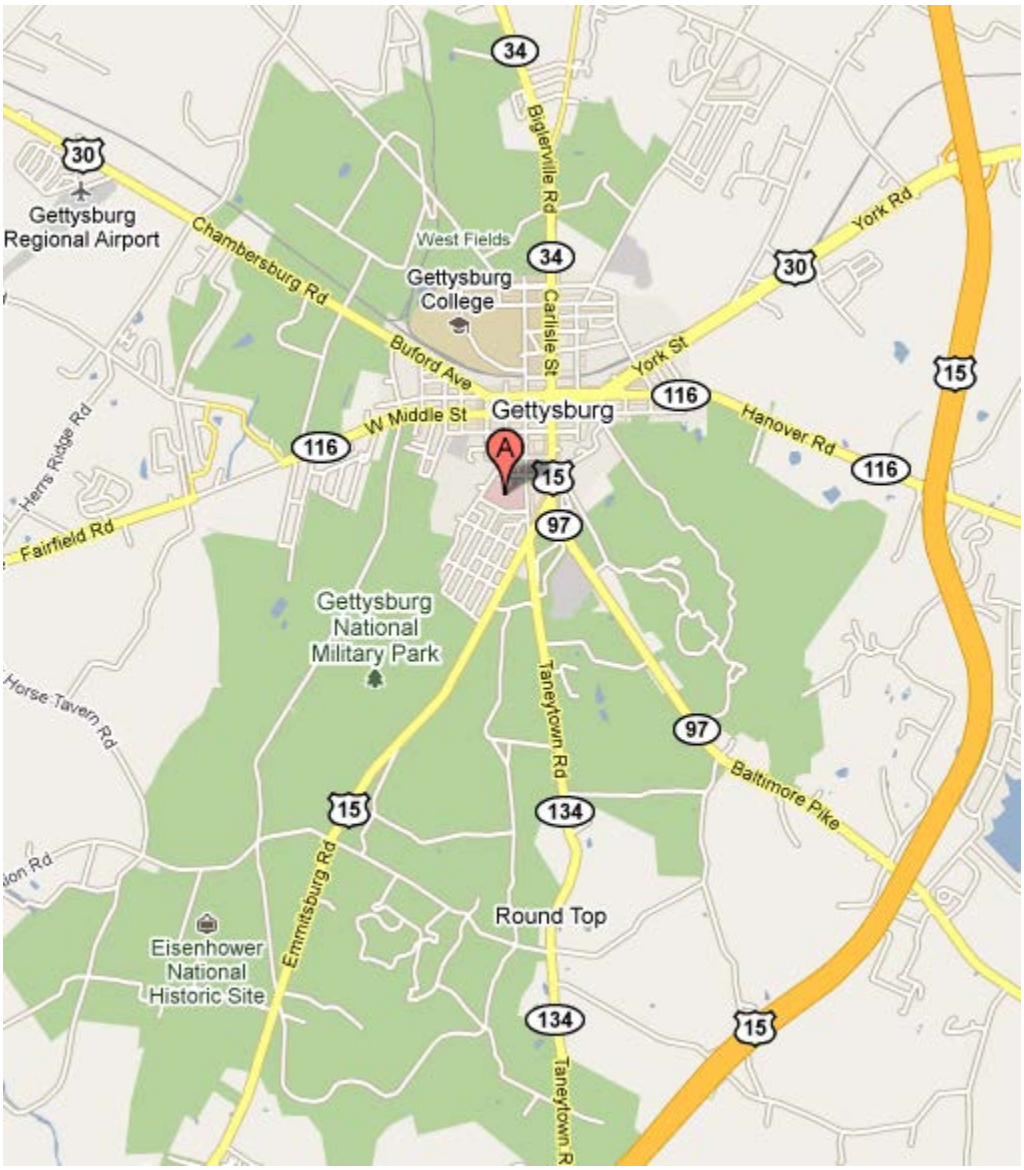


Figure S1.C.25. Map of Gettysburg NMP and Eisenhower NHP with Gettysburg Hospital marked at center.

Gettysburg National Military Park/Eisenhower National Historic Site (continued)

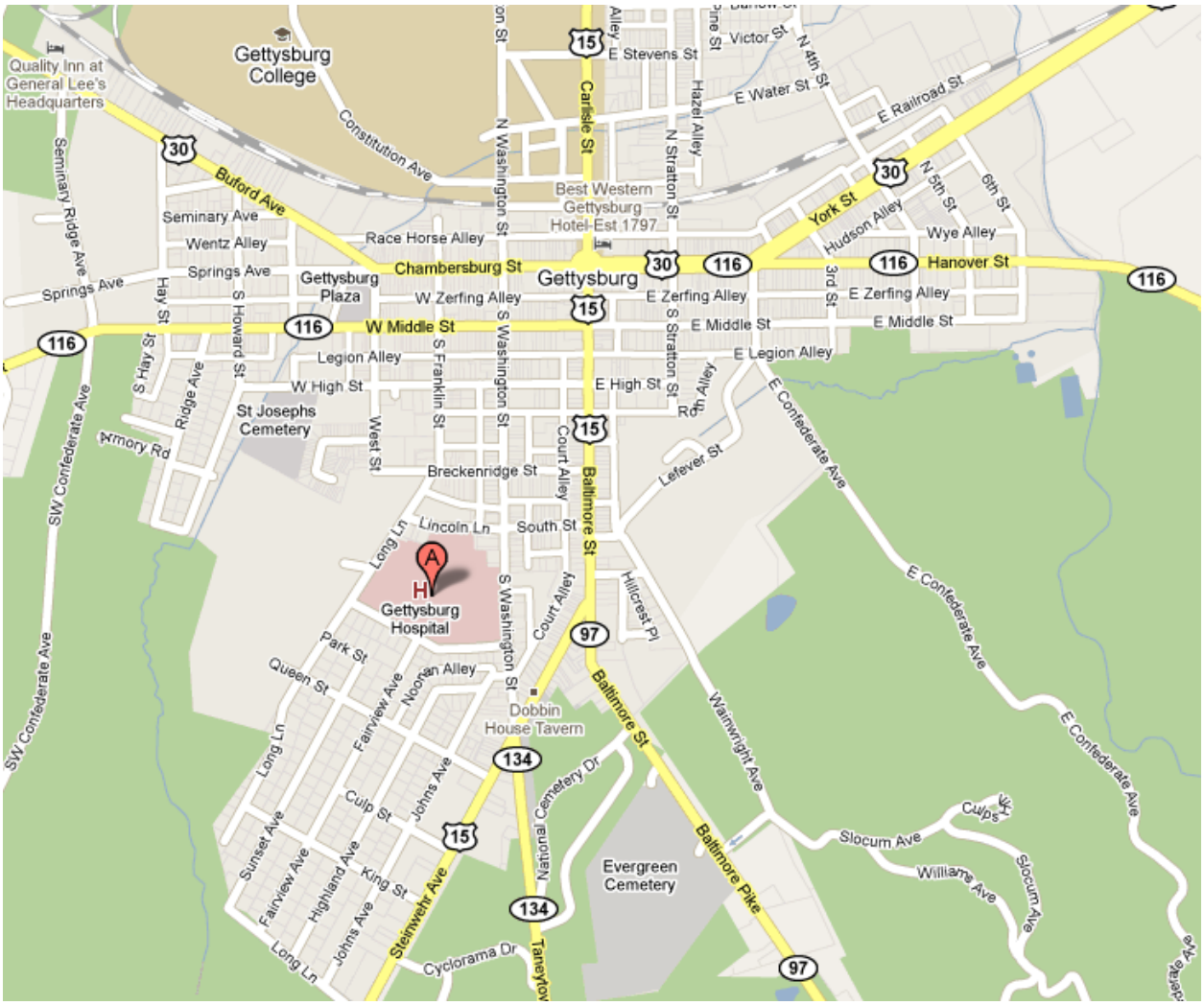


Figure S1.C.26. Map of Gettysburg downtown with Gettysburg Hospital marked near center.

George Washington Birthplace National Monument

Riverside Tappahannock Hospital
618 Hospital Rd, Tappahannock, VA 22560-5000 – (804) 443-3311
34.1 mi – about **55 mins**

1. Head **southwest** on **Popes Creek Dr/VA-204**
2. At the traffic circle, take the **2nd** exit and stay on **Popes Creek Dr/VA-204**
3. Turn **left** at **Kings Hwy/VA-3**
   Continue to follow VA-3
   About 35 mins
4. Turn **right** at **Main St**
   About 2 mins
5. Turn **right** at **Richmond Rd/US-360**
   Continue to follow US-360
   About 9 mins
6. Turn **left** at **S Church Ln/US-17/US-360**
   Continue to follow US-17/US-360
   About 4 mins
7. Slight **right** at **Richmond Hwy/US-360**
8. Turn **right** at **Hospital Rd/VA-708**
   About 1 min

Figure S1.C.27. Route from George Washington NM to Riverside Tappahannock Hospital.

Hopewell Furnace National Historic Site

Pottstown Memorial Medical Center
1600 East High Street, Pottstown, PA 19464 - (610) 327-7000
15.9 mi – about **25 mins**

Figure S1.C.28. Route from Hopewell Furnace NHS to Pottstown Memorial Medical Center.

345	1. Head **north** on **PA-345 N/Shed Rd** toward **Mark Bird Ln** Continue to follow PA-345 N	go 3.4 mi total 3.4 mi
↱	2. Turn **right** at **Crusher Rd** About 3 mins	go 1.4 mi total 4.8 mi
	3. Continue onto **Shed Rd**	go 0.5 mi
724	4. Slight **right** at **Main St E/PA-724 E** About 4 mins	go 2.5 mi total 7.8 mi
↰	5. Turn **left** at **River Rd**	go 407 ft total 7.9 mi
	6. Continue onto **River Bridge Rd**	go 0.4 mi
422	7. Turn **right** at **Benjamin Franklin Hwy/US-422 E** About 6 mins	go 6.1 mi total 14.4 mi
↗	8. Take the exit toward **Armand Hammer Blvd** About 1 min	go 0.4 mi total 14.8 mi
↰	9. Turn **left** at **Industrial Hwy** About 1 min	go 0.3 mi total 15.1 mi
↱	10. Turn **right** at **Moser Rd** About 1 min	go 0.7 mi total 15.8 mi
↗	11. Slight **right** at **E High St** Destination will be on the right	go 0.2 mi total 15.9 mi

Petersburg National Battlefield

Southside Regional Medical Center
801 S Adams Street, Petersburg, VA 23803 – (804) 862-5000
3.8 mi – about **9 mins**

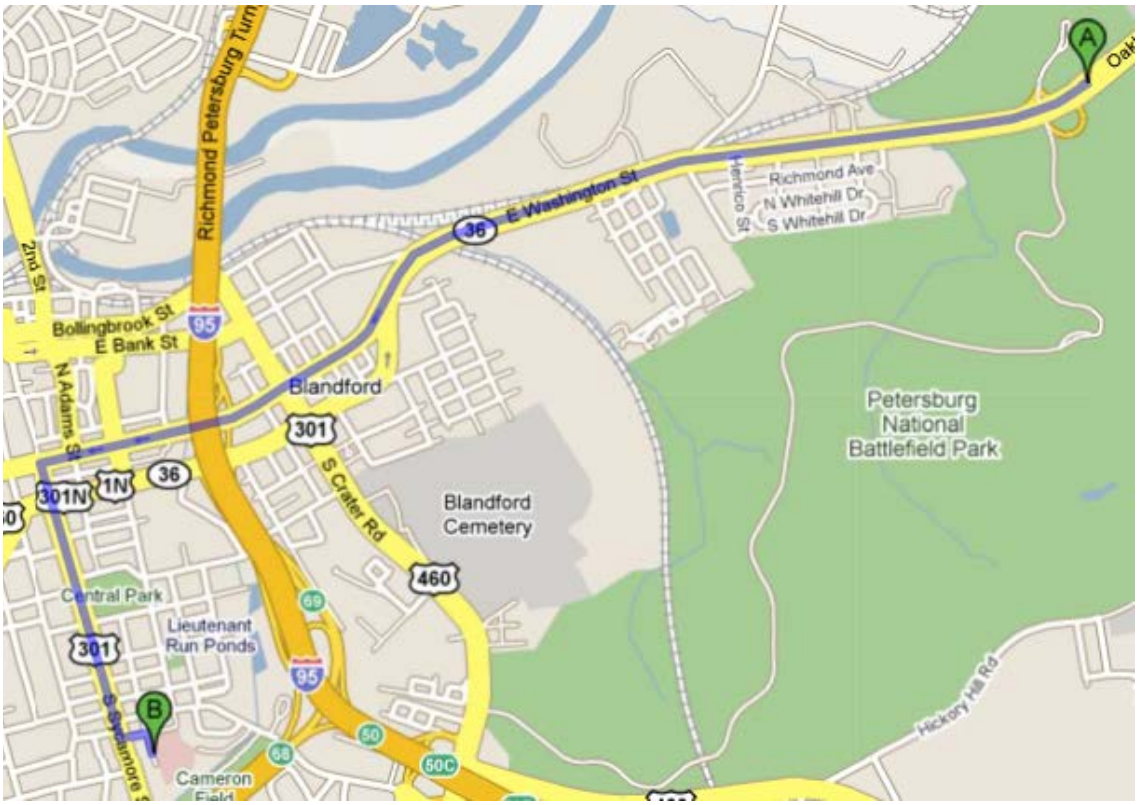


Figure S1.C.29. Route from Petersburg NB to Southside Regional Medical Center.

36	1. Head **southwest** on **Oaklawn Blvd/VA-36** Continue to follow VA-36 About 4 mins	go 2.3 mi total 2.3 mi
460	2. Continue on **US-301/US-460/E Washington St** Continue to follow US-460/E Washington St About 3 mins	go 0.7 mi total 2.9 mi
301	3. Turn **left** at **S Sycamore St/US-301** About 2 mins	go 0.7 mi total 3.6 mi
↰	4. Turn **left** at **Apollo St**	go 344 ft total 3.7 mi
↱	5. Turn **right** at **S Adams St** Destination will be on the left	go 276 ft total 3.8 mi

Chickahominy Bluff Battlefield Unit—Richmond National Battlefield Park

Bon Secours Memorial Regional Medical Center
8260 Atlee Rd, Mechanicsville, VA 23116 – (804) 764-6000
3.8 mi – about **9 mins**

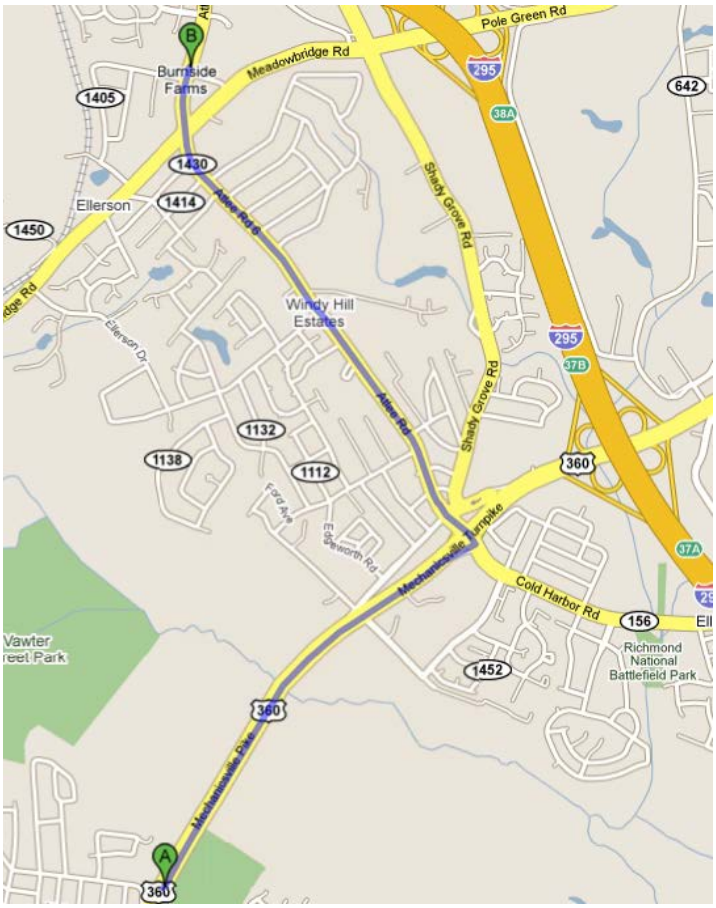


Figure S1.C.30. Route from Chichahominy Battelfield Unit—Richmond NBP *to Bon Secours Memorial Regional Medical Center.*

360 1. Head **northeast** on **Mechanicsville Pike/Mechanicsville Turnpike/US-360** toward **Mechanicsville Turnpike/US-360**
Continue to follow Mechanicsville Turnpike/US-360
About 3 mins

2. Take the exit toward **Cold Harbor Rd/VA-156**

156 3. Turn **left** at **Cold Harbor Rd/VA-156**
About 1 min

4. Continue on **Atlee Rd**
About 6 mins

Turkey Hill Unit—Richmond National Battlefield Park

Bon Secours Memorial Regional Medical Center
8260 Atlee Rd, Mechanicsville, VA 23116 – (804) 764-6000
10.4 mi – about **13 mins**

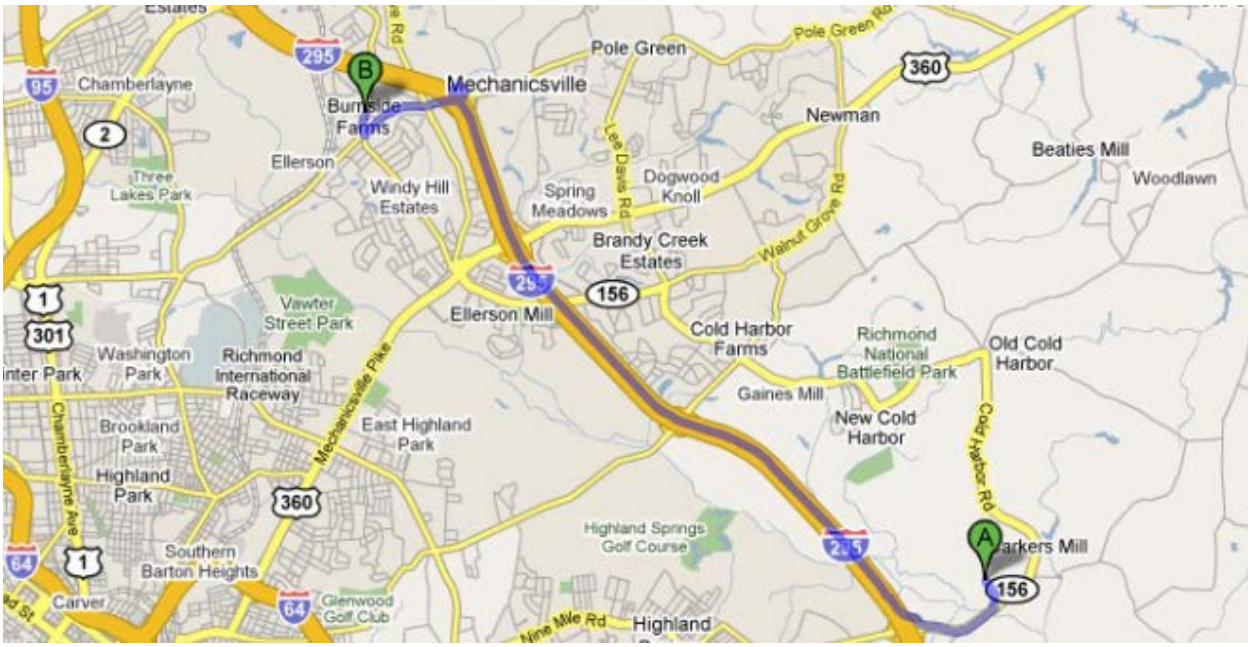


Figure S1.C.31. Route from Turkey Hill Unit—Richmond NBP to Bon Secours Memorial Regional Medical Center.

	1. Head **southeast** on **Turkey Hill Trail** toward **Cold Harbor Rd/VA-156** About 1 min	go 0.3 mi total 0.3 mi
156	2. Turn **right** at **Cold Harbor Rd/VA-156** Continue to follow VA-156 About 2 mins	go 0.8 mi total 1.1 mi
295	3. Take the ramp onto **I-295 N** About 8 mins	go 7.6 mi total 8.7 mi
↗	4. Take exit **38B** to merge onto **Meadowbridge Rd/Pole Green Rd** toward **VA-627** Continue to follow Meadowbridge Rd About 3 mins	go 1.5 mi total 10.2 mi
↱	5. Turn **right** at **Atlee Rd** About 1 min	go 0.2 mi total 10.4 mi

Cold Harbor Unit—Richmond National Battlefield Park

Bon Secours Memorial Regional Medical Center

8260 Atlee Rd, Mechanicsville, VA 23116 – (804) 764-6000

9.3 mi – about **14 mins**

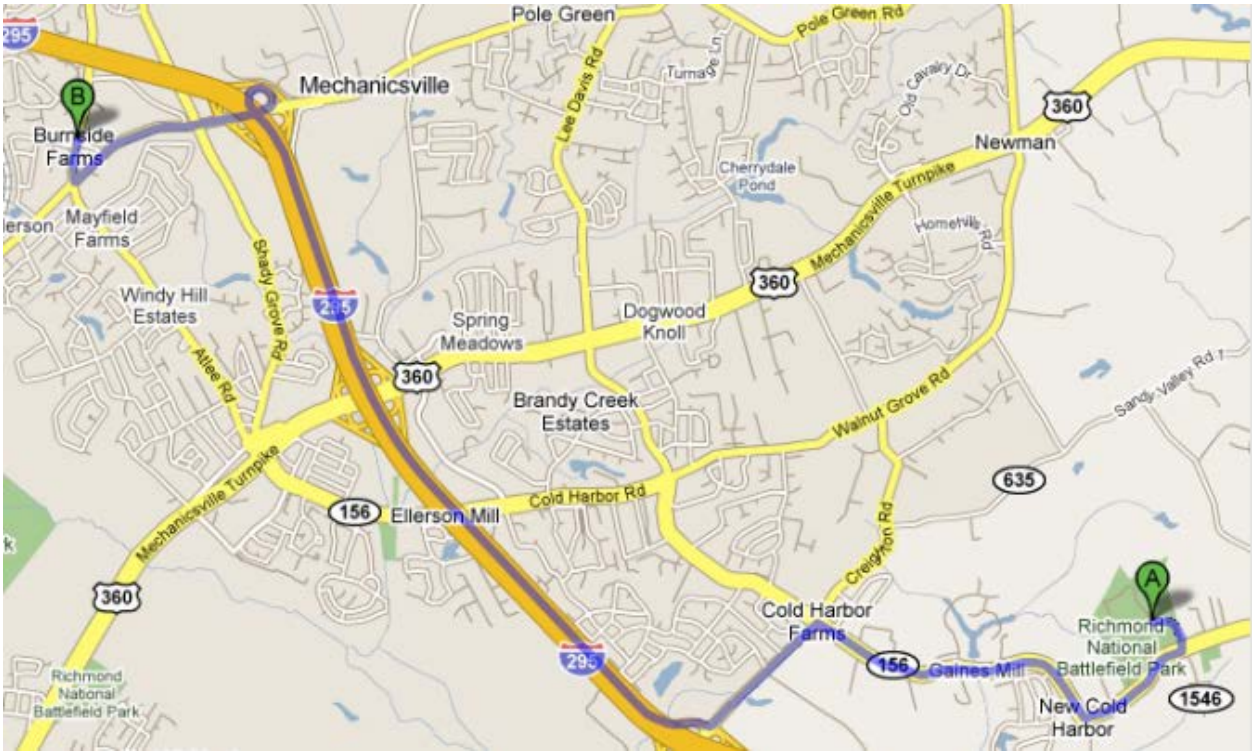


Figure S1.C.32. Route from Cold Harbor Unit—Richmond NBP to Bon Secours Memorial Regional Medical Center.

	1. Head **east** on **Anderson Wright Dr** toward **Cold Harbor Rd/VA-156**	go 0.3 mi total 0.3 mi
156	2. Turn **right** at **Cold Harbor Rd/VA-156** About 2 mins	go 0.7 mi total 0.9 mi
156	3. Turn **right** to stay on **Cold Harbor Rd/VA-156** About 3 mins	go 1.6 mi total 2.6 mi
↰	4. Turn **left** at **Creighton Rd** About 2 mins	go 0.8 mi total 3.3 mi
295	5. Merge onto **I-295 N** via the ramp to **Charlottesville** About 4 mins	go 4.2 mi total 7.6 mi
↱	6. Take exit **38B** to merge onto **Meadowbridge Rd/Pole Green Rd** toward **VA-627** Continue to follow Meadowbridge Rd About 3 mins	go 1.5 mi total 9.0 mi
↱	7. Turn **right** at **Atlee Rd** About 1 min	go 0.2 mi total 9.3 mi

Fort Harrison Unit—Richmond National Battlefield Park

Memorial Regional Hospital
701 E Grace St, Richmond, VA 23219 – (804) 775-4174
9.4 mi – about **21 mins**

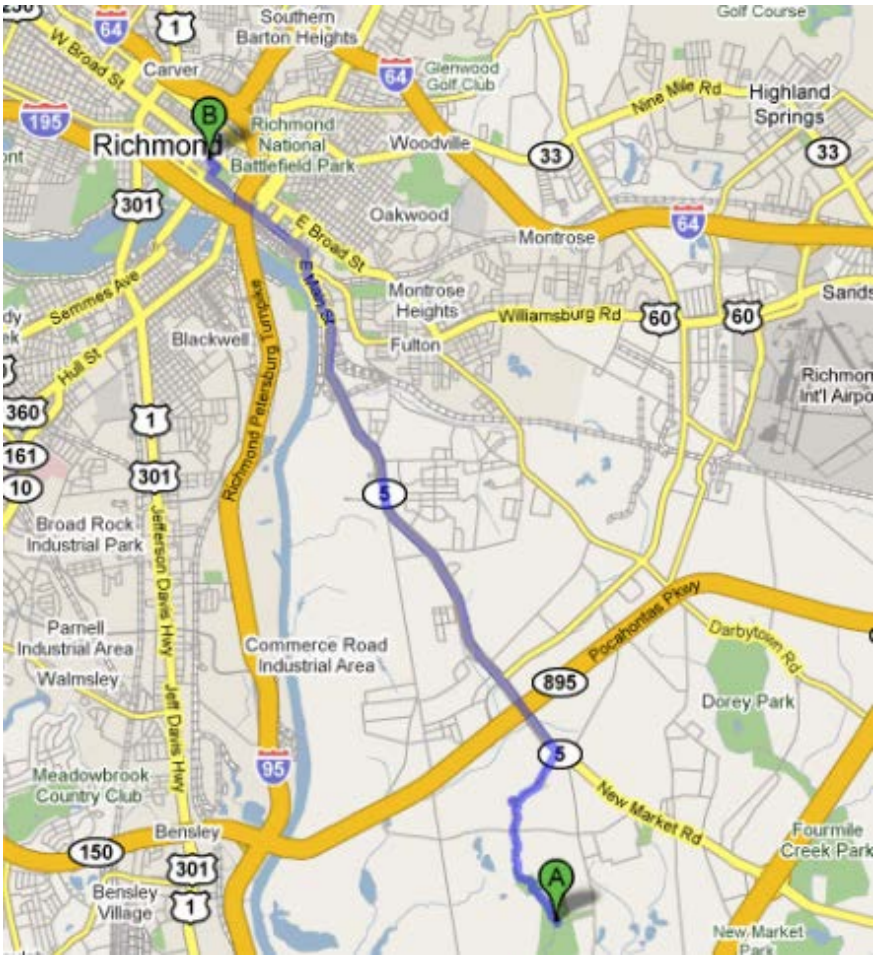


Figure S1.C.33. Route from Fort Harrison Unit—Richmond NBP to Memorial Regional Hospital.

	1. Head **north** on **Battlefield Park Rd** toward **Mill Rd** About 5 mins	go 2.2 mi total 2.2 mi
5	2. Turn **left** at **New Market Rd/VA-5** Continue to follow VA-5 About 10 mins	go 5.7 mi total 7.8 mi
↰	3. Turn **left** at **E Main St/VA-5** Continue to follow E Main St About 5 mins	go 1.3 mi total 9.2 mi
↱	4. Turn **right** at **N 9th St**	go 0.1 mi total 9.3 mi
↰	5. Turn **left** at **E Grace St**	go 0.1 mi total 9.4 mi

Malvern Hill Unit—Richmond National Battlefield Park

Memorial Regional Hospital
701 E Grace St, Richmond, VA 23219 – (804) 775-4174
15.9 mi – about **28 mins**

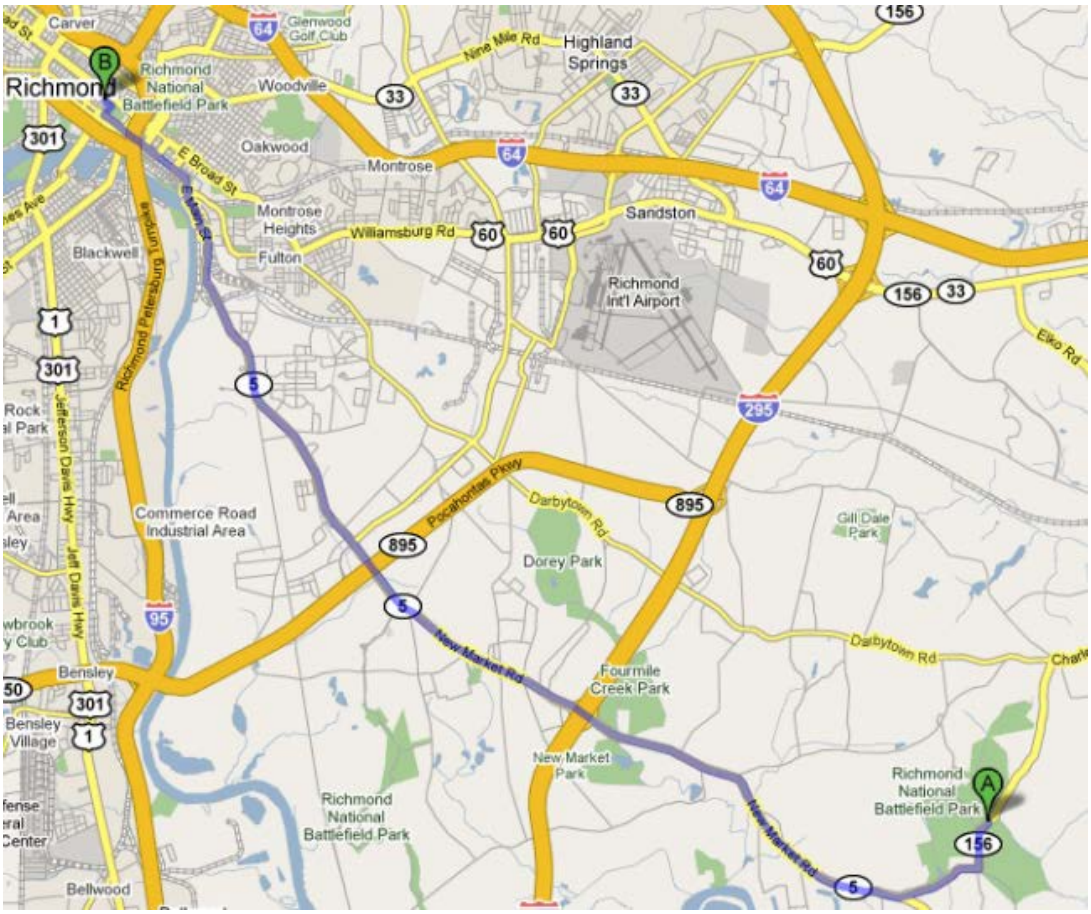


Figure S1.C.34. Route from Malvern Hill Unit—Richmond NBP to Memorial Regional Hospital.

156	1. Head **southwest** on **VA-156/Willis Church Rd** toward **Carters Mill Rd** About 1 min	go 0.6 mi total 0.6 mi
156	2. Turn **right** to stay on **VA-156/Willis Church Rd** About 2 mins	go 1.0 mi total 1.6 mi
5	3. Slight **right** at **New Market Rd/VA-5** Continue to follow VA-5 About 19 mins	go 12.7 mi total 14.3 mi
↰	4. Turn **left** at **E Main St/VA-5** Continue to follow E Main St About 5 mins	go 1.3 mi total 15.6 mi
↱	5. Turn **right** at **N 9th St**	go 0.1 mi total 15.8 mi
↰	6. Turn **left** at **E Grace St**	go 0.1 mi total 15.9 mi

Rural Point Unit—Richmond National Battlefield Park

Bon Secours Memorial Regional Medical Center
8260 Atlee Rd, Mechanicsville, VA 23116 – (804) 764-6000
4.7 mi – about **12 mins**

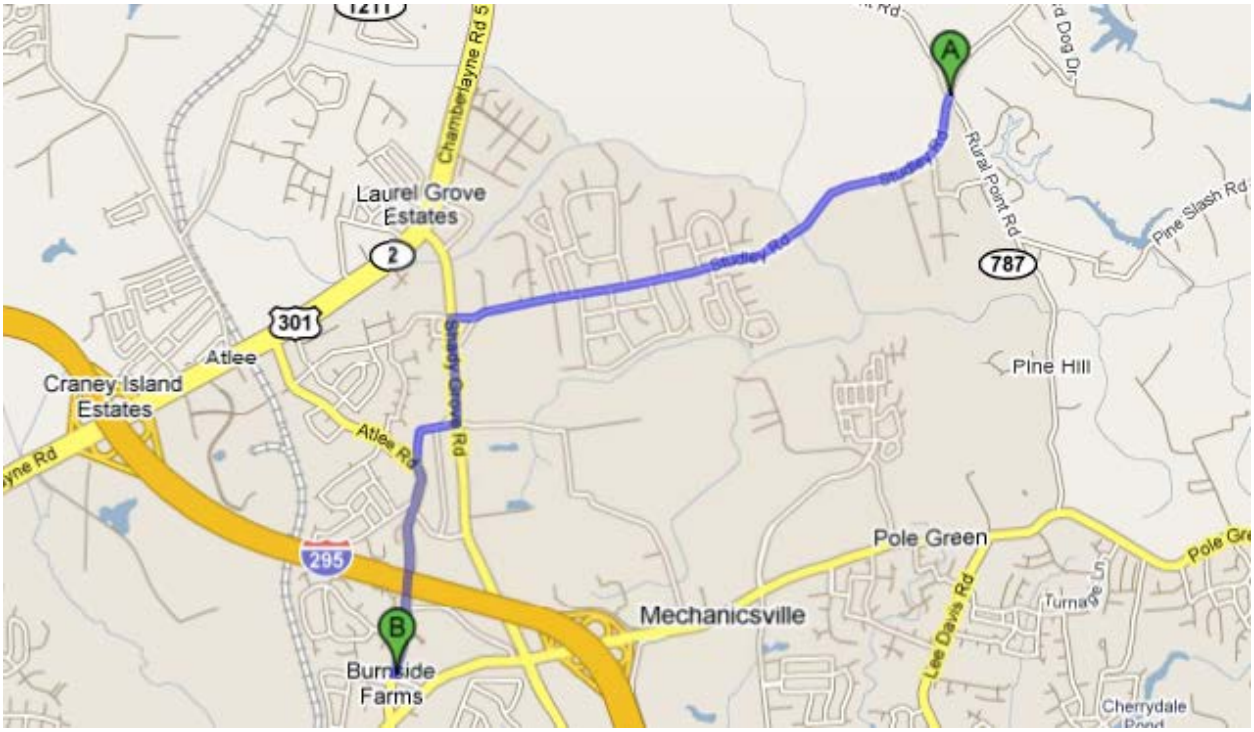


Figure S1.C.35. Route from Rural Point Unit—Richmond NBP to Bon Secours Memorial Regional Medical Center.

	1. Head **south** on **Studley Rd** toward **Sentry Station Rd** About 7 mins	go 2.8 mi total 2.8 mi
↰	2. Turn **left** at **Shady Grove Rd** About 2 mins	go 0.5 mi total 3.3 mi
↱	3. Turn **right** at **Mann Dr** About 1 min	go 0.3 mi total 3.6 mi
↰	4. Turn **left** at **Atlee Rd** About 3 mins	go 1.0 mi total 4.7 mi

Sagamore Hill National Historic Site

Syosset Hospital

221 Jericho Turnpike, Syosset, NY 11791– (516) 496-6500

6.3 mi – about **15 mins**

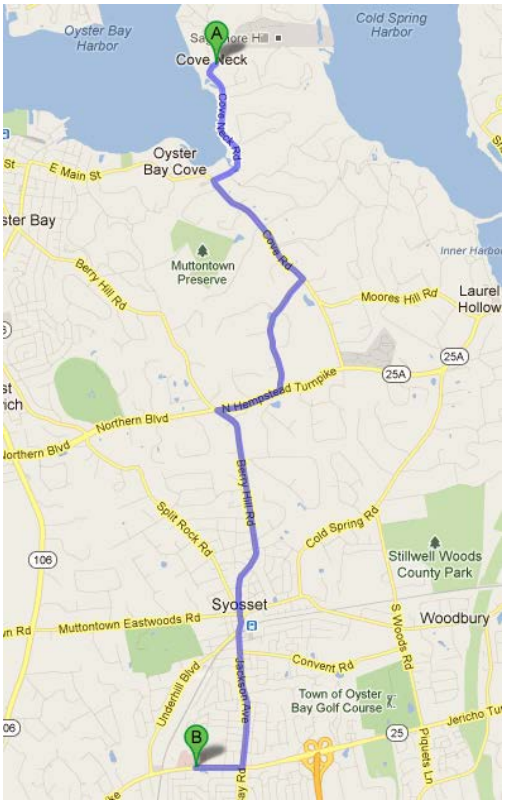


Figure S1.C.36. Route from Sagamore Hill NHS to Syosset Hospital.

	1. Head **southwest** on **Sagamore Hill Rd** toward **Cove Neck Rd**	go 161 ft total 161 ft
	2. Continue straight onto **Cove Neck Rd** About 2 mins	go 1.0 mi total 1.0 mi
↰	3. Turn left onto **Cove Rd** About 2 mins	go 1.0 mi total 2.0 mi
↱	4. Turn right onto **Yellow Cote Rd** About 2 mins	go 0.9 mi total 2.9 mi
↱	5. Turn right onto **N Hempstead Turnpike** About 1 min	go 0.5 mi total 3.3 mi
↰	6. Sharp left onto **Berry Hill Rd** About 4 mins	go 1.6 mi total 4.9 mi
	7. Continue onto **Jackson Ave** About 3 mins	go 1.1 mi total 6.0 mi
↱	8. Turn right onto **Jericho Turnpike** Destination will be on the right About 1 min	go 0.3 mi total 6.3 mi

Thomas Stone National Historic Site

Civista Medical Center

701 Charles St, La Plata, MD 20646-5930 – (301) 609-4000

4.9 mi – about **12 mins**

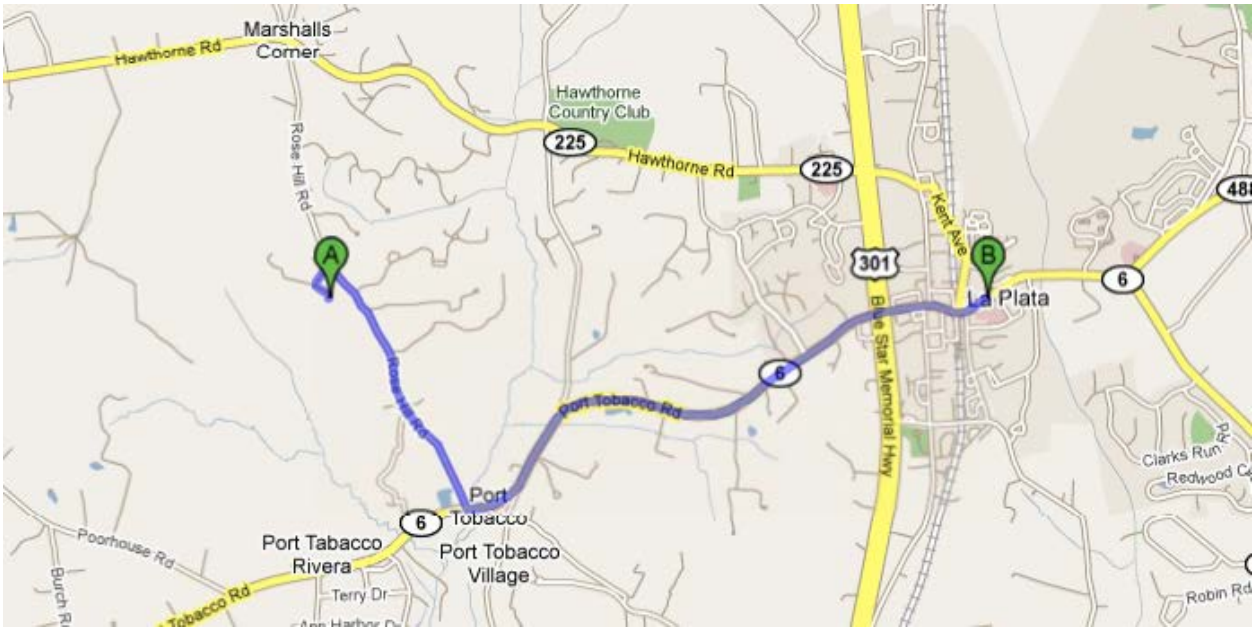


Figure S1.C.37. Route from Thomas Stone NHS to Civista MedicalCenter.

	1. Head **north** on **Thomas Stone National Hist Site**	go 0.1 mi total 0.1 mi
↱	2. Turn **right** to stay on **Thomas Stone National Hist Site**	go 0.1 mi total 0.2 mi
↱	3. Turn **right** at **Rose Hill Rd** About 4 mins	go 1.5 mi total 1.7 mi
6	4. Turn **left** at **MD-6/Port Tobacco Rd** Continue to follow MD-6 Destination will be on the right	go 3.1 mi total 4.9 mi

Valley Forge National Historical Park

Phoenixville Hospital

140 Nutt Rd, Phoenixville, PA 19460-3900 – (610) 983-1000

4.6 mi – about **10 mins**

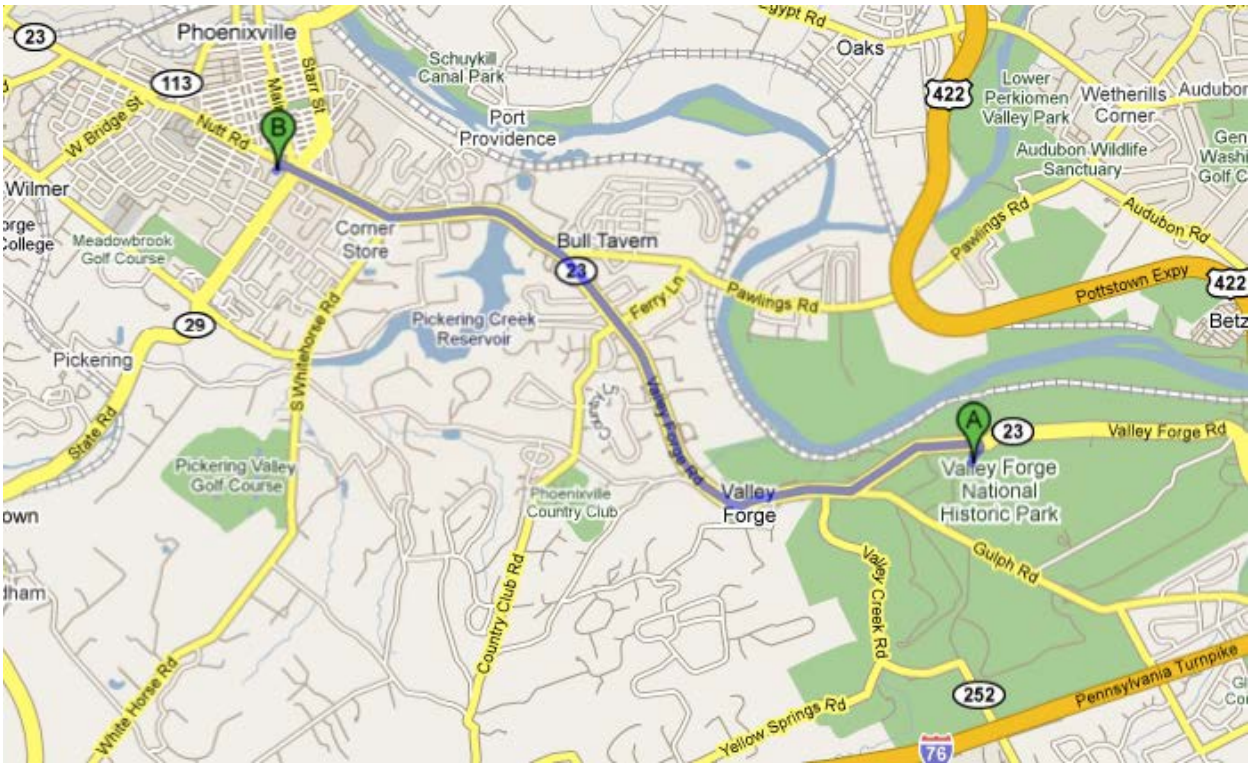


Figure S1.C.38. Route from Valley Forge NHP to Civista MedicalCenter.

	1. Head **north** on **N Inner Line Dr** toward **N PA-23/Valley Forge Rd**	go 0.1 mi total 0.1 mi
23	2. Turn **left** at **N PA-23/Valley Forge Rd** Continue to follow N PA-23 About 10 mins	go 4.5 mi total 4.6 mi
↰	3. Turn **left** Destination will be on the left	go 240 ft total 4.6 mi

Appendix S1.D. Emergency contacts/procedures for each park.

This Appendix lists the information for the first person to be contacted in the event of an emergency for each park. This information is to be used in emergency situations only, and should not to be distributed to the public. **The preferred contact is listed in bold.** In the event of a poisoning (including snake bite), call poison control center at 1-800-222-1222.

Northeast Temperate Network

Park	Contact	Phone	Radio	Notes
ACAD	**Dispatch**	**207-288-8791**	**"Dispatch"**	Dispatch is able to coordinate emergency responses (i.e. Search and Rescue, Ambulance, Police, etc.) faster than by dialing 911. Calling Dispatch by radio is the most reliable means, as cell coverage is poor throughout most of the park.
MABI	**911 Emergency Service**s	**911**	-	For emergencies, call 911, which will alert state emergency services. You can also call Woodstock Town Dispatch, but the state service is better at responding to emergencies. Note that cell phone service is poor on the west side of the park
	Woodstock Town Dispatch	802-457-2337		
	MABI Park (802) 457-3368	-	-	Also notify the park: If this is a time when the park visitor center is open, call the park visitor center at extension 22 on the radio or cell phone. If no one answers call anyone by name on duty. If the visitor center is not open but you know someone is at the carriage barn, call (802) 457-3368 and dial 0.
	Visitor's Center	Ext. 222	"22"	
	Carriage Barn	802-457-3368	-	
MIMA	**Emergency Services**	**911**	N/A	For medical emergencies call 911. To reach Protection Rangers call "400 Protection" on the radio. For staff without radios, call the Ranger on Duty number, 508-254-7491 which will go to the cell phone of the Ranger who's on duty at the time of the call. In the event of a poisoning (including snake bite), call the poison control center at 1-800-222-1222.
	Ranger on Duty	508-254-7491	"400 Protection"	
MORR	**Ranger Station**	973-543-7958	**Any 800 unit**	The first call should be to park law enforcement either by radio (first choice) or cell phone). Cell phone coverage is spotty in some areas of the park. If unable to reach the ranger station, contact the Morris County Communications Center. Provide your location and they will contact the park to dispatch a ranger.
	Morris County Communications Center	911 or 973-285-2900		

Appendix S1.D. Emergency contacts/ procedures for each park (continued).

Park	Contact	Phone	Radio	Notes
ROVA	**911 Dispatch Center** Cathy Newhard (Chief Ranger)	**911** 845-229-9380 or 845-489-0183	N/A 219	In an emergency call 911. Follow up with report to Chief Ranger Cathy Newhard at 845- 229-9380, or 845-489-0183. If unable to reach Chief Ranger Cathy Newhard, try contacting Ranger on Duty on the radio by calling "Duty Ranger".
SAGA	**Police/Fire/Ambulance**	**911**	-	There are no emergency services based in the park. Cell phone service may be limited in parts of the park.
SARA	**Emergency Services** Chris Martin Linda White	**911** 518-670-2950 518-441-9017	-	The primary emergency contact is 911. Cell phone service is reliable in most of the park. As soon as practical after contacting 911, or if you have a radio and cannot reach 911 by phone, contact the park law enforcement rangers. Greg Wozniak is the Chief Ranger. Numbers provided for each ranger are cell numbers, and ranger cell phones are carried at all times when on duty.
WEFA	**Emergency Services** Ridgefield Police Ridgefield Ambulance and Fire Wilton Police Wilton Fire Visitor Center Greg Waters Kevin Monthie Linda Cook	**911** 203-438-6531 203-431-2724 203- 834-6260 203- 834-6274 203-834-1896 x0 203-648-2800 203-648-2796 203-834-1896 x23	-	The primary emergency contact is 911, but emergency numbers for the two nearest towns are also provided (the park is on the border of the towns). Cell phone service is reliable in most of the park. Because the WEFA radio frequency only covers the 24 ha core of the park, cell phones should be the main source of communication. If unable to reach 911, call the visitor center phone number. As soon as practical after emergency services have been contacted, or as a last line of contact if unable to reach 911 or the visitor center, call Greg, Kevin, or Linda (park superintendent). Only one of the three needs to be contacted; they will inform each other.

Appendix S1.D. Emergency contacts/ procedures for each park (continued).

Mid-Atlantic Network

Park	Contact	Phone	Radio	Notes
In all cases, 911 should be your choice unless specified in Notes				
APCO	*Brian Eick, NRM*	*434-352-8987 x. 28*		
BOWA	*Timbo Sims, NRM*	*540- 721-2094*		
COLO	*Dorothy Geyer, NRM*	*757-898-2433*		
FRSP	*Chief Rangers Office*	*540-899-2698*		
	Gregg Kneipp, NRM	*540-760-7938*		
GETT	*Sara Koenig, NRM*	*717-338-4483 or 928-266-2197*	*"Ranger on Patrol"*	*If no radio available, call should be to 911.*
GEWA /THST	*Rijk Morawe, NRM*	*804-224-1732 x 237*		
HOFU	*Kate Jensen, NRM*	*610-582-8773 x 228 or 215-692-3340*	*"241" or "Kate Jensen"*	*First Kate Jensen, then visitor's center. Finally call 911.*
	Visitor Center Front Desk	*610-582-8773 x 232*		
PETE	*Tim Blumenschine, NRM*	*804-721-7527*	*"Any 200 Unit Emergency Traffic"*	*Radio or Tim Blumenschine.*
RICH	*Chief Ranger – Tim Mauch*	*804-640-7908*		*Contacts should be called in the order shown.*
	Protection Ranger – Leslie Winston	*804-640-7912*		
	Protection Ranger – Ben Olivencia	*804-640-7915*		
	Protection Ranger – Barry Krieg	*804-640-7917*		
	Kristen Allen, NRM	*804-795-5019*		
SAHI	*Scott Gurney, NRM*	*516-922-4788*		
FO	*Ranger on Duty*	*610-275-1222*		*For non-emergency call the general ranger number*
	Amy Ruhe, NR Office	610-783-1036		

Appendix S1.E. Workers compensation procedures for each park, Version 1.1.

Workers compensation procedures
January 7, 2010

Human Resources contacts for workers compensation are Cecelia Neugebauer (410-962-4290), the NER regional contact; and Carol D. Moore (202-619-7297), the contact for NER/NCR combined. A useful resource on Worker's Compensation is the NPS 2007 Supervisor's Guide to Worker's Compensation.

EXTREMELY IMPORTANT: Make sure that the employee gets prompt medical treatment, if medical attention is needed. If the injury is life-threatening, the employee should be taken to an emergency room immediately; the paperwork can wait. For non-life-threatening injuries, it is OK to issue a CA-16 and CA-17 before the on-line information is entered.

IMPORTANT: Makes sure the employee sees a doctor, not a nurse, nurse practitioner, or physician's assistant. The Worker's Compensation Program tends to deny payment when a doctor is not seen, according to Frank Alvarez (7/11/2008).

Initial Reporting:

If the injured person is a volunteer, Cecelia Neugebauer will likely need to set up a profile for them in SMIS. A volunteer who is a foreign national (and does not have a social security number) will need to be processed on paper; Frank will need to help with this as well.

If an employee has an accident or other workers compensation incident (e.g., bitten by a deer tick), the first step is for them to report the incident. THIS MUST BE DONE WITHIN 48 HOURS, AND MUST BE DONE FOR EACH INCIDENT. Note that if there is a recent claim in the system for this employee, he or she may not be able to start a new report. Contact Cecelia Neugebauer for assistance.

1. Go to https://www.smis.doi.gov, and click on Accident Reporting.
2. Click on "File a Worker's Compensation Claim (CA1/CA2)".
3. Log in using your last name and the last four of your Social Security Number
4. Enter your e-mail address if needed, then click "Verify E-mail and Request a Claim ID". This can be any e-mail address that you have regular access to.
5. Check your e-mail to get your claim ID, then enter the claim ID in the box on the web site.
6. Verify or input all information requested on the next page. Tick bites would be an injury/traumatic injury rather than an occupational disease or illness.

7. On the next page, enter the details that are asked for, including date, location, and cause and nature of injury.

Fill out the employee certification. I have not been able to get solid guidance on this, but apparently checking "Continuation of Regular Pay (COP)" will allow employees to claim doctor's visits and other lost time due to the incident as regular pay (i.e., not use sick or annual leave). This box should probably be checked. Make sure to read all the statements, and click the check box that you have read the statements. Then click "Complete your claim submission".

Make sure to send a note to your supervisor. Don't forget to *include the claim number* generated by the system. He or she will need to enter information into the same system about your report, and will also need to issue the CA-16 form that you will need to bring to any doctor's appointment.

Once the employee fills out the CA-1 or CA-2, the supervisor needs to go into SMIS (Safety Management Information System) to fill out the supervisor portion of the form. The supervisor should receive an automated message from the SMIS system.

1. Go to https://www.smis.doi.gov, and click on Accident Reporting.
2. Click on "Perform All Supervisor Safety Activities", and click "Proceed".
3. Log in using your last name and the last four of your Social Security Number
4. Enter your e-mail address if needed, then click "Submit/Verify your E-mail Address". This can be any e-mail address that you have regular access to.
5. Choose "Complete the supervisor section of a CA-1 or CA-2" and click "Perform".
6. Enter the Claim Identifier provided by the employee, and click "Submit".
7. Fill in the Supervisor's Report and Certification, and click "Submit". Each box has hyper-linked help if you have any questions about what is needed.
8. Fill in the additional information requested about the supervisor's investigation into the accident, and click "Submit".
9. Next, print and sign the CA-1, and also have the employee sign the CA-1. Keep the form on file in the employee's local personnel file.
10. Print the OSHA Form 301, and save this with the CA-1

Fill out form CA-16. The CA-16 MUST be issued within seven days of the incident. DO NOT post this form on any web site; it should not be accessible to employees (it was described as a "blank check" by Carol Moore).

1. Fill in blocks 2 through 14. Box 1 can be filled in by the employee.
2. NOT CLEAR on whether tick bites require OWCP approval (box 7).

3. Cecelia Neugebauer will fill in box 12 at a later date.

Fill out form CA-17. This form is available at http://www.dol.gov/libraryforms/go-us-dol-form.asp?FormNumber=367. It is the supervisor's statement about the injury, and information about the employee's job.

1. Fill out all information on Side A.

2. On page 2, supply the agency address (e.g., network mailing address). Cecelia Neugebauer will supply the OWCP address at a later date.

Give the CA-16 and CA-17 to the employee. The employee will need the doctor to fill in the back of form CA-16 (boxes 15 – 39), side B and address on page 2 of form CA-17, and return the form to the employee. Things to keep in mind:

1. Employees need to ask the doctor's office whether they accept federal Worker's Compensation BEFORE they go for their appointment.

2. Employees should be provided with the information at http://www.dol.gov/esa/owcp/dfec/regs/compliance/infoinjuredwrkers.htm.

3. Employees should provide the information at http://www.dol.gov/esa/owcp/dfec/regs/compliance/infomedprov.htm to the doctor. Among other things, the doctor must be aware that they are responsible for signing up in an online system (ACS) in order to be paid for the Worker's Compensation case.

4. If possible, a typed medical summary (from the doctor's office) should be attached to the medical form; at the very least, employee should ensure that doctor's responses on the CA-16 are legible.

When the employees return forms CA-16 and CA-17 to you:

Everything needs to go to Cecelia Neugebauer. Keep copies and send her the originals at the address below.

Cecelia R. Neugebauer
National Park Service/Northeast Region
Central Servicing Human Resources Office
2400 E. Fort Avenue
Baltimore, MD 21230-5393
(410) 962-4290 x111 (voice)
(410) 962-2182 (fax)

Other important information:

Use this link to find forms used by OWCP:
http://www.dol.gov/owcp/dfec/regs/compliance/forms.htm

Employees can use this link for tracking the progress of their claim:

http://owcp.dol.acs-inc.com/portal/main.do

Jim Comiskey compiled information about billing from a series of interactions with Frank Alvarez (previous OWCP contact). The document covers information on billing for the employee, and information on billing for doctors, hospitals, and pharmacies.

Alternative Work Assignment (AWA):

If the doctor says that the employee cannot return to regular work, then it is important to set up an Alternative Work Assignment for the employee.

- Use the AWA template to describe the alternative work assignment. The Supervisor's Guide has a filled-out example.
- Use the AWA physician letter template to create a letter to the employee's doctor.
- Use the AWA employee letter template to create a letter to the employee.
- Send the above documents to the employee, along with a copy of their PD. Copy Cecelia Neugebauer on the e-mail.
- The employee should return to the doctor with the AWA, physician letter, PD, and CA-17, and discuss the alternative work assignment with the doctor. The doctor will need to sign off on the AWA or make suggestions.
- Once you receive the doctor's input, discuss the AWA with Cecelia Neugebauer to ensure that the AWA is within the doctor's restrictions before the employee returns to work.

Time sheets:

Make sure that the employee's time sheet is filled out correctly to reflect any lost time due to the injury; this is required under FECA, the Federal Employees Compensation Act.

1. Time lost on the day of injury due to a traumatic injury is coded as Administrative Leave (060).
2. Lost time ("Continuation of Pay" or COP) after the day of injury includes time spent going to doctor's appointments, physical therapy, or time the employee is not able to work due to the injury.
3. Record the amount of hours lost due to the injury on the employee's time sheet using the appropriate code. NOTE: Frank Alvarez (7/11/2008) recommended claiming the full day that has any time lost as COP. Even if the employee only spends 1 hour at a doctor's appointment, he thought that the full day should be coded COP. This advice seems to run

counter to the pay code information that Carol Daye supplied: "Code the T&A Record with the actual number of hours absent."

4. If the employee is unable to work for a period that includes lieu days, use the codes for Unpaid COP on each lieu day.
5. Continuation of Pay codes:
    a. 160 – FECA/COP Paid (1st Occurrence)
    b. 164 – FECA/COP Paid (2nd Occurrence)
    c. 166 – FECA/COP Paid (3rd Occurrence)
    d. 168 – FECA/COP Paid (4th Occurrence)
    e. Other codes are available for 5th through 11th occurrences; starting at 16L
    f. My assumption is that an "occurrence" is any time related to a specific accident or injury. So if an employee has a tick bite and then sprains an ankle, you'd use the "first occurrence" codes for the tick bite and the "second occurrence" codes for the sprain.
6. Unpaid Continuation of Pay codes:
    a. 161 – FECA/COP Unpaid (1st Occurrence)
    b. 165 – FECA/COP Unpaid (2nd Occurrence)
    c. 167 – FECA/COP Unpaid (3rd Occurrence)
    d. 169 – FECA/COP Unpaid (4th Occurrence)
    e. Other codes are available for 5th through 11th occurrences; starting at 16M
7. There are separate codes for "Light Duty" work, but the NPS 2007 Supervisor's Guide says to use code Regular Hours (010) for "Light Duty" or an AWA.

Revision Log

June 26, 2009 – Added a paragraph about handling injured volunteers.

January 7, 2010 – Added section "Other important information".

January 31, 2012 – Changed NPS OWCP contact to Cecelia Neugebauer.

Appendix S1.F. Procedures and guidance for proper use of park radios.

Overview

The following information applies to radios owned and programmed specifically for NETN.

Each radio has three zones that are indicated by A, B, and C on the top of the radio (Figure 1, feature 12). Zone (A) is programmed with radio communication frequencies for all parks <u>except</u> ROVA and is programmed with NOAA weather report frequencies. Zone B and C do not have programmed radio frequencies. Crews should check with the resource managers when they arrive in each park to determine the type of use allowed for each park (i.e., for emergency use only, or daily communication).

Channels 1-4, and 8-14 are programmed with park-specific frequencies. Channel 16 is programmed to broadcast NOAA weather report. Channels can be changed by dialing the knob on top of the radio to the correct channel (Figure 1, feature 15). Use the label on the radio to determine which channel to use for each park. Channels with DIR are for direct radio-to-radio communication, and require radios to be relatively close (less than a mile, and depending on terrain). Channels with RPT use the park's repeater radio towers to broadcast the signal over a longer distance. This requires radios to be within range of the repeaters, but also means the entire park will hear the conversation.

Channel 15 (Zone A) is the "NETN direct talk" frequency. This frequency is unique to NETN radios and is to be used for direct radio-to-radio communication without interfering with any park-based frequencies. As the name implies, this is radio-to-radio communication and is therefore limited by the distance between radios and terrain.

Radio procedures during normal operating conditions

Proper radio communications are paramount to efficient use of radio system resources. Standard procedures promote effective communications. This document has been developed following information on various online procedural documents although your unique environment may require further modification.

Before you press the Push to Talk (PTT) button (Figure 1, feature 5), gather your thoughts about what you are going to say. Many people with radios have a tendency to talk and/or repeat too much. Say what you need to say without unnecessary repeats. Keep in mind the others who may be on the same frequencies you are using. Those frequencies are unavailable to others until they are released, so you should strive to get your message through clearly the first time.

In general, there are five parts to Calling/Communications. The more serious or complex the situation, the more important these procedures become. The information contained herein MUST be practiced until it is second nature. Practicing proper day-to-day radio procedures will make radio procedures automatic and reduces confusion. Another way of saying this is that the secret to working quickly and efficiently is to use common approved radio communication procedures and guidelines, especially in priority/emergency situations.

1st…Give the radio call sign of the station you are calling. This alerts that station that they are being called and that they should listen to determine who is calling.

2nd…Say “THIS IS”. The called station knows your tactical call follows. This is extremely important in cases where there is a lot of confusion or poor signal conditions.

3rd…Give your radio call sign. Generally, it’s advisable not to use personal names since it may be confusing especially with common names. Call signs are usually dictated by the site radio system managers. They are usually based on departmental and individual assignments. Remember that call signs only make sense if the other parties know who is using the specific call signs. In temporary situations such as temporary work at a remote location you can sometimes use a descriptive call sign such as “NETN Forest Crew”. In ACAD, your call sign is 318 and your last name. Make sure you verify call signs with the personnel or station you will be communicating with during the day.

4th…Give your message and speak clearly. Don’t speak too fast especially if the message needs to be written down. Pause after logical phrases. Do not use the word “break” when you pause. It is confusing, wastes time and has other connotations. Merely release the PTT button and pause. If the other station has questions, they should key up and make their request known. This also permits other stations to break in if they have emergency traffic.

5th…You can end your conversation with “CLEAR” however it isn’t required.

It is sometimes permissible to omit the radio call sign designator of the station you are calling, BUT only after communications have been established and no confusion will occur. Don’t waste time, by using superfluous tactical call sign.

The term “THIS IS” is used to separate the FROM and TO call signs. If, and only if, confusion will not result, omitting the “THIS IS” phrase is permissible.

If you are the calling station and you omit your own radio call sign, you can create confusion. In certain situations, such as quick replies between operators, it can be accomplished without confusion. You must NOT use this simplification where messages can be interpreted incorrectly.

Elimination of the words “OVER” and “OUT” is possible where it doesn’t introduce problems. Unkeying after your message implies “OVER”. To comply with FCC regulations, you must give your radio call sign when you first start to talk and when you finish your communication. Giving your radio call sign can imply an “OUT” ending. Should giving your call sign cause any confusion, do not hesitate to add the word “CLEAR”.

Radio procedures during an emergency

1. Identify yourself at the beginning of each transmission especially where confusion may result if omitted.

2. Identification is a requirement of the FCC. According to the FCC, radio users must give their call sign when they first start to talk and when they finish their communication.

3. Listen before transmitting. Be sure you are not on the air with someone else.

4. Know what you are going to say before you push the mike button; in other words, engage your brain before you put your mouth in gear.

5. Hold the transmit button down for at least a second before beginning your message to insure that the first part of your message is not cut off.

6. TALK ACROSS THE FACE OF YOUR MICROPHONE. This technique makes the communications more understandable. In other words, hold the face of the microphone almost at a right angle to your face.

7. Speak slowly, distinctly, clearly, and do not let your voice trail off at the end of words or sentences. Give each and every word equal force. For some this takes a lot of practice and conscious effort but do it.

8. Never acknowledge calls or instructions unless you understand the call or instructions perfectly. If you do not understand, recontact and “say again” the missed traffic.

9. When you have understood the message, acknowledge the receipt with the words “copy”, “received” or “acknowledged.” The word “copy” is preferred.

10. The word “break” is never used UNLESS there is an emergency. Give your call sign to gain access to a net.

11. Always acknowledge calls and instructions. Nothing is more disruptive to the smooth flow of communications than dead silence in response to a message. If you cannot copy or respond to the call immediately, then tell the caller to “repeat” or “stand by.” Otherwise, acknowledge each call immediately.

12. Under stress, many operators have a tendency to talk too fast. ACCURACY FIRST, SPEED SECOND.

13. At times, radio conditions are poor and words must be overly exaggerated to be understandable. In general, speak very slowly and distinctly to carry through static and weak signals.

14. If you are relaying a message for another person, be sure you repeat the message exactly, word for word as it is given to you. If it makes no sense to you, get an explanation before you put it on the air. If necessary, refer the message back to the originator for clarification.

15. There is no place for Ham radio “Q” signals or signals from any other radio service during official and emergency communications. They are too easily misunderstood, rarely save time, and often result in errors. Use signals from the Local Government Public-Safety Radio Service or “plain English” only.

16. Do not act as a relay station unless Dispatch, or another radio station, asks for a relay – and you can fulfill the requirement with your station.

17. When transmitting numbers (house numbers, street & telephone numbers, etc.), always transmit number sequences as a series of individual numbers. Never say numbers in combinations.

18. If a proper name needs to be transmitted, try to spell it out using the recognized radio phonetic alphabet. Do not use cute or self-invented phonetics. There is no place for them in official and emergency communications. Avoid using the phrase “common spelling” to reduce confusion.

19. ONLY TRANSMIT FACTS. If your message is a question, deduction, educated guess, or hearsay, identify it as such. Do not clutter up the air with non-essential information. Be careful what you say on the air. There are many ears listening. Many facts will be taken out of context even when carefully identified.

20. If you do not understand the whole message given to you or if you missed a word out of the transmission, reply with “Say again.” Do not say “please repeat” because it sounds too much like the word “received” when conditions are poor.

21. Chewing gum, eating, and other activities with items in the mouth tend to clutter up the clarity of your speech. Don’t do this.

22. Avoid angry comments on the air at all costs. Obscene statements are not necessary and are out of place in all communications.

23. Sound alert. Nothing destroys confidence as much as a bored or weary sounding radio operator. If you are tired, get a relief operator.

24. During an incident, communication suffers enough confusion without wisecracks and jokes. When providing emergency communications you must remember that it is serious business and should be treated as such at all times.

25. Stay off the air unless you are sure you can be of assistance. It does no good to offer advice, assistance, comments or other input unless you can truly provide clarification. It is better to remain silent and be thought a fool than to open your mouth and remove all doubt!

26. Always know your location. If you are mobile or portable and moving around, always keep a sharp lookout for landmarks. You must be able, if called upon, to accurately describe your location at any time.

27. When you are on the fringes of communications, look for a receiving “hot spot” site and use it. Don’t walk around talking while in a communications fringe area. Repeaters have much more power than your handheld. Even if you have a good signal from a repeater, it does not mean you are good going into the repeater.

28. Park dispatchers are often very busy with work that is not on the air. If you call Dispatch and do not get a reply, be patient and call again in a minute or two. If you have an emergency, say you have “Emergency traffic” after you identify yourself.

In conclusion, these few rules and suggestions are intended to help you become a better radio operator. Analyze your present operating methods and try to polish each element so your participation in radio communications is professional and worthwhile.

Appendix S1.G. Personal Locator Beacon Management

Personal Locator Beacons are emergency devices that directly alert search and rescue services. They should only be used as a last resort and in situations where immediate assistance is required. Field crews will be trained with and provided the FastFind PLB owner's manual, which provides easy-to-follow illustrated instructions on how to deploy the PLB in the event of an emergency. The owner's manual can also be downloaded from the following website:
http://lib.store.yahoo.net/lib/landfallnav/FASTFINDmanual.pdf#_ga=1.124929742.590391232.1481749960

This Appendix covers the periodic management that is required to maintain the PLBs.

Model Information

McMurdo FastFind 210 GPS
website: http://www.mcmurdomarine.com/personal-locator-beacons

When activated, McMurdo FastFind 210 GPS transmits to your unique emergency identifier to the Cospas Sarsat satellite system, which will then pinpoint your location and alert local Search and Rescue teams. The unit will transmit continuously for 24 hours and is waterproof up to 10m. It will not float or transmit underwater.

Testing

The McMurdo FastFind PLB has a battery and GPS test routine. It is important to ensure that each unit is working correctly, but units should not be too frequently tested to avoid draining the battery. Each unit is limited to 12 battery tests and 2 GPS tests per year. Therefore, test each unit once before the field season and only retest if necessary. For test routine, see owner’s manual.

Registration

Each unit must be reregistered with the NOAA Satellite and Information Service every two years. Visit beaconregistration.noaa.gov to update emergency contact information or renew a registration. New registration stickers will be sent to the registered owner. You can recover login-in information for a PLB with the UIN and the owner name and phone number.

User Name: Forestcrew
Password: Forestcrew2016! (as of Jan. 2016)
Owner: Kate M Miller

PLB Unit Information (Spring 2016)						
Name	**UIN**	**Assigned to**	**Owner**	**Owner Phone**	**Primary Contact**	**PC Phone**
MIDN	2DCE65F056FFBFF	Forest Crew	Kate M Miller	207-288-8736	Adam Kozlowski	801-389-6070
NETN 1	2DCE65F1AAFFBFF	Forest Crew	Kate M Miller	207-288-8736	Adam Kozlowski	801-389-6070
NETN 2	2DCE65F170FFBFF	Wetlands	Kate M Miller	207-288-8736	Adam Kozlowski	801-389-6070
NETN 3	2DCE6CAD4CFFBFF	Land Birds	Kate M Miller	207-288-8736	Kate Miller	207-288-8736

Emergency Contact Information for Forest Crew PLBs (Spring 2016)				
Role	**Contact**	**Work Number**	**Cell Number**	**Other**
Owner	Kate M Miller	207-288-8736	207-801-8368	207-610-4225
Primary Contact	Adam Kozlowski	801-457-3368 ext. 240	801-389-6070	
Secondary Contact	Mark Johnson	540-693-3200 ext. 6060	610-764-0068	

Battery Life

The PLB unit batteries last for 5 years. The expiry date is listed on the back of the PLB. If the batteries are set to expire before or during the field season, the unit must be serviced before the field season. In 2016, the units were serviced for $120/unit by the Hamilton Marine in Searsport, ME.

PLB Management Timeline		
Task	**Interval**	**Expires/Revisit**
Confirm/Update emergency contact information	Annually	Before field season
Test battery life and GPS function	Annually	Once before field season
Renew PLB registration	Biennially	December 2018
Replace Batteries	Every five years	January 2022

Appendix S1.H. Instructions for responding to an automobile accident in an NPS-owned vehicle.

1. Stop immediately and turn on emergency flashers.
2. Take steps to prevent another accident at the scene.
3. Call 911 or ambulance if necessary.
4. Notify police, NPS law enforcement and your supervisor.
5. In the event of death, actual or potential serious injury, or significant property damage (damage greater than $2,500), the employee involved must immediately notify the NER Regional Tort Claims Officer (TCO), Cyrille Young (215-597-7701), in addition to their supervisor.
6. In reporting an accident, employee should state the facts to the best of her/her knowledge. **Conclusions as to fault or responsibility should not be stated.** The employee should report the accident only to authorized representatives of the Government, the employee's insurance company, and police officers investigating the accident. The employee shall also file any report required by law.
7. Get name and address of witness (preferably two witnesses). Ask witness to complete Standard Form (SF) 94, Statement of Witness, contained in vehicle glove compartment.
8. State/provide your name, address, place of employment, name of your supervisor, and upon request show your driver's license and vehicle registration information.
9. Complete Standard Form (SF) 91, Motor Vehicle Accident Report at the scene. If conditions prevent this, make notes of the following:
    a. Registration information for other vehicle(s) (owner's name, owner's address, tag number, VIN, and vehicle description)
    b. Information on other drivers (name, address, operator's permit, and expiration date)
    c. Name and address of each person involved and extent of injury, in any.
    d. Name and address of company insuring other vehicle(s) and insurance policy number
    e. General information such as location, time, measurements, weather, damage, etc.
10. Encourage police to provide a Police Report and, if available, submit a copy with SF 91.
11. If you have a camera, take pictures of the accident scene and any damage to the vehicles involved. Submit along with SF 91.

12. If vehicle is unsafe to operate, arrange for a towing services and pay for these services on vehicle charge/gas card.

13. Submit all reports and data to your supervisor within one working day.

14. If federal employee is injured, workers compensation process needs to be initiated within 48 hours of incident. Supervisor will assist with this process. It is important for injured employee to receive prompt medical treatment. Make sure the employee sees a doctor, not a nurse, nurse practitioner, or physician's assistant.

15. Supervisor will submit copies of all reports and data to the employee's regional TORT Claims Officer (TCO) [Cyrille Young 215-597-7701] as soon as possible but no later than 10 calendar days after the accident.

Accident/collision reports should be filed for:

1. All motor vehicle accidents involving federally owned or leased vehicles and employee-owned or rented vehicles while being used on official business, regardless of the amount of damage.

2. All public/visitor accidents will be reported on a SF-91 when a government-owned vehicle is involved, government property is damaged, fatality occurs, medical treatment is required and/or a reasonable possibility of a tort claim is expected.

3. Thefts and Vandalism should be reported to Park Law Enforcement Officials rather than reported on SF-91.

4. Reporting Multiple Vehicle Accidents – when a privately owned vehicle damages Government property, two reports (SF-91) are required: one report for the Government property and one for the private operator.

Appendix S1.I. Northeast Region accident/incident reporting process.

Northeast Region
TORT Claims – Accident/Incident Reporting Process

Regional office employees travel on official government business and may be injured and/or involved in a motor vehicle accident while in travel status. Use this checklist to ensure all required report information is gathered and proper notifications have been made immediately following an injury and/or accident that may result in a possible **tort** claim against the Government in accordance with Departmental Manual, Part 451, *Claims*.

REPORTING GUIDELINES

1. Employees will immediately report any incident or accident involving a private person or private property which may give rise to a tort claim against the Government.

2. In the event of death, actual or potential serious personal injury or significant property damage the employee involved will immediately notify his or her supervisor and the Regional Tort Claims Officer (TCO), Cyrille Young [215.597.7701].

3. Employee supervisor will immediately follow up with the regional TCO to ensure the employee report was received and determine if additional information is needed.

4. Damage to a government motor vehicle (GMV), as defined by Reference Manual 50B, Occupational Safety and Health Program as any vehicle owned, leased, rented or otherwise acquired for official purposes, or to private property resulting from GMV operation will be reported immediately as described above.

5. Standard Form (SF) 91, Motor Vehicle Accident Report, and SF 94, Statement of Witness, as necessary must be completed for all motor vehicle accident cases and promptly submitted to the regional TCO. These forms should be printed and kept with you while on official government travel when operating a GMV. Copies of all accident reports will be furnished to the employee's regional TCO as soon as possible but no later than 10 calendar days after the accident.

6. In reporting an accident, employee should state the facts to the best of his/her knowledge. Conclusions as to fault or responsibility should not be stated. The employee should report the accident only to authorized representatives of the Government, the employee's insurance company, and police officers investigating the accident. The employee shall also file any report required by law.

7. If an employee involved in an accident carries liability insurance which may cover the employee or the Government, the employee shall report the accident to the insurance company and shall also furnish the regional TCO a copy of the insurance policy together with applicable endorsements and amendments.

DEFINITIONS

Government Motor Vehicle: Any vehicle owned, leased, rented or otherwise acquired for official purposes.

Incident: An event involving National Park Service employees or other personnel directly supervised by the NPS, that results in a near-hit, injury, illness, fatality, damage to government property, or damage to other property being used for government business.

Minor Incident/Accident: An event involving National Park Service employees, or other personnel directly supervised by the NPS, that results in:

1. Injury or illness requiring only first-aid treatment (per OSHA definition) and is not otherwise a recordable injury/ illness; and/or

2. Property damage of less than $2,500.

NPS Employee: All NPS employees, or other Federal, State, or local agency employees under NPS supervision/jurisdiction, and/or contractors and volunteers directly supervised by NPS or under NPS jurisdiction.

Significant Property Damage/Operating Loss Incident: Incidents that result in property damage or operating loss from $2,500 up to, but less than $250,000.

Serious Accident: An incident involving National Park Service employees, or other Federal, State, or local agency employees under NPS supervision/jurisdiction, and/or contractors and volunteers directly supervised by NPS (e.g. volunteers, SCA, emergency workers, etc.), that results in:

1. One or more work-related fatalities, or imminently fatal injuries or illnesses;

2. Hospitalization of three or more employees from a single occurrence;

3. Property damage under Departmental/NPS control, and/or operating loss of $250,000 or more; and/or consequences that the NPS Designated Agency Safety and Health Official (DASHO) or the Regional Designated Safety and Health Official (RDSHO) judges to warrant investigation under the serious accident investigation procedures.

Appendix S1.J. SF-91 Motor Vehicle Accident Report

MOTOR VEHICLE ACCIDENT REPORT	Please read the Privacy Act Statement on Page 3	INSTRUCTIONS: Sections I thru IX are filled out by the vehicle operator. Section X, items 72 thru 82c are filled on by the operator's supervisor. Section XI thru XIII are filled out by an accident investigator for bodily injury, fatality, and/or damage exceeding $500.

SECTION I - FEDERAL VEHICLE DATA

1. DRIVER'S NAME (Last, first, middle)	2. DRIVER'S LICENSE NO./STATE/LIMITATIONS	DATE OF ACCIDENT

4a. DEPARTMENT/FEDERAL AGENCY PERMANENT OFFICE ADDRESS	4b. WORK TELEPHONE NUMBER ( )

5. TAG OR IDENTIFICATION NUMBER	6. EST. REPAIR COST $	7. YEAR OF VEHICLE	8. MAKE	9. MODEL	10. SEAT BELTS USED ☐ YES ☐ NO

11. DESCRIBE VEHICLE DAMAGE

SECTION II - OTHER VEHICLE DATA (Use Section VIII if additional space is needed)

12. DRIVER'S NAME (Last, first, middle)	13. SOCIAL SECURITY NO./ TAX IDENTIFICATION NO.	14. DRIVER'S LICENSE NO./STATE/LIMITATIONS

15a. DRIVER'S WORK ADDRESS	15b. WORK TELEPHONE NUMBER ( )
16a. DRIVER'S HOME ADDRESS	16b. HOME TELEPHONE NUMBER ( )
17. DESCRIPTION OF VEHICLE DAMAGE	18. ESTIMATED REPAIR COST $

19. YEAR OF VEHICLE	20. MAKE OF VEHICLE	21. MODEL OF VEHICLE	22. TAG NUMBER AND STATE

23a. DRIVER'S INSURANCE COMPANY NAME AND ADDRESS	23b. POLICY NUMBER
	23c. TELEPHONE NUMBER ( )

24. VEHICLE IS ☐ CO-OWNED ☐ RENTAL ☐ LEASED ☐ PRIVATELY OWNED	25a. OWNER'S NAME(S) (Last, first, middle)	25b. TELEPHONE NUMBER ( )

26. OWNER'S ADDRESS(ES)

SECTION III - KILLED OR INJURED (Use Section VIII if additional space is needed)

A

27. NAME (Last, first, middle)	28. SEX	29. DATE OF BIRTH

30. ADDRESS

31. MARK "X" IN TWO APPROPRIATE BOXES	32. IN WHICH VEHICLE	33. LOCATION IN VEHICLE	34. FIRST AID GIVEN BY
☐ KILLED ☐ INJURED ☐ DRIVER ☐ HELPER ☐ PASSENGER ☐ PEDESTRIAN	☐ FED ☐ OTHER (2)		

35. TRANSPORTED BY	36. TRANSPORTED TO

B

37. NAME (Last, first, middle)	38. SEX	39. DATE OF BIRTH

40. ADDRESS

41. MARK "X" IN TWO APPROPRIATE BOXES	42. IN WHICH VEHICLE	43. LOCATION IN VEHICLE	44. FIRST AID GIVEN BY
☐ KILLED ☐ INJURED ☐ DRIVER ☐ HELPER ☐ PASSENGER ☐ PEDESTRIAN	☐ FED ☐ OTHER (2)		

45. TRANSPORTED BY	46. TRANSPORTED TO

47. Pedestrian

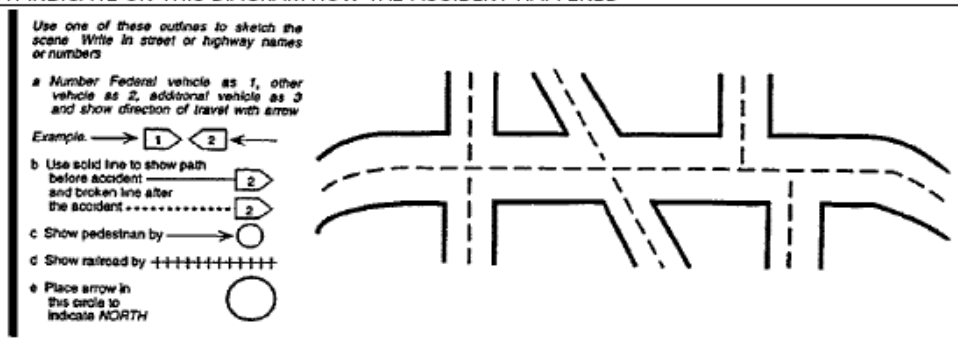
a. NAME OF STREET OR HIGHWAY	b. DIRECTION OF PEDESTRIAN (SW corner to NE corner, etc.)	
	FROM	TO

c. DESCRIBE WHAT PEDESTRIAN WAS DOING AT TIME OF ACCIDENT (Crossing intersection with signal, against signal, diagonally; in roadway playing, walking, hitchhiking, etc.)

SECTION IV - ACCIDENT TIME AND LOCATION (Use Section VIII if additional space is needed.)

48. DATE OF ACCIDENT	49. PLACE OF ACCIDENT (Street address, city, state, ZIP Code; Nearest landmark; Distance nearest intersection; Kind of locality (industrial, business, residential, open country, etc.); Road description).
50. TIME OF ACCIDENT AM PM	

51. INDICATE ON THIS DIAGRAM HOW THE ACCIDENT HAPPENED



52. POINT OF IMPACT (Check one for each vehicle)

FED	2	AREA
		a. Front
		b. R. Front
		c. L. Front
		d. Rear
		e. R. Rear
		f. L. Rear
		g. R. Side
		h. L. Side

53. DESCRIBE WHAT HAPPENED (Refer to vehicles as "Fed", "2", "3", etc. Please include information on posted speed limit, approximate speed of the vehicles, road conditions, weather conditions, driver visibility, condition of accident vehicles, traffic controls (warning light, stop signal, etc.), condition of light (daylight, dusk, night, dawn, artificial light, etc.), and driver actions (making U-turn, passing, stopped in traffic, etc.)

SECTION V - WITNESS/PASSENGER (Witness must fill out SF 94, Statement of Witness) (Continue in Section VIII.)

A	54. NAME (Last, first, middle)	55. WORK TELEPHONE NUMBER ( )	56. HOME TELEPHONE NUMBER ( )
	57. WORK ADDRESS	58. HOME ADDRESS	
B	59. NAME (Last, first, middle)	60. WORK TELEPHONE NUMBER ( )	61. HOME TELEPHONE NUMBER ( )
	62. WORK ADDRESS	63. HOME ADDRESS	

SECTION VI - PROPERTY DAMAGE (Use Section VIII if additional space is needed.)

64a. NAME OF OWNER (Last, first, middle)	64b. WORK TELEPHONE NUMBER ( )	64c. HOME TELEPHONE NUMBER ( )
64d. WORK ADDRESS	64e. HOME ADDRESS	
65a. NAME OF INSURANCE COMPANY	65b. TELEPHONE NUMBER ( )	65c. POLICY NUMBER
66. ITEM DAMAGED	67. LOCATION OF DAMAGED ITEM	68. ESTIMATED COST

SECTION VII - POLICE INFORMATION

69a. NAME OF POLICE OFFICER	69b. BADGE NUMBER	69c. TELEPHONE NUMBER ( )
70. PRECINCT OR HEADQUARTERS	71a. PERSON CHARGED WITH ACCIDENT	71b. VIOLATION(S)

SECTION VIII - EXTRA DETAILS

SPACE FOR DETAILED ANSWERS. INDICATE SECTION AND ITEM NUMBER FOR EACH ANSWER. IF MORE SPACE IS NEEDED, CONTINUE ITEMS ON PLAIN BOND PAPER.

PRIVACY ACT STATEMENT

The information on this form is subject to the Privacy Act of 1974 (5 U.S.C. section 552a). Authority to collect the information is Title 40 U.S.C. Section 491 and title 31 U.S.C. Section 7701. The information is required by Federal Government agencies to administer motor vehicle programs, including maintaining records on accidents involving privately owned and Federal fleet vehicles, and collecting accident claims resulting from accidents. Federal employees, and employees under contract, will use the information only in the performance of their official duties. Routine uses of the collected information may include disclosures to: appropriate Federal, State, or local agencies or contractors when relevant to civil, criminal, or regulatory investigations or prosecutions; the Office of Personnel Management and the General Accounting Office for program evaluation purposes; a Member of Congress or staff in response to a request for assistance by the individual of record; another Federal agency, including the Departments of Treasury and Justice, or a court under judicial proceedings; agency Inspectors General in conducting audits; private insurance and collection agencies (including agencies under contract to Treasury to collect debt), and to other agency finance offices for fiscal management and debt collection. Furnishing the requested information is mandatory, including the Social Security Number or Taxpayer's Identification Number (TIN) for use as a unique identifier to ensure accurate identification of individuals or firms in the system.

SECTION IX - FEDERAL DRIVER CERTIFICATION

I certify that the information on this form (Sections I thru VIII) is correct to the best of my knowledge and belief.

72a. NAME AND TITLE OF DRIVER	72b. DRIVER'S SIGNATURE AND DATE

SECTION X - DETAILS OF TRIP DURING WHICH ACCIDENT OCCURRED

73. ORIGIN	74. DESTINATION

75. EXACT PURPOSE OF TRIP

	DATE	TIME (Include AM or PM)		DATE	TIME (Include AM or PM)
76. TRIP BEGAN			77. ACCIDENT OCCURRED		

78. AUTHORITY FOR THE TRIP WAS GIVEN TO THE OPERATOR

☐ ORALLY ☐ IN WRITING (Explain)

79. WAS THERE ANY DEVIATION FROM DIRECT ROUTE?

☐ NO ☐ YES (Explain)

80. WAS THE TRIP MADE WITHIN ESTABLISHED WORKING HOURS?

☐ YES ☐ NO (Explain)

81. DID THE OPERATOR, WHILE ENROUTE, ENGAGE IN ANY ACTIVITY OTHER THAN THAT FOR WHICH THE TRIP WAS AUTHORIZED?

☐ NO ☐ YES (Explain)

82. COMPLETED BY DRIVER'S SUPERVISOR	a. DID THIS ACCIDENT OCCUR WITHIN THE EMPLOYEE'S SCOPE OF DUTY	
	☐ YES ☐ NO	b. COMMENTS

83a. NAME AND TITLE OF SUPERVISOR	83b. SUPERVISOR'S SIGNATURE AND DATE	83c. TELEPHONE NUMBER
		( )

SECTION XI - ACCIDENT INVESTIGATION DATA

84. DID THE INVESTIGATION DISCLOSE CONFLICTING INFORMATION. ☐ NO ☐ YES (If checked, explain below.)

85. PERSONS INTERVIEWED

NAME	DATE	NAME	DATE
a.		c.	
b.		d.	

86. ADDITIONAL COMMENTS (Indicate section and item number of reach comment).

SECTION XII - ATTACHMENTS

87. LIST ALL ATTACHMENTS TO THIS REPORT

SECTION XIII - COMMENTS/APPROVALS

88. REVIEWING OFFICIAL'S COMMENTS

89. ACCIDENT INVESTIGATOR			90. ACCIDENT REVIEWING OFFICIAL		
a. SIGNATURE		b. DATE	a. SIGNATURE		b. DATE
c. NAME (First, middle, last)			c. NAME (First, middle, last)		
d. TITLE			d. TITLE		
e. OFFICE			e. OFFICE		
f. OFFICE TELEPHONE NUMBER			OFFICE TELEPHONE NUMBER		
AREA CODE	NUMBER	EXTENSION	AREA CODE	NUMBERf.	EXTENSION

Appendix S1.K. SF-94 Statement of Witness.

STATEMENT OF WITNESS (*Attach additional sheets if necessary*)	1. DID YOU SEE THE ACCIDENT?	2. WHEN DID THE ACCIDENT HAPPEN? a. TIME ☐ *a.m.* ☐ *p.m.*	b. DATE	FORM APPROVED O.M.B. NUMBER 3090-0118

3. WHERE DID THE ACCIDENT HAPPEN? (*Give street location and city*)

4. TELL IN YOUR OWN WAY HOW THE ACCIDENT HAPPENED

5. WHERE WERE YOU WHEN THE ACCIDENT OCCURRED?

6. WAS ANYONE INJURED, AND IF SO, EXTENT OF INJURY IF KNOWN?

7. DESCRIBE THE APPARENT DAMAGE TO PRIVATE PROPERTY

8. DESCRIBE THE APPARENT DAMAGE TO GOVERNMENT PROPERTY	9. IF TRAFFIC CASE, GIVE APPROXIMATE SPEED OF:
	a. GOVERNMENT VEHICLE *Miles per Hr.*
	b. OTHER VEHICLE *Miles per hr.*

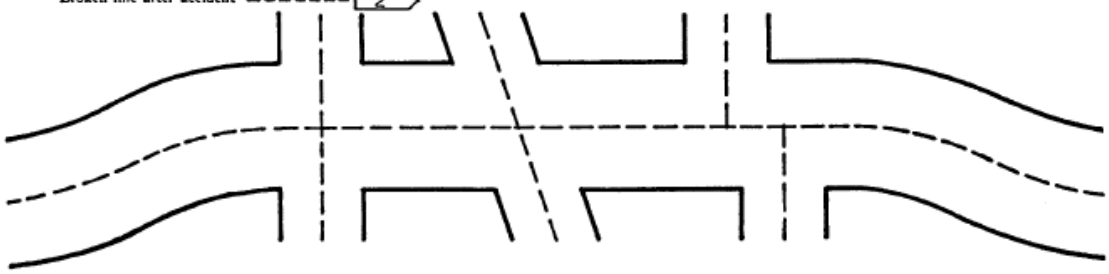
10. GIVE THE NAMES AND ADDRESSES OF ANY OTHER WITNESSES TO THE ACCIDENT (*If known*)

a. NAMES	b. ADDRESSES (*Include ZIP Code*)

WITNESS COMPLETING THIS FORM	11. HOME ADDRESS (*Include ZIP Code*)	12. WITNESS (Print Name)	a. HOME TELEPHONE NO.
		Sign here ►	b. TODAY'S DATE
	13. BUSINESS ADDRESS (*Include ZIP Code*)		TELEPHONE NO.

14. INDICATE ON THE DIAGRAM BELOW WHAT HAPPENED:

1. Number Federal vehicle as 1—other vehicle as 2—additional vehicle as 3, and show direction of travel by arrow (*Example:* → 1 2 ←)
2. Use solid line to show path before accident —— 2
   Broken line after accident - - - - - - 2
3. Show pedestrian by ——→ ○
4. Show railroad by +++++++++++++++
5. Give names or numbers of streets or highways
6. Indicate north by arrow in this circle ○



NSN 7540-00-634-4045
94-105

STANDARD FORM 94 (REV. 2-83)
Prescribed by GSA, FPMR 101-39.8

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	January 2009	Kate Miller	Initial version.	
1.01	March 2009	Kate Miller	Added more information about poisonous snakes and MIDN and NETN. Added Appendices I-IV.	
1.02	April 2009	Kate Miller Brian Mitchell	Clarified that supervisor must be notified immediately after an incident. Changed hospital for MABI and added Dartmouth Hitchcock Medical Center as an option for SAGA. Added WEFA emergency contact information. Minor editorial changes.	
1.03	May 2009	Sarah Lupis Kozlowski	Minor editorial changes, formatting.	Conform to NPS standards.
1.04	December 2009	Kate Miller Andrew Vincello Jim Comiskey Brian Mitchell	MIDN emergency contact info and directions to hospitals were added. Updated workers compensation Appendix. Minor editorial changes	
1.05	October 2010	Kate Miller Jesse Wheeler	Added risks associated with using permethrin and deet. Added more information on poisonous snakes, and how to respond to a bite. Added information on GSA roadside assistance	
1.06	January 2012	Kate Miller	Added more information on ticks and Lyme Disease, based on ERMN SOP. Added procedures for using park radios, based on ERMN SOP. Added Appendix F and H to provide more information on vehicle accident reporting procedures, based on ERMN SOP. Added forest monitoring JHA as Appendix A Added directions for using park radios in emergency and non-emergency situations Defined daily check in procedures Added Green Amber Red risk assessment Added user guide for SPOT Messenger	
1.07	January 2013	Kate Miller	Changed DOS communication rules to allow the forest crew leader to assume DOS responsibilities when safely out of the field. Updated nearest hospital for MIMA. Updated VAFO contact info.	
1.08	January 2016	Camilla Seirup	Removed SPOT Messenger Appendix. Updated DOS and Emergency Contact Information.	

SOP 1 - Preparation and Equipment List

Mid-Atlantic Network/Northeast Temperate Network

Version 2.11

Overview

This SOP delineates preparations for the summer field season and includes a list of necessary field equipment. Preparations should be complete by the start of the summer field season in May or early June.

Staff

This forest monitoring protocol can be staffed by any of several crew configurations, including

a) a forest crew leader plus a crew of two to three crew members, or b) two teams each comprised of a crew leader and one crew member. In addition to the forest crew, a contract botanist (for NETN monitoring) and network staff support will probably be needed as described below.

The forest crew leader(s) should have good northeastern plant identification skills and be knowledgeable about forest sampling methods. If a forest crew leader does not have strong plant identification skills, then contract botanists and/or network staff must be available for each park to identify unknown specimens or to sample the understory vegetation quadrats. The crew should have good northeastern woody plant ID skills. The contract botanist(s) should be well trained in local flora at each park sampled. The protocol also requires some GIS mapping in ArcGIS, and support by network personnel including the data manager.

To secure field personnel, the networks may wish to advertise locally at northeastern universities, as well as nationally on environmental job websites such as the Society for Conservation Biology job board (http://www.conbio.org/jobs) or listserves such as the Ecological Society of America's 105illing listserve (ecolog-l@listserv.umd.edu). Network staff may also find it useful to network with regional environmental professors and professionals to identify skilled seasonal staff.

To ensure travel charge cards and uniforms are issued by the first day of training, it is advisable to start crew members 2 pay periods before the first day of training. Crew members can claim hours spent filling out paperwork, and then be on intermittent status until the first day of training. Background investigations must be cleared before this can happen.

Soon after they are hired, each crew member should receive a welcome packet in the mail to help them prepare for the field season. Welcome packets should contain information about the Inventory and Monitoring program, suggestions on personal gear to bring for the season, directions for ordering uniforms, a schedule for the field season, park specific information, lists of common species in each park, and a NPS passport.

Planning and Coordination

Network personnel or the field crew leader should ensure that each park natural resource manager has a current version of the forest protocol including all SOPs, as well as a current map of sampling locations. A map clearly showing the location of each plot must be provided to each park's cultural resource specialist at least one month prior to any soil sampling, to provide time for determination of the presence of cultural artifacts that might be compromised by soil sampling. Each network's plot marking and tree tagging procedures must be cleared with each park natural resource manager prior to plot establishment at each park, and these procedures may vary by park in response to individual park requirements. Network staff must check with each park to determine whether aluminum or stainless steel tree tags and nails must be used. Aluminum tree tags are used at parks in which trees are or may be cut to ensure human safety during logging. Stainless steel tags are used at parks without logging to avoid adding aluminum to the environment.

Networks should select a soil chemistry laboratory with experience analyzing forest soils, and have a purchase order or other contract in place for analysis of soil samples collected each field season. It may be cost-efficient to join together with other eastern NPS networks to contract a soil chemistry lab to obtain better pricing. Several soil laboratories have sufficient capabilities, including the Analytical Lab at the University of Maine (http://anlab.umesci.maine.edu, contact Sue Erich, erich@maine.edu or Bruce Hoskins, 106illing@maine.edu).

Maps

Prior to each field season, network personnel should prepare both GIS maps and aerial photographs showing sampling locations at each park in the annual panel at scales of 1:24000 or larger. Maps should clearly show location of all plots in relation to topography, roads, trails and park features. Line and point symbols for roads, streams, plots and other features should be clearly visible but not large enough to obscure other features. Scalebars should show miles in addition to kilometers, to aid navigation by car. If possible, smaller locator maps should be included on large scale maps. These maps and aerial photographs should be printed on Rite-in-Rain paper using a color LaserJet printer. Note that inkjet printing does not properly adhere to Rite-in-the-Rain paper. Two full sets (one for each vehicle) of maps for each park should be provided to the forest crew prior to sampling.

The crew should also be supplied with road maps for the region surrounding each park visited.

Coordinates of each plot should be exported, printed, and downloaded directly into the network GPS unit. Trails, park boundaries, and topographic maps should also be loaded on GPS units.

Schedule

The order in which parks are visited during the field season must remain static from year to year in order to reduce the confounding of seasonal with annual variation. In the Northeast Temperate Network (NETN), parks should be sampled from southwest to northeast over the course of the summer in coordination with seasonal progression across the region. This schedule will allow southwestern parks to be sampled when spring ephemerals may still be evident, and allow

northeastern parks to be sampled after shrubs and trees have fully expanded their leaves. For Mid-Atlantic Network (MIDN) parks, sampling should be conducted from northeast to southwest.

Horse-racing season in Saratoga Springs, New York runs from late July to early September, and lodging is difficult and expensive to acquire during this time. Thus Saratoga National Historical Park (SARA) should be sampled prior to late June if possible.

Network staff and the crew leader should carefully consider the crew's capabilities when deciding upon a workday schedule. Flex-time (e.g., four 10-hour days) offers some advantages—but is not appropriate if crew members tire too much to maintain data quality on a long workday. The crew schedule should start as a standard work week (e.g., five 8-hour days, starting at 8:00 or 8:30 am), and only convert to flextime if both the crew leader and supervisor agree that it will work well for that particular crew.

Network personnel and collaborators should hold a mid-season meeting with the crew to discuss the crew's progress and any concerns that have surfaced. This meeting should take place after the first round of QA/QC sampling has occurred.

Logistics

Network personnel or the crew leader should reserve or acquire a field vehicle for transport to and within parks.

Network personnel or the crew leader should contact the natural resource manager at each park represented in the annual panel to schedule a visit and reserve park lodging if available. If no park lodging is available, lodging reservations should be made. Wherever possible, lodging should include access to kitchen facilities and internet. Lodging space should be sufficient to comfortably accommodate all crew members and their gear.

Training

Prior to commencement of each field season, the networks must ensure that all field personnel fully understand administrative responsibilities and field procedures by conducting in-situ training sessions. Training should include PowerPoint presentations that cover the following topics:

- Introductions to NPS, the Inventory and Monitoring Program and the forest monitoring protocol.
- Regulations and procedures related to travel authorizations, credit cards and use of NPS vehicles.
- Guidelines regarding timesheets, credit leave versus comp time and requesting leave.
- Safety and workers compensation
- Examples of how forest data are being used and importance of quality data.
- Introduction to databases and tour of forest database

- Summary of each SOP and unusual situations

Crew preparation should involve careful review and discussion of all protocols, in addition to training sessions led by designated personnel in which training plots are set up and measured. Trainers should start each SOP with a presentation that summarizes procedures and unusual situations before crew members read the SOP. After reading and discussing each SOP, trainers and crew should practice each procedure on test plots in the field.

Training should cover:

- safety hazards such as steep slopes and deer ticks;
- safe field practices to avoid injury such as how to properly pack and wear a field pack and work in areas with poison ivy;
- emergency procedures;
- introduction to network forest and woodland ecosystems;
- review of common northeastern tree and shrub species;
- proper use of all equipment including GPS, field computer, and digital camera;
- proper use of compasses, especially declination settings;
- proper use of clinometer to measure slope as percent and in degrees;
- practice reading sampling maps of plot locations;
- plot layout and installation;
- rules for selecting or rejecting pre-selected plot locations;
- use of laser and sonin rangefinders;
- measurement of horizontal vs. slope distance with measuring tapes and rangefinders;
- estimation of slope distance using slope conversion table;
- determination of physiographic class, stand structure, stand disturbance and crown closure;
- methods for tree tagging;
- accurate measurement of DBH and DRC using a DBH tape, logger’s tape and ruler;
- determination of tree crown class;

- identification of specific tree condition and foliage problems from SOP 9 - Tree Measurements;
- identification of high priority exotic pests and pathogens for the northeastern U.S., such as hemlock woolly adelgid, Asian longhorned beetle, and emerald ash borer;
- snag and CWD decay classes;
- procedures for measuring seedling and shrub height;
- practice estimating percent cover classes;
- visual inspection of forest floor for humus and earthworm casts and burrows;
- procedures for collecting soil samples, using a soil corer and separating by soil horizon;
- procedures for labeling, drying and storing soil samples;
- procedures for labeling unknown plant specimens;
- practice using procedures for careful data collection described in SOP 5 - Data Management & Quality Assurance/Quality Control;
- procedures to minimize plot trampling;
- expectations of crew behavior; and
- proper use and maintenance of park radios.

Training should include both demonstration of all measurements by trainers, and hands-on practice of all measurements by trainees. Training groups should be small to ensure that all trainees have sufficient opportunity to practice measurements thoroughly and question the trainer as needed. Training should thoroughly demonstrate how to enter data into the forest database for each SOP. Training materials should include screen captures of each form in the database.

Training must emphasize the critical importance of careful, accurate and steady data collection to this long-term monitoring program. Trainers must stress the importance of exact adherence to SOP instructions to prevent bias in measurements among years, which will inhibit the networks' ability to detect long-term trends. Trainees should be encouraged to discuss with network supervisors any concerns that arise over field procedures or the datasheet or database recording systems during training or later during the field season—the crew should never deviate from established protocols or alter the datasheet or database without first taking this step.

Training must emphasize the critical importance of careful plot behavior to minimize plot trampling. Packs should be put down and unloaded outside the plot, or placed carefully at the center of the plot where most equipment is first used. Crew should not enter the plot or move within the plot without

an explicit reason to do so. Crew should walk outside the perimeter of the plot whenever possible. Crew should arrange the taking of measurements to minimize walking within the plot. Crew should plan ahead to retrieve all gear needed for a particular set of measurements at once, rather than taking extra trips back and forth across the plot. Extra care must be taken to avoid trampling the regeneration microplot, the herb quads on the inside of each plot corner and mid-point, and any CWD that falls on or near a line transect. Extra care should also be taken in plots with a delicate or moss-covered forest floor.

During training, one crew member should be designated as the field computer lead and another as the GPS lead. The field computer lead should receive extra training in all aspects of the use and care of the field computer and the use of the forest database. Likewise, the GPS lead should receive extra training in the use of the GPS unit, and should carefully study SOP 3 - Using the Global Positioning System (GPS) and the Garmin manual.

Network staff must decide what location provides sufficient logistical support for the initial training session. However, it may be advantageous to begin training at a national historic park to allow familiarization with the larger plots used at National Historical Parks (NHP) and the deciduous forests found within NHP. Marsh-Billings-Rockefeller NHP (MABI) may have sufficient facilities if affordable housing is available. Initial training should include orientation to forest and woodland ecosystems and common shrubs and trees in the area at which training occurs. Supplemental orientation to ecosystems and common shrubs and trees at other parks should occur as the crew traverses the network. At Acadia NP (ACAD), orientation should include a visit to the Wild Gardens of Acadia which showcases plants and ecosystems native to the area.

Training to recognize specific tree health problems noted in SOP 9 - Tree Measurements, and identification of high priority exotic pests and pathogens for the northeast U.S. listed above, should utilize forest pest factsheets available on the web from many sources such as U.S. Forest Service (USFS) and Animal Plant Health Inspection Service (APHIS). Links to useful pest and pathogen fact sheets are listed below. Crew should also carry Early Detection ID cards to help with priority pest identification.

1. USFS Pest Links: http://www.fs.fed.us/ne/morgantown/4557/AFPE/links.html
2. Asian Longhorned Beetle: http://www.na.fs.fed.us/pubs/palerts/alb/alb_pa.pdf
3. Balsam Woolly Adelgid: http://www.na.fs.fed.us/pubs/fidls/bwa.pdf
4. Dogwood Anthracnose: http://www.na.fs.fed.us/spfo/pubs/howtos/ht_dogwd/ht_dog.htm
5. Elongate Hemlock Scale: http://www.na.fs.fed.us/spfo/pubs/pest_al/ehscale/ehscale.htm
6. Emerald Ash Borer: http://www.na.fs.fed.us/spfo/pubs/pest_al/eab/eab.pdf
7. Gypsy Moth: http://www.na.fs.fed.us/spfo/pubs/pest_al/gm/gm.htm
8. Hemlock Woolly Adelgid: http://na.fs.fed.us/spfo/pubs/pest_al/hemlock/hwa_05.pdf

9. Sirex Wood Wasp: http://na.fs.fed.us/spfo/pubs/pest_al/sirex_woodwasp/sirex_woodwasp.pdf

10. Sudden Oak Death: http://www.na.fs.fed.us/spfo/pubs/pest_al/sodeast/sodeast.htm

It may also be useful to organize a day-long forest pest and pathogen workshop during crew training that is led by a regional forest pest expert, such as Wayne Millington (NPS Northeast Region Integrated Pest Management Coordinator, wayne_millington@nps.gov). The workshop should contain both lecture and field identification sections, and cover identification of high priority forest pests and diseases in the eastern US, including emerald ash borer, Asian longhorned beetle, hemlock woolly adelgid and sudden oak death.

Communication and Crew Oversight

It is essential for the crew to keep in regular contact with network program managers and any other supervisors throughout the field season. The crew should carry NETN radios in parks where there is a radio use agreement (currently: ACAD, MABI, Minute Man NHP, Morristown NHP Saint-Gaudens NHS, Saratoga NHP, and Weir Farm NHS). The crew should also carry a cell phone in the field every day in any parks with cell coverage—both for safety and to attempt to call in if any important questions arise. A regular (perhaps twice weekly) telephone call or meeting should be setup between crew leader and supervisors to discuss the week's events while they are still fresh. This regular update should include discussion of any questions or problems encountered with plots, the work, the protocol, logistics, etc. The crew should contact supervisors shortly after arrival at each new location to check in and provide contact information if necessary.

The division of labor among crew leader and crew must allow the crew leader to maintain awareness of crew activity on the plot during the regular course of data collection.

Network program managers and any other supervisors should endeavor to join the crew in the field at least twice during the course of the field season for direct observation of data collection.

Equipment

Equipment and supplies on the equipment list, below, should be obtained. Equipment should be organized and maintained in good working condition. At the end of each season, the crew leader should inventory the condition of all equipment and prepare a list of equipment that needs to be repaired or replaced.

The field computer must be handled carefully and the screen protected from injury at all times. When traveling between plots, the computer should be closed with the screen facing inwards. During hard rain, the field computer should be put away in a waterproof bag and datasheets should be used instead.

General Field Equipment

Park topo maps showing plot locations
Protocols with slope conversion table
Park permits
Park plant species list
Field computer and harness
Datasheets (on Rite-in-the-Rain paper)
Enclosed clipboard
GPS unit with USB cable
Compass (3)
Clinometer
NETN Park Radio (ACAD), cell phone (all but ACAD), Personal Locator Beacon (PLB) and Spot Messenger
Batteries- 9v (4), AA (4), CRV3 (2)
Flagging and survey flags (14)
Sharpened pencils and permanent markers
Daypacks
First aid kit
Insect repellant
Water
Briar-proof chaps and field vests (optional)
Field notes and Early Detection ID cards
Raingear
Lens tissues
10x hand lens (2)
Tree, Shrub and Herb field guides
Arborist throw bag
TruPulse and tripod

Plot Establishment

NETN: 65 cm fiberglass posts (7 per plot)
NETN: 35 cm fiberglass stakes (as needed)
NETN: 45 cm #3 rebar with 90 degree bend (4 per plot); 30 to 45 cm #4 rebar with cap (1 per plot)
MIDN: 45 cm #6 rebar and cap (one per plot); 45 cm #3 rebar with 90 degree bend (7 per plot).
Rubber mallet
Reflective card
Kite string reel

Plot Measurements

Pre-numbered tree tags – aluminum at MABI, MIMA, ROVA, SARA, WEFA and MIDN; stainless steel at ACAD, MORR, SAGA
Digital camera, batteries
Sonin electronic distance measurer
Work belt
DBH tape (2)
PVC pole cut to breast height (1.37 m)
30-cm UV-stabilized nylon cable ties
Compact, waterproof binoculars (8x power)
Sturdy ruler (30 cm)
8-12 cm tree nails: aluminum at MABI, MIMA, ROVA, SARA, WEFA and MIDN; galvanized steel at ACAD, MORR, SAGA
Hammer
Quadrat frame: 1x1 m (0.5x2 m at MIDN)
Clippers
Watch with timer
Sealable plastic bags (both small and large)
Knife or keyhole saw
Soil sampling frame (10x10 cm)
Trowel
Soil corer with extra tip
Cloth to clean corer
Increment borer, and plastic trays

Back in Field Office

Manual of Vascular Plants of Northeastern US and Adjacent Canada (Gleason & Cronquist), and Illustrated Companion (Holmgren)
ACAD: Flora of Maine (Haines and Vining)
Full-size plant press
Acid-free copy paper
Garmin Nuvi GPS Unit (2)
10x dissecting microscope

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
1.01	June 2006	Geri Tierney and Brian Mitchell	Added Flora of Maine to equipment list. Changed plot markers to fiberglass and included shorter markers for shallow soils.	
2.00	September 2006	Geri Tierney and Brian Mitchell	Added need for crew tree id skills. Added section describing map needs/production. Added section describing schedule. Suggested park order west to east. Added section describing logistics. Expanded list of training needs. Added need for training to id watch list of high priority forest pests/pathogens of northeastern U.S. Included training in use of slope conversion table for plot setup on steep slopes. Included recommendation for special crew member training in field computer and GPS. Emphasized need to minimize trampling. Emphasized need to follow protocols. Added section describing communication and crew oversight. Added suggestions for finding staff. Added caution to protect field computer screen. Added discussion of safety hazards to training. Added need for supplemental orientation to ecosystems and plants as crew travels. Added request for kitchen and internet access for crew lodging. Added note on racing season at SARA. Changed soil lab recommendation. Added need to keep equipment organized and in good working order. Added full-size plant press to gear list. Removed tree calipers from gear list. Added road maps for park regions to gear list. Added Collection of Forest Health Fact Sheets as Appendix E.	

Revision History Log (continued).

Version #	Date	Revised by	Changes	Justification
2.01	December 2006	Brian Mitchell and Geri Tierney	Clarified that optimal crew size is 4-person crew including crew leader. Suggested that regular use of contract botanist in field could reduce need for one crew member. Included suggestion that training could occur in discrete phases. Included recommendation that hands-on training sessions be comprised of a small group. Added soil sampling frame and clippers.	
2.02	April 2007	Kate Miller, Geri Tierney, Brian Mitchell	Clarified use of aluminum tags/nails at ROVA, WEFA, steel at MORR. Added acid-free copy paper to equipment list.	
2.03	November 2007	Geri Tierney, Kate Miller, and Brian Mitchell	Revised staff description to add two team option. Clarified the option for herb quads to be sampled by contract botanists or NETN staff. Added need to discuss in training how the data will be used to assess forest integrity. Added mid-season meeting with NETN and crew. Added more database training Added park radio to equipment list. Added bullet to train crew how to use radios.	
2.04	May 2008	Kate Miller, Jim Comiskey, Brian Mitchell	Minor edits. Removed reference to the GPS real-time correction system. Added MIDN equipment and equipment for new plot establishment method. Removed items no longer needed (plumb bob, one of the 50-m tapes). Revised text to include MIDN methods.	
2.05	December 2008	Kate Miller, Jim Comiskey	Added safe field practices to avoid injury to the list of topics covered during training. Minor editorial changes.	
2.06	April/May 2009	Kate Miller, Sarah Lupis Kozlowski	Minor editorial changes.	
2.07	December 2009	Kate Miller Andrew Vincello	Fixed equipment list format. Added info about forest pest workshop and links to pest ID brochures. Minor editorial changes.	
2.08	October 2010	Kate Miller Jesse Wheeler	Added that starting crews 2 pay periods before training ensure credit cards and uniforms are issued before training. Added importance of sending welcome packet to crew. Added training to include presentations that cover admin, forest database and introduce SOPs Added that GPS units should have topo, trail and boundary maps loaded. Minor editorial changes	
2.09	March 2012	Kate Miller	Added rebar to equipment list in Plot Establishment section.	

Revision History Log (continued).

Version #	Date	Revised by	Changes	Justification
2.10	March 2013	Kate Miller	Revised equipment list to include TruPulse and battery, and removed LAR.	
2.11	December 2015	Kate Miller	Clarified that two full sets of forest plot maps should be provided to the forest crew.	

SOP 2 - Using the Global Positioning System (GPS)

Mid-Atlantic Network/Northeast Temperate Network

Version 2.01

Overview

This Standard Operating Procedure was adapted from a SOP written by Shenandoah National Park for the Garmin 76CS. It explains the methods that all observers should follow to learn to use Global Positioning System (GPS) with the Garmin GPSMAP 60CSX unit. Forest monitoring crews use GPS to help navigate to and locate pre-existing plots as well as document the location of new plots.

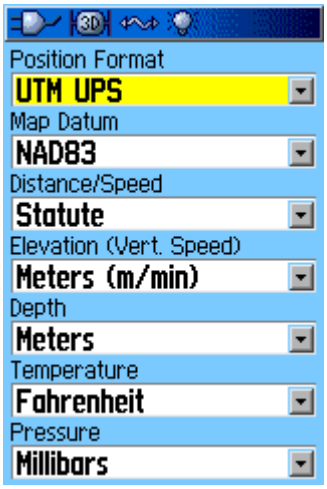
Suggested Reading

Garmin GPSMAP 60CSX Owner's Manual

Setting Up and Using the GPS Unit in the Field

Global positioning system equipment is used in the field to navigate to monitoring sites and locate reference bolts. 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 UTM NAD83.

    a. Go to the Main Menu by pressing 'Menu' twice.

    b. Toggle to 'Setup' and press 'ENTR'.

    c. Toggle to 'Units' and press 'ENTR'.

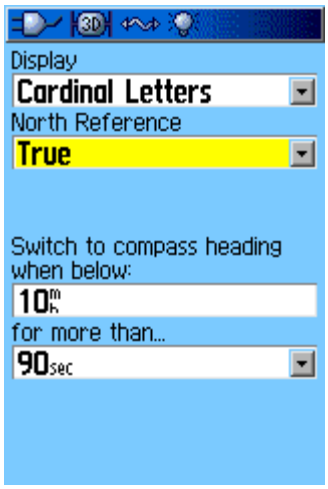
    d. Set the 'Position Format' to '**UTM UPS'** and the 'Map Datum' to '**NAD83'**. To change these, highlight the field press 'ENTR'. Then toggle to the appropriate setting and press 'ENTR' again.

    e. To get back to the Setup menu press 'QUIT'.

2. Make sure the GPS is set to True North.

   a. Toggle to ‘Heading’ on the Setup menu and press ‘ENTR’.

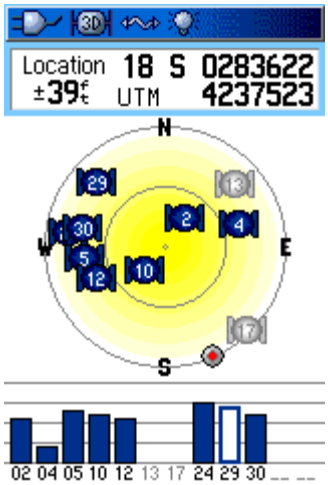
   b. Set the ‘North Reference’ to **‘True’**.



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 by pressing ‘Page’ until you reach the Satellite screen. 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.



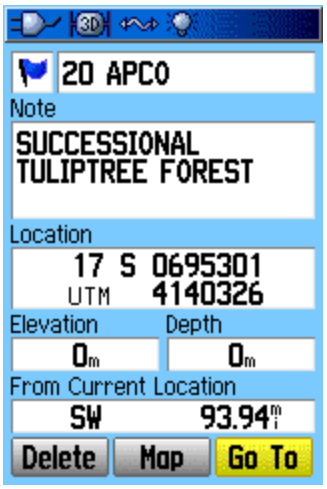
5. The current estimated accuracy of the receiver is also displayed on this page. The accuracy fluctuates as satellite signals are gained and lost. An accuracy of +/– 10 m (30 ft) or better is desirable to precisely document location.

Navigating to a Site

After the receiver is turned on and has adequate reception, press the ‘FIND’ button, highlight ‘Waypoints’ and press ‘ENTR’.

Use the keypad to enter the first number or two and then press ‘QUIT’ to get out of the keypad. Now you can scroll to the appropriate waypoint and press ‘ENTR’.

The waypoint screen will give you detailed information about the waypoint including the Note field and the distance to the point. ‘Go To’ should already be highlighted so press ‘Enter’.



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.

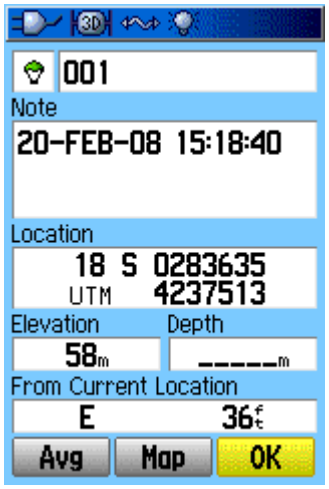
Selecting a Waypoint Symbol

1. Waypoint symbols are a way to group waypoints on your GPS unit. The default symbol for waypoints uploaded to the unit from a computer is the Flag (Blue). The default symbol for waypoints collected in the field is the Parachute Area.

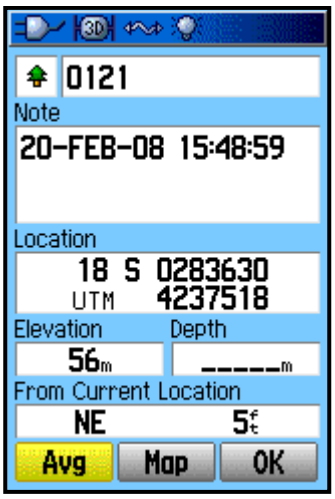
2. It is a good idea to pick a new symbol to distinguish individual and/or groups of waypoints that you collect in the field. This will make it easier to manage, download and delete waypoints on your GPS unit. An example is using a car symbol for a waypoint at the car before you wander into the forest.

Marking a Waypoint

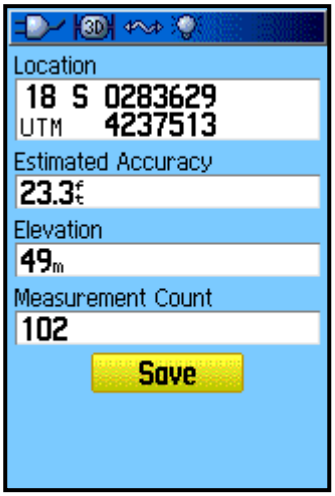
1. Press ‘MARK’ and the Mark Waypoint screen appears.
2. Toggle up to the symbol and press ‘ENTR’ for the Waypoint Symbols screen.
3. Toggle to the symbol you want to use and press ‘ENTR’.
4. The default name of a waypoint is a sequential number starting with ‘001’. To change the default name toggle to the number and press ‘ENTR’.



5. Toggle up and down through the numbers and letters and left and right between characters. Once the last letter or digit has been selected, toggle to ‘OK’ and press ‘ENTR’ to save the name and highlight the whole name field. Reference bolts should have waypoints created based on their six-letter site code plus bolt name (e.g. BASHARASC for the *Ascophyllum* reference bolt at the Bass Harbor Head site).

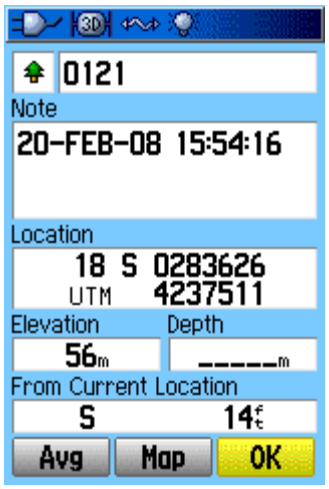


6. The most accurate way to document a location is to collect a waypoint position that averages at least 100 points. After you have named the waypoint. Toggle to ‘Avg’ at the lower left corner and press ‘ENTR’.
7. The ‘Average Location’ screen appears and measurement counts automatically begin. After the ‘Measurement Count’ reaches 100, highlight ‘Save’ and press ‘ENTR’ to return to the Map Page.



8. You still need to highlight ‘OK’ and press ‘ENTR’ on the map page to save the point.

9. 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. 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 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 the Garmin 60CSX Unit to a Computer

1. Connect the Garmin 60CSX unit to a computer using a USB cable.

2. Turn the unit on.

3. There are 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 S7.1).

    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 S7.2).

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.

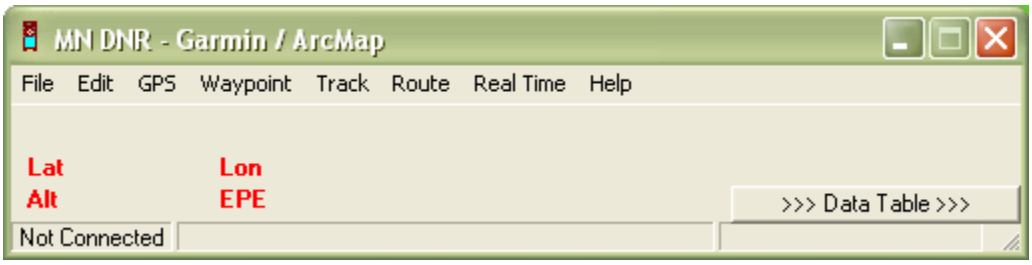


Figure S7.1. MN DNR—Garmin/ArcMap with GPS not connected.

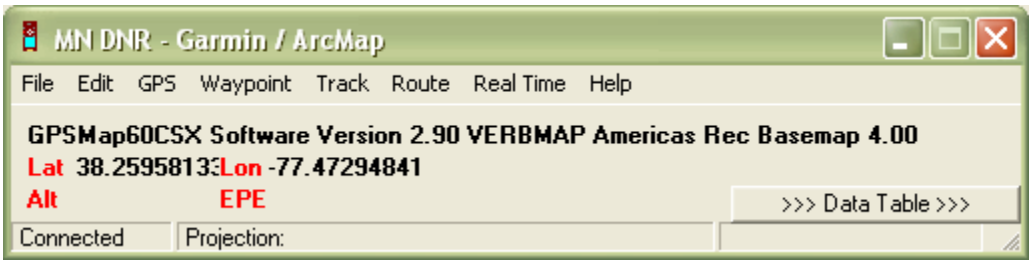


Figure S7.2. MN DNR—Garmin/ArcMap with Garmin unit GPSmap 60CSX connected.

6. Set the default projection to NAD 83, UTM Zone 19N. To open the DNR Garmin Properties window (Figure S7.3); select File > Set Projection. You will need to set the projection three times.

    a. Select ESRI on the Projection tab and select ‘NAD_1983_UTM_Zone_19N’ from the Datums/Projections drop-down box. You may want to type some of it in to narrow the options.

    b. On the bottom of the same tab, click the ‘Load PRJ’ button and navigate through ‘Projected Coordinate Systems’, ‘UTM’, ‘Nad 1983’, and then select ‘NAD 1983 UTM Zone 19N’.

    c. 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 S7.4).

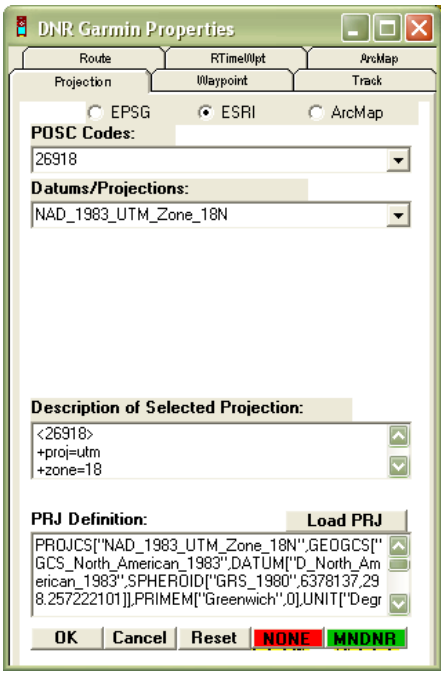


Figure S7.3. DNR Garmin Properties window with projection set to NAD 1983, UTM Zone 18N.

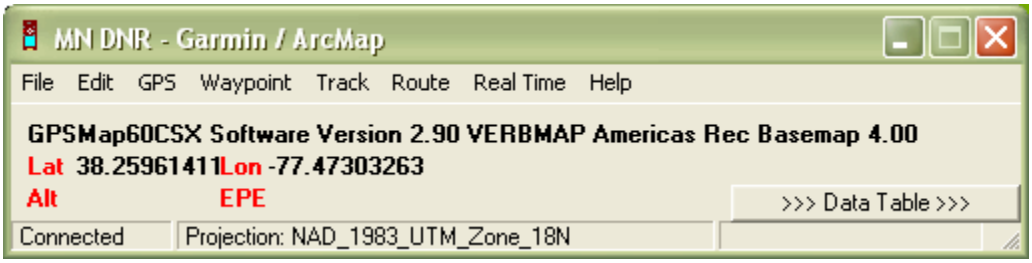


Figure S7.4. MN DNR—Garmin/ArcMap with Garmin unit GPSmap 60CSX connected and projection set to NAD 1983, UTM Zone 18N.

Uploading Waypoints to the Garmin Unit

In order to navigate to existing reference bolts, waypoints with plot Universal Transverse Mercator (UTM) 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 S7.5).

2. Connect the GPS unit to the computer using the USB cable and turn the unit on.

3. Open MN DNR Garmin.

4. Select File > Load From > ArcMap > Layer. The Identify Fields dialog box will appear and you will need to select an Ident and Comment field. *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.

5. To upload the waypoints to the GPS unit. Select Waypoint > Upload.

6. 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.

7. 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.

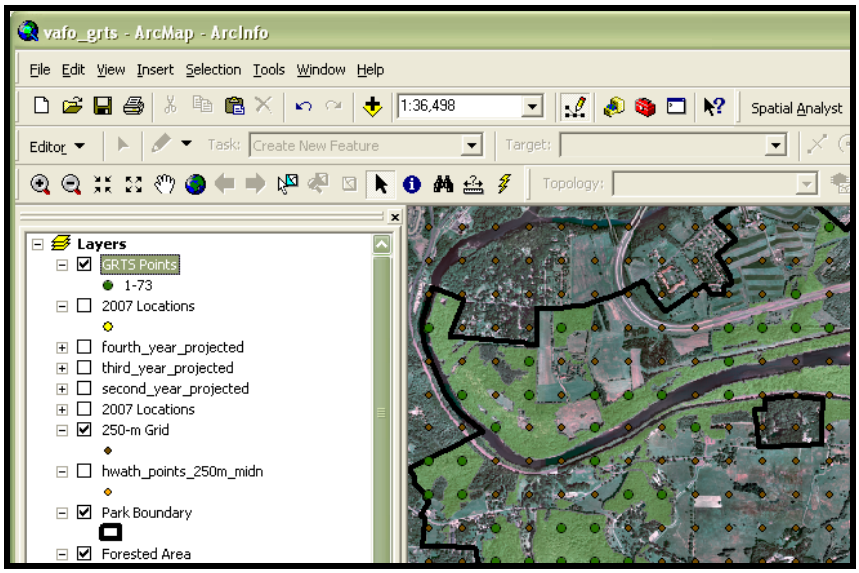


Figure S7.5. ArcMap screenshot, showing that the GRTS Points layer is active in the Table of Contents.

Downloading Waypoints

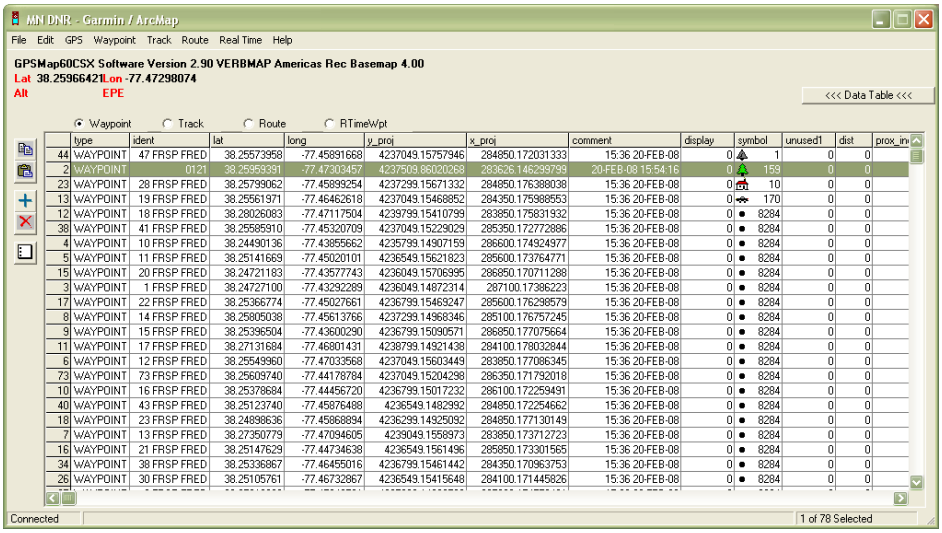
Waypoints for newly established reference bolts as well as updated waypoints for plots with inaccurate GPS locations need to be downloaded onto the computer upon return to the office from the field.

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 NAD 83, UTM Zone 19N. 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 (Figure S7.6).



	type	ident	lat	long	y_proj	x_proj	comment	display	symbol	unused1	dist	prox_in
44	WAYPOINT	47 FRSP FRED	38.25573958	-77.45891668	4237049.15757946	284850.172031333	15:36 20-FEB-08	0	1	0	0	
2	WAYPOINT	0121	38.25959391	-77.47303457	4237509.86020268	283626.146299799	20-FEB-08 15:54:16	0	159	0	0	
23	WAYPOINT	28 FRSP FRED	38.25799062	-77.45899254	4237299.15671332	284850.176388038	15:36 20-FEB-08	0	10	0	0	
13	WAYPOINT	19 FRSP FRED	38.25561971	-77.46462618	4237049.15468852	284350.175988553	15:36 20-FEB-08	0	170	0	0	
12	WAYPOINT	18 FRSP FRED	38.28026083	-77.47117504	4239799.15410799	283850.175831932	15:36 20-FEB-08	0	8284	0	0	
38	WAYPOINT	41 FRSP FRED	38.25585910	-77.45320709	4237049.15229029	285350.172772886	15:36 20-FEB-08	0	8284	0	0	
4	WAYPOINT	10 FRSP FRED	38.24490136	-77.43855662	4235799.14907159	286600.174924977	15:36 20-FEB-08	0	8284	0	0	
5	WAYPOINT	11 FRSP FRED	38.25141669	-77.45020101	4236549.15621823	285600.173764771	15:36 20-FEB-08	0	8284	0	0	
15	WAYPOINT	20 FRSP FRED	38.24721183	-77.43577743	4236049.15706995	286850.170711288	15:36 20-FEB-08	0	8284	0	0	
3	WAYPOINT	1 FRSP FRED	38.24727100	-77.43292289	4236049.14872314	287100.17386223	15:36 20-FEB-08	0	8284	0	0	
17	WAYPOINT	22 FRSP FRED	38.25366774	-77.45027661	4236799.15469247	285600.176298579	15:36 20-FEB-08	0	8284	0	0	
8	WAYPOINT	14 FRSP FRED	38.25805038	-77.45613766	4237299.14968346	285100.176757245	15:36 20-FEB-08	0	8284	0	0	
9	WAYPOINT	15 FRSP FRED	38.25396504	-77.43600290	4236799.15090571	286850.177075664	15:36 20-FEB-08	0	8284	0	0	
11	WAYPOINT	17 FRSP FRED	38.27131684	-77.46801431	4238799.14921438	284100.178032844	15:36 20-FEB-08	0	8284	0	0	
6	WAYPOINT	12 FRSP FRED	38.25549960	-77.47033568	4237049.15603449	283850.177086345	15:36 20-FEB-08	0	8284	0	0	
73	WAYPOINT	73 FRSP FRED	38.25609740	-77.44178784	4237049.15204298	286350.171792018	15:36 20-FEB-08	0	8284	0	0	
10	WAYPOINT	16 FRSP FRED	38.25378684	-77.44456720	4236799.15017232	286100.172259491	15:36 20-FEB-08	0	8284	0	0	
40	WAYPOINT	43 FRSP FRED	38.25123740	-77.45876488	4236549.1482992	284850.172254662	15:36 20-FEB-08	0	8284	0	0	
18	WAYPOINT	23 FRSP FRED	38.24898636	-77.45868894	4236299.14925092	284850.177130149	15:36 20-FEB-08	0	8284	0	0	
7	WAYPOINT	13 FRSP FRED	38.27350779	-77.47094605	4239049.1558973	283850.173712723	15:36 20-FEB-08	0	8284	0	0	
16	WAYPOINT	21 FRSP FRED	38.25147629	-77.44734638	4236549.1561496	285850.173301565	15:36 20-FEB-08	0	8284	0	0	
34	WAYPOINT	38 FRSP FRED	38.25336867	-77.46455016	4236799.15461442	284350.170963753	15:36 20-FEB-08	0	8284	0	0	
26	WAYPOINT	30 FRSP FRED	38.25105761	-77.46732867	4236549.15415648	284100.171445826	15:36 20-FEB-08	0	8284	0	0	

Figure S7.6. Data table in the MN DNR – Garmin/ArcMap application displaying downloaded waypoints.

5. Note that all the waypoints on the GPS are downloaded. 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 Figure S7.6, clicking on '2' highlighted the row which is Plot 0121.

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

    a. To <u>save as a text file</u>, select File > Save To > File…

For rocky intertidal plots and reference bolts, 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_60CSX_waypoints.txt**".

    b. To <u>save as a shapefile</u>, select File > Save To > ArcMap > Shapefile Layer...

For rocky intertidal plots and reference bolts, 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_60CSX_waypoints.shp**".

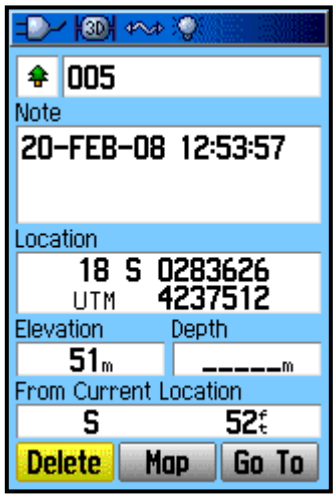
8. This file will automatically appear in the Table of Contents of the ArcGIS Map Document that you have open.

9. 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 it is advisable to delete the downloaded waypoints from the GPS periodically to keep it from becoming full while in the field. You have three options for deleting waypoints on the GPS receiver.

1. Deleting a single waypoint:



b. Press ‘Find’ to open the Find screen.

c. Select ‘Waypoints’ to open the Waypoints screen.

d. Toggle to highlight the waypoint you would like to delete and Press ‘ENTR’ to open the Waypoint screen.

e. Toggle to highlight ‘Delete’ in the lower left corner and press ‘ENTR’

f. 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. Highlight ‘Delete’ and press ‘ENTR’

e. Highlight ‘All Symbols’ and press ‘ENTR’

f. Confirm that you really want to delete all waypoints and press ‘ENTR’

3. Deleting all waypoints represented by the same symbol
   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. Highlight ‘Delete’ and press ‘ENTR’
   e. Highlight the symbol representing the group of waypoints that you want to delete and press ‘ENTR’
   f. Confirm that you really want to delete all the waypoints with the selected symbol by highlighting ‘Yes’ and press ‘ENTR’

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
1.05	December 2006	Geri Tierney Brian Mitchell	Included advice for navigating with GPS and compass.	
1.06	September 2007	Brian Mitchell	Added section about uploading GPS waypoints from DNRGarmin to the Garmin GPS V.	
2.00	May 2008	Jim Comiskey Kris Callahan Brian Mitchell	Major revisions.	Switch to Garmin 60CSX GPS.
2.01	May 2009	Sarah Lupis Kozlowski	Minor editorial changes, formatting.	Conform to NPS standards.

SOP 3 - Using the LTI TruPulse 360ºR

Mid-Atlantic Network/Northeast Temperate Network

Version 1.00

Overview

This SOP describes proper use of the Laser Technology Inc. (LTI) TruPulse 360ºR (LTI model 0144860).

Suggested Reading

The following manual should be read to ensure proper use of the Hypsometer:

LTI TruPulse 360ºR User Manual First edition, 2011.

The manual is available in PDF format from the Mid-Atlantic Network (MIDN) or Northeast Temperate Network (NETN).

General Use

The TruPulse 360ºR consists of a laser range sensor, an internal compass (horizontal angles), tilt sensor (vertical angles) and digital processor encased in a water resistant housing (Figure S4.1). The TruPulse 360ºR has three buttons ("Fire", up arrow, and down arrow) that access the unit's internal software, which operates the integrated sensors. The device is powered by a single 3 volt Lithium rechargeable battery commonly referred to as CR123A or CR123. The batteries must be recharged every night for the next day's use. Spare batteries should always be available in the field. The Tenergy combo Li-Ion battery charger (TN268) should be used to recharge the batteries (allow at least 4 hours).

A liquid crystal display (LCD) is mounted within the optical system, displaying measurements and units when the operator looks through the adjustable eyepiece. Avoid exposing the eyepiece's internal components to direct sunlight by fastening the cover when not in use.

The TruPulse 360ºR has two lenses at the front of the unit, a transmitting and receiving lens. Do not touch these lenses. Avoid obstructing them while in use. If they need to be cleaned, they should be treated as sensitive optical lenses, using only a soft clean lens tissue to clean it. The measuring point of the TruPulse 360ºR is located at the tripod mount at the center of the unit.

When using a tripod, it must be non-ferrous (non-magnetic) to avoid influencing the angle measurements from the internal compass (Figure S4.2). The tripod should be used to enable accurate distance and angle measurements when positioned over plot center.

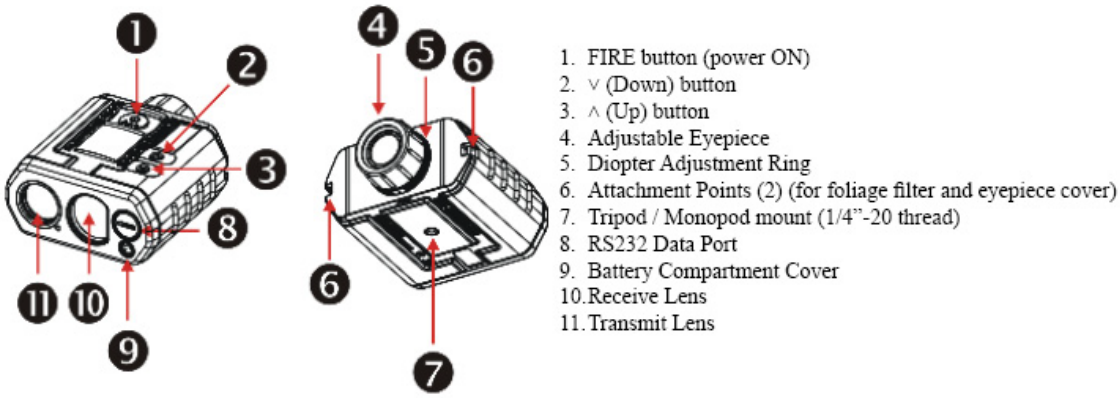


Figure S4.1 TruPulse 360ºR features (© LTI).

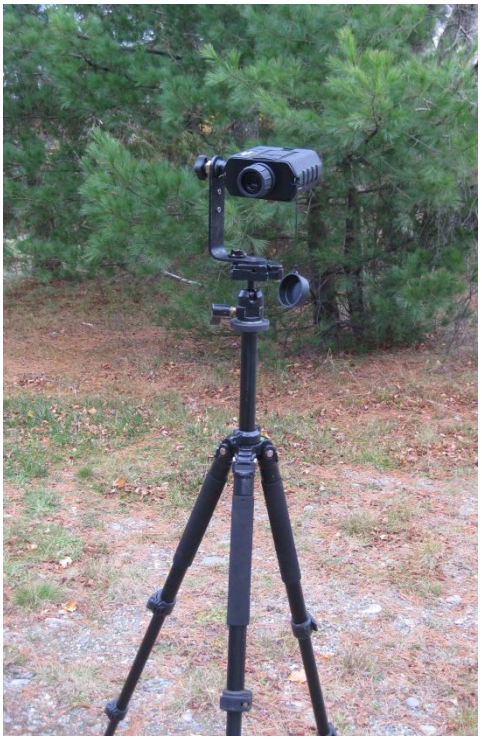


Figure S4.2. TruPulse 360ºR setup mounted on an LTI non-ferrous tripod with L-bracket mount and bubble level.

Getting Started

Insert a charged CR123A Lithium-Ion battery, negative end first into the battery compartment at the front of the unit (Figure S4.3). If needed, extend the adjustable eyepiece to fit eyeglasses and block extraneous light by rotating counter-clockwise while pulling up. The diopter adjustment ring at the base of the eyepiece can be used to focus the LCD display relative to the target (Figure S4.4).

With the TruPulse 360ºR in your right hand and looking through the eyepiece, the round “Fire” button will be under your index finger and ∧ and ∨ will be on the top-left of the unit (Figure S4.1). The “Fire” button is used to switch the unit on and to select items on the internal display. The ∧ and ∨ buttons are used to scroll through measurement and setup functions. Simultaneously press-and-hold ∧ and ∨ for 4 seconds to switch the unit off. To conserve power, the unit will shut itself off after 2 minutes of no use. When switching on the TruPulse 360ºR, the display prompts the measurement mode that was last used (Figure S4.5).

Setup

Units of Measure

From the Measurement Mode, press-and-hold ∨ for 4 seconds to access System Setup Mode (“UnitS” will appear). Press “Fire”, then ∨ to scroll through units (Yards, Meters, and Feet), select “Meters” by pressing “Fire” again. You will then be prompted to select angle units (Degrees or Percent). Select “Degrees” by pressing ∨ and “Fire” again.

Figure S4.3. Battery compartment with CR123A inserted.

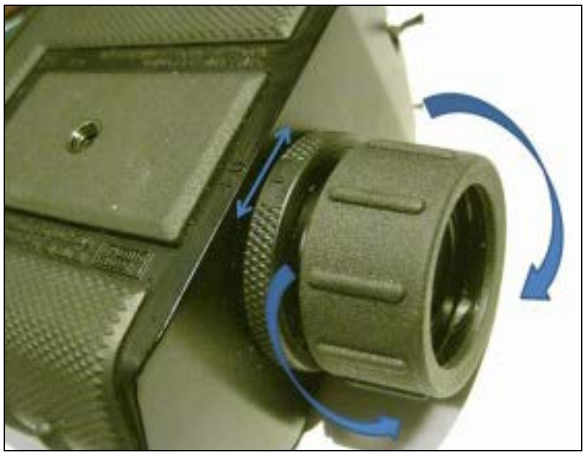


Figure S4.4. Eyepiece adjustment and diopter adjuster ring.

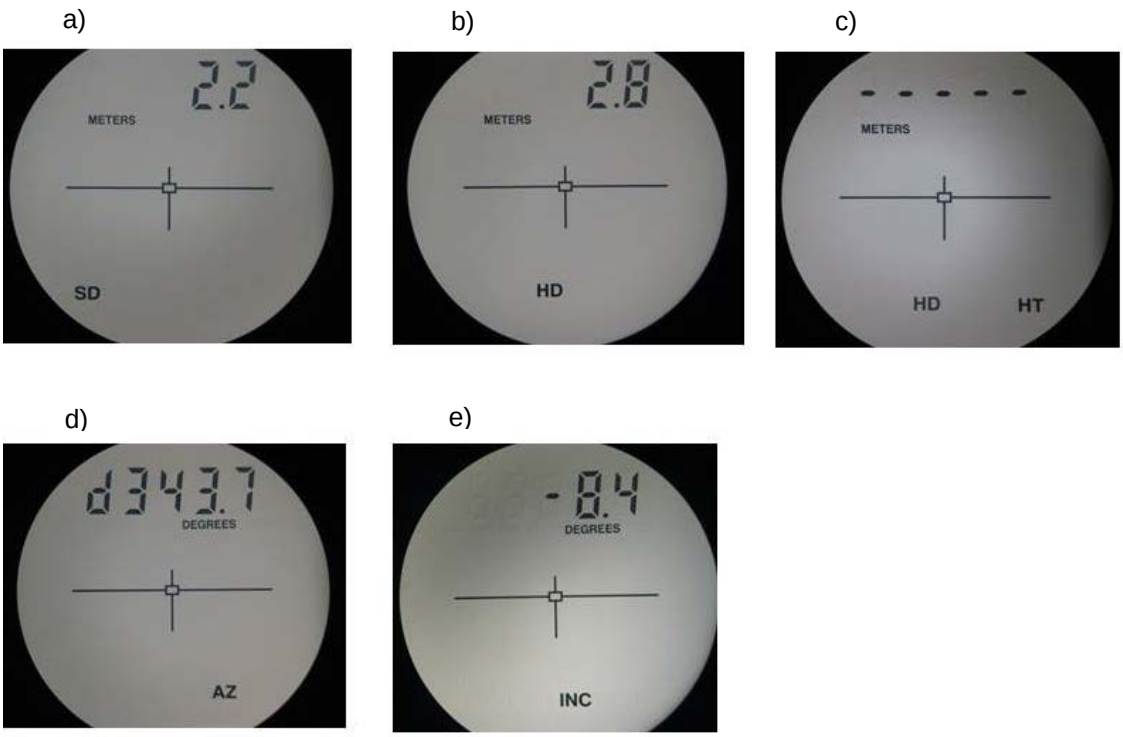


Figure S4.5. Measurement modes used in forest health monitoring; a) SD - slope distance, b) HD – horizontal distance, c) HD (flashing) + HT – tree height routine, d) AZ – horizontal azimuth, e) INC – inclination (slope angle).

Compass Declination

Set the internal compass magnetic declination every time you change Park locations (NETN Park declinations can be found in SOP 6 – Site Selection, Plot Establishment and Remeasurement). From the Measurement Mode, press-and-hold ∨ for four seconds to access System Setup Mode where "UnitS" will appear in the Main Display. Press ∨ to select the "H_Ang" (horizontal angle) option, press "Fire" to bring up "dECLn" (declination) on the Main Display. Select "yes" "dECLn" using ∧ or ∨, then press "Fire" to enter a declination value. The right-most digit will flash, indicating that it can be edited. Press ∧ or ∨ to increase or decrease the flashing number. Press "Fire" to accept the desired value and move the editing to the next digit. After all three digits (##.#) have been entered, the whole value flashes. **IMPORTANT** – The declination value should always be negative for all MIDN and NETN parks (e.g. ACAD is -17.0). Press ∧ or ∨ to toggle the value from positive (East declination) to negative (West declination). Press "Fire" to accept final declination value. **Note:** When in AZ measurement mode, "d" appears as the left-most character in the Main Display as a reminder that a declination value has been entered (Figure S4.5d).

Tilt Sensor

Calibrate the Tilt Sensor any time the battery is changed, the unit is dropped, or the compass calibration is failing repeatedly. Always perform Tilt Sensor calibration on a flat, fairly level surface. Press-and-hold ∨ for four seconds to access System Setup Mode where "UnitS" will appear in the Main Display. Press ∨ to display the "inC" (inclination) option, and then press "Fire". The message "no" "CAL" (no calibrate) will appear in the Main Display. Press ∧ or ∨ to display "YES" "CAL"

(yes calibrate), then press “Fire” to begin tilt calibration routine (Figure S4.6). The Main Display will show “PASS” or “FAiL” when the tilt calibration routine is complete. If the tilt calibration results in a “FAiL” message, repeat the tilt calibration until it passes.

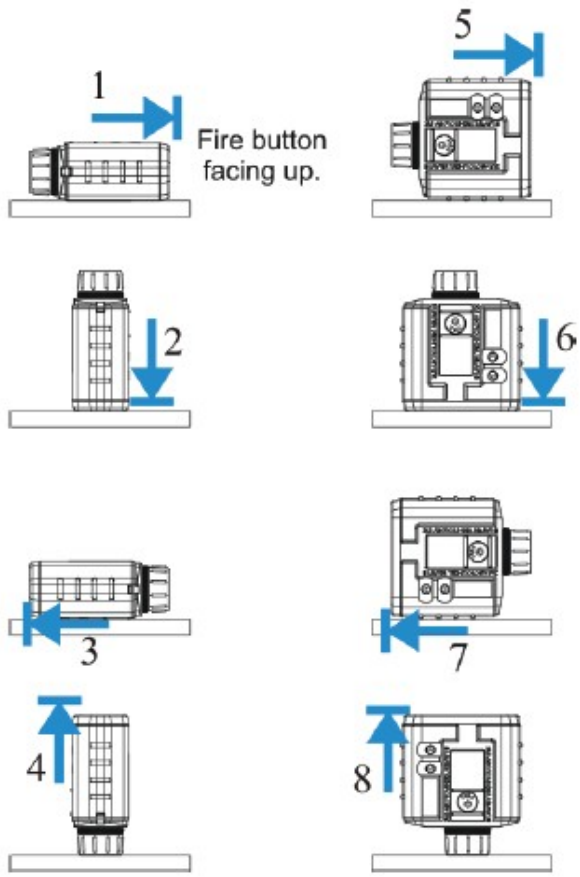


Figure S4.6. Tilt Sensor Calibration Routine, steps 1-8. Press “Fire” button at every step, with 1 second pauses between steps. Hold the TruPulse 360ºR on a flat, relatively level surface (+/-15 degrees of level) (© LTI).

Compass Calibration

Calibrate the Horizontal Angle Compass settings every morning before sampling forest plots for the day. This ensures that the azimuths measured will be accurate and relative to true north, no matter the location of the site. From the Measurement Mode, press-and-hold ∨ for 4 seconds to access System Setup Mode where “UnitS” will appear in the Main Display. Press ∨ to select the “H_Ang” (horizontal angle) option, press “Fire” to bring up “dECLn” (declination) on the Main Display. Press ∨ to display the “HACAL” (horizontal angle calibration) option. Press “Fire” to select, then the message “no” “HACAL” will appear on the Main Display. Press ∧ or ∨ to display “YES” “HACAL”, then press “Fire” where “C1_Fd” appears, signifying the start of the compass calibration routine (Figure S4.7). The Main Display will show “PASS” or “FAiL” when the compass calibration routine is complete. If the routine fails, try again, making sure you do the steps slowly and away from magnetic or metal sources (e.g., compass, field computer, and hand lens).

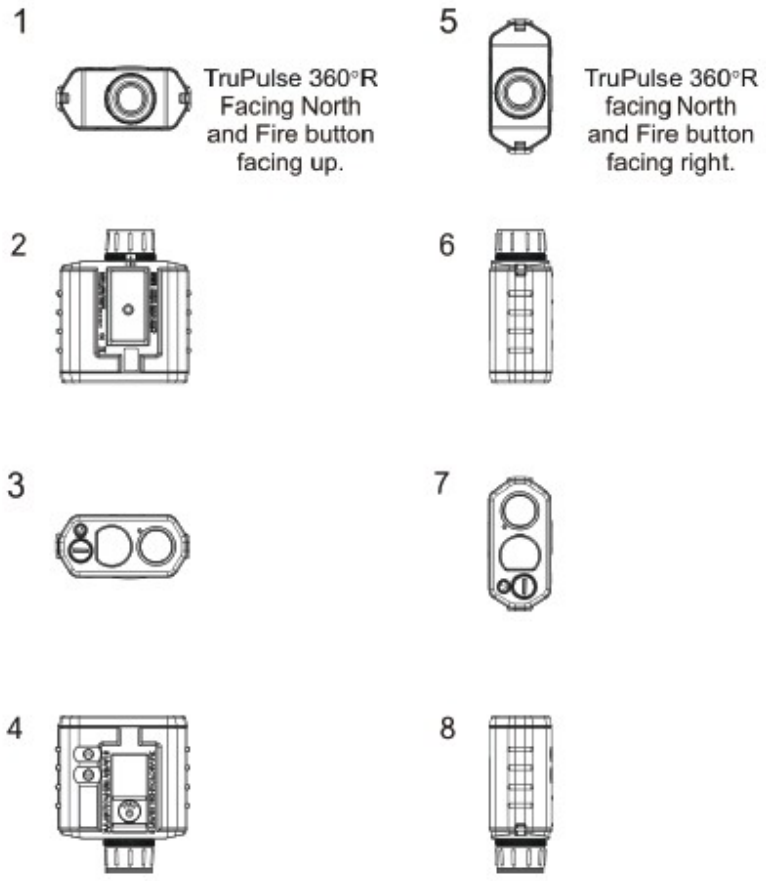


Figure S4.7. Compass Calibration Routine, steps 1-8. Press “Fire” button at every step, with 1 second pauses between steps. Hold the TruPulse 360ºR close to magnetic North (+/- 15 degrees towards North) during the compass calibration routine (© LTI).

Targeting Mode

Select a Targeting Mode theme for your distance measurements. For most applications, where brush and other vegetation may interfere with the distance measure, use the Filter mode with a Foliage filter installed on the receiving lens at the front of the unit. The Filter Targeting Mode will allow for more accurate measurements even when the view is partially obstructed. The most accurate Filter Mode measurements will display distance values with a decimal value included (e.g. 7.3) but when the target is too obstructed, a less accurate, whole digit value will be displayed instead (e.g. 7). Note that the Foliage filter must be installed for the filter mode to read off of a reflective surface.

To change between targeting modes (Standard is the default), press-and-hold ∧ for 4 seconds to bring up System Setup Mode where “Std” (Standard) will appear on the Main Display. Press “Fire” to select for Standard Mode, or press ∧ or ∨ to toggle through other Targeting Modes; Filter (FLt), Farthest (FAr), Closest (CLo) and Continuous (Con), pressing “Fire” to select final choice.

Taking Measurements

For all measurements made from plot center, the TruPulse 360ºR should be mounted on a tripod and leveled using the tripod's built in bubble level. Once mounted and placed over plot center, the unit is ready for use for plot re-establishment and tree mapping. The TruPulse 360ºR can be operated on its own without a tripod, which is useful for measuring stand height.

To take a measurement, align the cross hairs in the scope with the required target and press-and-hold the "Fire" button on the top of the instrument. The measurement will appear at the top of the display area, at which point release the "Fire" button (Figure S4.5). Two of the measurements that are of most interest are the azimuth or horizontal angle (AZ) and the horizontal distance (HD). These measurements are used for establishing the plot as well as for mapping the location of trees within the plot.

Setting Up the Plot

When setting up the plot, the TruPulse 360ºR is rotated and the red "Fire" button pressed until the AZ gives the desired horizontal angle reading (one can hold down the "Fire" button to show instant changes in angle while rotating). For the upper right corner of the plot this angle is 45° greater than the plot orientation (to the nearest 0.5°). **IMPORTANT:** Plots that are not oriented to True North will need to have the angle difference accounted for when re-establishing plot stakes (e.g. a plot oriented upslope at an azimuth of 30º will have its upper right stake at an azimuth of 75º).

Once the angle has been established, a distance measurement is taken. This will require that a second team member holding a reflector move toward or away from the TruPulse 360ºR. The desired horizontal distance (HD) should be measured to the nearest 10 cm. Slope Distance (SD) is only used for CWD transects and establishing microplots in NETN parks.

NOTE: In cases where a tree obstructs the view, the distance measurement (HD) can be taken to either side of the tree and the horizontal angle (HA) registered as that of the obstructing tree.

Mapping Trees

All trees ≥ 10 cm DBH in the plot are mapped. The Horizontal Distance (HD) and Horizontal Angle (HA), to the nearest unit, are recorded. This requires that a measurement be taken with the TruPulse 360ºR to each tree. Care should be taken to aim at the center of the tree trunk when measuring AZ. Accurately measure the HD by positioning the reflector on the side of the tree, ensuring a distance measured to the center of the tree bole.

Stand Height

In each plot, three co-dominant trees and three intermediate trees are chosen and their height is measured with the TruPulse 360ºR. After all plot-level measurements have been taken with the TruPulse 360ºR, move it to a point where you can see the base and the top of the tree, then conduct the automated Height Routine to measure tree heights (Figure S4.8). The 3-Shot Height routine should be used with filter mode and a reflector. Once HT and HD (flashing) are displayed, press "Fire" to start routine. Aim crosshair at a reflector at the tree, press-and-hold "Fire" until a value appears with HD, followed by "Ang_1" at top of display. Aim crosshair to top of tree, press-and-hold "Fire" and when released the display will show a positive angle (INC). The angle value will flash

once, then “Ang_2” appears at the top of the display. Aim crosshair to base of the tree, press-and-hold “Fire” and when released the display will flash a negative (INC) angle, followed by the calculated tree height. **Note:** In order to measure tree heights as accurately as possible, do not select a location downslope or drastically upslope from the tree base. The top and base angles of the tree can be either “Ang_1” or “Ang_2”.

Completing the Survey

When the plot has been delineated and all trees have been mapped, the TruPulse 360ºR can be turned off. Upon completing the work at the plot, the unit should be disassembled from the tripod and each piece of equipment returned to their respective carrying cases. At the end of each day the batteries should be taken out of the TruPulse 360ºR for recharging.

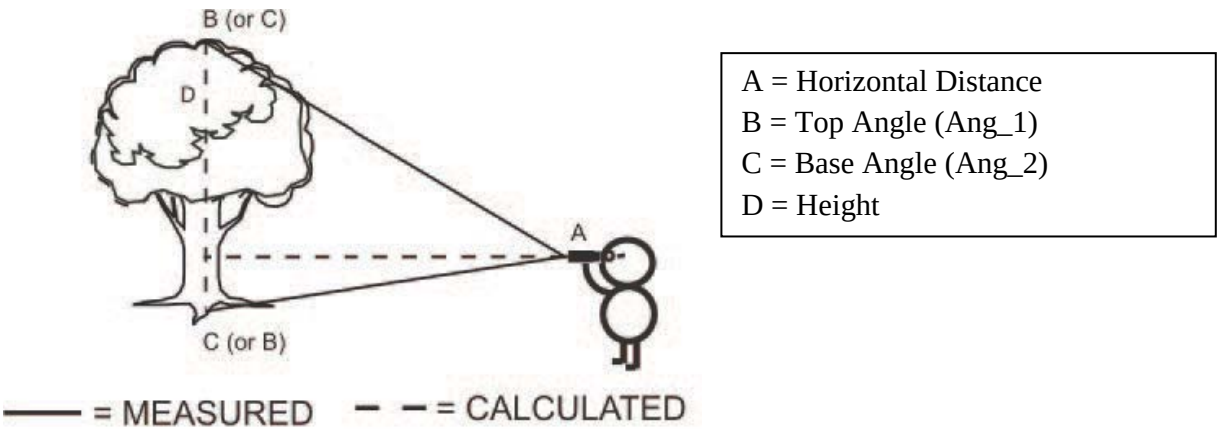


Figure S4.8. Measurements required for the Tree height routine (© LTI).

Troubleshooting

Be aware that when the battery voltage is low there will be a flashing warning “BATT”, and when the power is too low for operation the “BATT” will constantly be displayed. There will not be much operating time left when the battery is low.

The TruPulse 360ºR is protected from dust and rain, but will not withstand submersion. If water leakage is suspected, power unit off, remove the battery and air dry the equipment at room temperature.

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 2013	Jesse Wheeler	Initial protocol	New Equipment to replace Laser Rangefinder

SOP 4 - Data Management & Quality Assurance/Quality Control

Mid-Atlantic Network/Northeast Temperate Network

Version 2.13

Acknowledgements

This SOP benefited greatly from the content and ideas expressed in these documents:

Heartland Network. 2004. Standard operating procedure #11: Data management. *In* Vegetation community monitoring protocol for the Heartland I&M Network and Prairie Cluster Prototype Monitoring Program. Version 1.0. National Park Service, Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program, Republic, Missouri.

Thomas, S., and B. Moore. 2007. Standard operating procedure #6: Data management. *In* A protocol for monitoring Allegheny woodrats (*Neotoma magister*) at Mammoth Cave National Park. Version 2.1. National Park Service, Cumberland Piedmont Inventory and Monitoring Network, Mammoth Cave, Kentucky.

Southeast Coast Network. 2008. Quality assurance/quality control & field data collection standards. Version 1.0. National Park Service, Southeast Coast Inventory and Monitoring Network, Atlanta, Georgia.

Overview

Careful, accurate collection of data as directed in these SOPs is critical to the success of Vital Signs monitoring. This SOP describes quality assurance/quality control (QA/QC) procedures for accurate data collection, transcription and stewardship, and assessment of data quality (Appendix S5.A). Networks will use a field computer database or standardized datasheet for data collection, as weather conditions and technology permit.

Field Procedures

Network staff shall use the following procedures to record data in the field:

- To measure distance using a measuring tape, do as follows. When ready, the measurer shall alert the crew member holding the tape origin by calling “mark.” The crew member holding the tape origin will then hold the tape securely and directly over the starting location, and reply “mark” to signal readiness. The measurer then pulls the tape taught and reads the measurement.

- To record data, do as follows. The measurer shall clearly call out a data value to be recorded. The recorder shall clearly repeat the value aloud as it is recorded, to ensure the value was

- heard and recorded accurately. If the measurer does not hear a response from the recorder, the measurer shall repeat calling out the measurement until a response is obtained.

Field Computer

When weather and technology permit, networks will record data directly into the forest database using a field computer. This will eliminate the time and potential error involved in data transcription from field notes. The database will include clearly designated fields for each measurement to be recorded, including notes, and should have appropriate upper and lower bounds for values. Before concluding data entry on a plot, database users must indicate via their initials that they have checked all of the forms in the database to ensure they are complete and accurate.

The computer database should be backed up daily upon returning from the field, using an external hard disk provided by the network data manager. Furthermore, the database should be uploaded to the network's server periodically during the course of the summer as directed below.

The field computer should not be used in rain more than a light sprinkle—in case of steady rain the computer should be packed away and Rite-in-the-Rain datasheets used as directed below. The database should be designed to match the datasheets as closely as possible, and vice versa.

Datasheets

The crew must always bring datasheets copied onto Rite-in-Rain paper as a backup for data collection in case of rain or computer malfunction. Datasheets will contain as much preprinted project information as possible with designated labels for specific data elements, including general data such as date and collectors' names. Datasheets will clearly identify all required information, using examples where needed to ensure that the proper data are recorded. After paper datasheets have been initialed in the field check box as having been filled out in their entirety, a complete set of working copies will be made (see Data Stewardship section below). Most post-field collection data entry notes and remarks shall be made only on the copies, not to the original datasheets. Post-field collection remarks added to either the original (e.g., unknown species identifications) or copies of the datasheets should be written using a different colored pencil. Using the template at the top of the datasheet, all network staff members (including the crew) who make modifications to the datasheet shall indicate their identity (initials), date of modifications, purpose of their review, and the color used to provide comments or make changes (Figure S5.1).

Data Verification

Data quality and verification involve checking the accuracy of field data at each stage it is transcribed from its original source. To minimize the possibility of carrying entry errors forward into analysis, the data quality and verification process for this protocol involve multiple checks. After computerized data are verified to accurately reflect the original field data (i.e., the entered data match the collected data), the paper forms will be archived and remaining data manipulation shall be done in the database.

Field Data Transcribed Directly to Computer

During the data entry process, the crew member entering the data will verbally double check all field values for accuracy and completeness with the crew member collecting/announcing the data. All discrepancies will be corrected prior to moving to the next data field.

Upon completing data collection at each site, the crew member entering the data will check the entire computer form for completeness. The crew member responsible for completing this field verification should initial each datasheet in the appropriate location.

After completing the last site of the day the number of records present in the digital file shall be compared against the known number of sites for which data were recorded.

Purpose	Color	Date	Initials
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Figure S5.1. Verification log found at the top of NETN Forest Health paper datasheets. Log is used to track changes and record the verification and validation status of datasheets for each plot.

Field Data Transcribed to Paper Datasheets

- Datasheets should be protected within an enclosed clipboard.
- All information added to a datasheet must be printed using pencil and clearly legible.
- While manually recording data, the crew member entering the data will verbally double check all field values for accuracy and completeness with the crew member collecting/announcing the data. All discrepancies will be corrected prior to moving to the next data field.
- Information shall never be erased and incorrect or older information shall never be overwritten.
- Revisions shall be accomplished by crossing-out the erroneous data with a single line.
- Upon completing data collection at each site, original datasheets shall be reviewed and checked for legibility and completeness. The crew member responsible for completing this field verification should initial the datasheet in the appropriate location.

Paper Data Transcribed to Computer

During the process of transcribing data from paper datasheets into the database, the crew member will double check all entries and correct discrepancies prior to advancing to the next datasheet.

Following data entry into the computer, a crew member shall review 100% of the records entered to ensure that values present on field forms were accurately and completely transcribed into digital

form. All efforts should be made to prevent the same crew member who originally entered the data from conducting the 100% verification check. Notes or changes made to the datasheets should only be made on the complete set of copies made for this purpose.

Ten percent of records are reviewed a second time by either the data manager or the plant ecologist. All comments and changes should be recorded on the copies of the datasheets. If a significant transcription error (e.g., incorrect values or missing records) is found in one out of 10 datasheets during the 10% review, then the entire data set will be verified again (i.e., repeat the 100% and subsequent 10% checks until the data manager is satisfied with the data quality). In cases where the transcription errors detected follow a pattern (e.g., data entry errors on datasheets with quadrat data that was recorded out of order), then a subset of the datasheets following that pattern will be checked, instead of the entire set of datasheets.

Database Merge Tool

There are several important considerations to ensure the merge tool will merge records between databases correctly:

- The process of merging works best when field backends are merged into a master backend that is stored/managed by the protocol lead or data manager.
- The database backends should only be merged at the end of the week when visits in each backend are complete. For example, if everything except quadrats were sampled on a plot one week, and a contract botanist is scheduled to sample the quadrats the following week, the databases should not be merged. The contract botanist and crew member must also either use the same field computer/database associated with the other data for that visit, or record quadrat data on datasheets.
- One field computer/database is used on a plot, as the merge tool will not recognize two visit records created on the same day and plot, but on different computers, as the same visit.
- QA/QC plots should have a backend that contains the initial visit by the crew that year, to ensure any changed plot-level data are merged correctly.

If these guidelines are not followed, the merge tool may not function properly, and some records may not be incorporated into the merged database.

Schedule of Data Management Duties

A number of data management duties should be performed regularly to ensure that all datasheets, files, and samples are properly accounted for. At the beginning of the field season, each crew member is assigned a specific set of duties to perform over the course of the season, and duties are performed on a daily or weekly basis.

Daily Duties: Backup and Tracking

At the end of every day, one crew member must copy photopoint photos to the designated field computer, and use the rename utility to name the photos correctly. The backend on each Toughbook,

along with the renamed photos should then be backed up onto the provided external drive. The external drive should be stored in a different location than the field computers. The tracking form should also be updated with information on the plots that were sampled that day, including whether the database or datasheets were used on the plot, which Toughbook the plot was sampled on, and the number of soil and unknown samples collected from each plot (Appendix S5.B).

Weekly Duties: Merging the Data

At the end of every week, the forest crew leader will post the latest backends from both field computers on Google Drive. The protocol lead will merge the two field backends into a master backend database. The protocol lead will then check for issues in the plots sampled that week, including running the checker for each plot, and scanning the species recorded in each tab. After the merge is complete and the data are checked, the protocol lead will send the newly merged database to the forest crew leader before the start of the work week. At the beginning of each week, the forest crew leader will then copy the new backend to each field computer and reset the links in the frontend database.

Data Validation

Although data may be correctly transcribed from the original field forms, their values may not always be accurate or logical. For example, some plant species found in southern parks do not occur in northern parks, such as MABI or ACAD. If a southern plant is identified erroneously to be present in a northern park, this would represent a logic error. As often as possible components of the data validation process has been built into the database (e.g., value range restrictions, separate species pick-lists for trees and shrubs, separate favorites species lists for each park, etc.). Although many validation problems can be addressed by a well-designed database, the plant ecologist (NETN) or program manager (MIDN) must also review and validate the data after verification is complete. The plant ecologist and network program manager are the authorities on the methodologies and species involved.

Once the verification process has been completed, statistics should be used to evaluate the data present in the database. The plant ecologist and/or network program manager should generate range and average values to help identify outliers.

Data Stewardship

Good data stewardship practices play a critical role in long term data security and help prevent irretrievable loss of information.

- Sequential copies of the field database should be backed-up to an external hard disk on a daily basis. The computer and the hard disk shall be stored separately. For example, when the computer is being used in the field, the hard disk shall be stored in another location (i.e., a hotel room, or in a vehicle).

- The database should be uploaded by the crew to the NPS ftp site at the end of every sampling week. Network staff should then check the database for errors on a weekly basis during the

first month of sampling, and periodically thereafter to catch and prevent recurring data entry errors. Login information for the NPS ftp site will be provided to the crew during training.

- Datasheets should be photographed or scanned at the end of each field day to preserve a temporary digital record of the datasheet, should the original datasheet get lost. Once data are transferred and certified in the database, the images can be deleted.
- Datasheets should be copied onto acid-free paper within one week of collection, and shall be checked to ensure that all original data are present and legible. Once produced, photocopies of the datasheets should be affixed as coversheets to their corresponding originals and used for all computer data entry and verification procedures. All post-field corrections and remarks should be recorded on the copies. All post-field corrections and remarks should be annotated with the date and initials of the person making the changes.
- Once the computerized data are verified as accurately reflecting the original field data and validation is complete, the paper field forms shall be delivered to the network data manager. The electronic version of the data is used for all subsequent data activities.

Field QA/QC

The networks will resample at least 5% of sampled plots annually to determine reliability of field data collection. Field QA/QC will occur as close as possible to original sample date of the plot to reduce seasonal variability, and will not occur before the plots are sampled by the forest crew. Field staff for remeasurement must not include members of the field crew that originally measured the plot; and unknown plant identification must not be performed by the botanist who undertook this function for the original measurement. In order to control trampling impacts, remeasurement should not occur at plots which are particularly sensitive (e.g., moss dominated ground-layer), and no plot should be measured more than four times in 12 years. The QA/QC team should sample the plot as it was left by the previous crew. Plot markers, the location of tree DBH measurements, and all plot-level data (e.g., tree distance and azimuth, tree species, and plot slopes) should not be changed. If the QA/QC team detects issues with the plot-level data, they should be recorded in the notes, and the protocol lead will review the issues to determine if the original data should be modified.

The field QA/QC team can consist of several combinations of network staff. The QA/QC team must include a botanist capable of identifying all woody and herbaceous plants on the plot, and at least one network staff member who is well versed on the forest protocol. Appropriate QA/QC teams include 1) plant ecologist and/or contract botanist with network program manager, 2) plant ecologist with forest crew leader or member, 3) forest crew leader with contract botanist, and 4) two forest crew members with contract botanist. The QA/QC team must not include anyone who was present at the original sampling event. In the event that the plant ecologist or other network staff were present at the original sampling event (not ideal), a separate contract botanist must identify all species during the QA/QC sampling, and the plant ecologist/ network staff must not participate in any data collection that he/she participated in during the original sampling event.

The QA/QC team must use a database that contains the initial visit from the crew. This will allow for the QA/QC team to view any plot-level data that are changed, such as corrections to plot orientation, tree azimuths, or tree species. If the QA/QC team does not have the initial visit, plot-level records that were changed by the initial visit for that year will have an older time stamp than plot-level records for the QA/QC visit, and the automatic setting on the merge tool will not adopt the correct records.

Importing Soil Data from the Lab into the Database

Once analysis of the soil samples is complete the analytical lab will report the results on a spreadsheet. Data contained in the spreadsheet will need to be imported into the most recent version of the Forest Monitoring Database so that it links up accurately with the plot and visit upon which it was collected. The following are step-by-step instructions on how to prepare, format, and import the spreadsheet into the database.

Preparing the spreadsheet

1. The spreadsheet received from the lab will have the NETN sample number (e.g. 1, 2, 3, etc.) , and a series of data columns: soil PH, % LOI, % TN, % TC, Ca, K, MG, P, Al, Fe, Mn, Na, Zn, acidity, and ECEC.

2. Make a copy of the original spreadsheet from the lab before starting any modifications.

3. Original spreadsheets should use ‘from_lab” in the file name. Modified spreadsheets should use ‘for_DB’ in the file name. Only make changes to the ‘for_DB’ version of the spreadsheet.

4. Final storage of all soil files should be here: Z:\PROJECTS\MONITORING\Forest_Health\5_Data\Data_Files\Soils

Formatting the spreadsheet

1. On the ‘for_DB’ version of the spreadsheet, rename the existing ‘Sample’ column to ‘UMO_Sample”.

2. Insert 8 new columns before the UMO_Sample column: Soil_Data_ID, Unit_Code, Plot_Number, Sampling_Year, QA/QC, Layer, Date_SoilCollected, and Date_Dry, and provide the data corresponding to each sample using the crosswalk datasheet created when the samples were sent to the lab.

    a. ‘Soil_Data_ID’ will remain empty; it will be populated by the database.

    b. ‘QA/QC’ should be “Yes” or “No”, depending on whether the sample was collected during a QC visit.

    c. ‘Layer’ should be the horizon: “O”, “A”, or “10cm”.

    d. ‘Date_SoilCollected’ is the date the sample was collected.

   e. ‘Date_Dry’ is the date the sample was completely dry.

3. Review the data provided by UMO. Entries of “I.S.” refer to samples where there was not enough soil available for the test. Delete “I.S.” where it occurs to leave a blank cell.

4. In some cases, data are reported as “< N”, where N is a numerical value. These entries are situations where the data are below the reporting limit of the analysis. In these cases, we use the reporting limit as the value for our analyses. We’ve never had data below the reporting limit for Ca, Mg, or MN. For the other columns (K, P, Al, Fe, Na, Zn, and acidity), do the following:

   a. Insert a new column next to the original column.

   b. Copy the column with data into the blank column.

   c. Rename the original column “X-Reported”, where X is the nutrient name (e.g., “K” becomes “K-Reported”)

   d. Rename the new column “X-Analysis”, where X is the nutrient name (e.g., “K” becomes “K-Analysis”)

   e. Highlight the data in the “Reported” column, right-click on the data, and select Format Cells. On the Number tab, choose the Text category and select OK.

   f. Scan the data in the “Analysis” column for “<” symbols, and delete them and the space after them wherever they occur in the column.

5. Save and close the spreadsheet.

Importing data into the database

1. Open the Forest Database (front-end).

2. Make sure the database is linked to the most recent backend (Switchboard → Admin → Link Databases).

3. From the Switchboard/Tools select Append Soil Data.

4. Follow the steps provided in the database tool.

   a. Step 1: Click ‘Import’ and browse to and select the Excel file with the soil data. NOTE: The workbook may have multiple sheets, but the data to be imported ***must*** be the first sheet. Click ‘View’ to verify that the import was successful (e.g. all records were imported, all data fields were populated). Soil_Data_ID field should be blank. It will be added in the next step.

   b. Step 2: Click ‘Add ID Field’ to populate the Soil_Data_ID field with data from the database (based on the unique combination of Unit_Code, Plot_Number, QA/QC, and

Date_SoilCollected). Click ‘View’ to verify that all records now have a Soil_Data_ID value. Take note of/remember the number of records in this file. It will help verify that all are appended in the next step.

c. Step 3: Click ‘Append’ to append the soil data from the temporary file to the tbl_Soil_Data_Lab table. Review the import results using the ‘View’ button. If the file was not formatted properly or there are duplicate records already in the database a error/notification message will appear. The main messages have been defined to help you trouble shoot what went wrong. Click the ‘Troubleshooting Errors’ button at the top of the form to review these. Any changes made to the data itself need to be clearly documented in the table’s ‘Notes’ field.

d. Step 4: Clean up the now redundant temporary file using the ‘Delete Temporary File’ button. Even if the append was aborted during an intermediate step, this button can be used to delete the temporary file.

Appendix S5.A. QA/QC steps quick-reference.

Data Collection	For each measurement, verbally verify its value with crew member before recording it. If raining, record data on paper datasheets to protect the computer.
Data Entry	Never overwrite or erase incorrect information; cross out erroneous data with a single line. After each site, verify with your initials that each form was completed in its entirety. At the end of each day, verify that completed forms exist for each site visited.
Track and Back-up Data	Daily: download and rename photopoint photos. Backup each database and photos onto provided external drives and store in a location separate from the field computer. Daily: update tracking forms for the plots that were sampled that day At the end of every week: post the latest backends of the database using Google Drive. At the end of every week: make a complete set of copies for all paper datasheets.
Merge Databases	Before the start of every week: protocol lead merges the two field backends to a master backend database, checks that week's data for issues and posts the newly merged backend to Google Drive. Before the start of every week: Forest crew leader copies new backend to field computers and links to the new backend in the front end.
Verify Data	A crew member will transcribe all paper records into the computer database. A different crew member will conduct a 100% review of all newly transcribed records. All corrections/remarks should be recorded on copies of the datasheets. Log of all post-field data corrections should be recorded on top of each paper datasheet. Protocol lead will conduct 10% review of all transcribed records. Verification steps will be repeated until Project Lead is satisfied with data quality.
Validate Data	Protocol lead will check data for data logic errors not prevented by database design.
Data Stewardship	After all verification and validation procedures are completed all paper datasheets will be delivered to the Network Data Manager and prepared for archiving. The electronic version of the data is used for all subsequent data activities.

Appendix S5.B. Example tracking form for plots in Weir Farm National Historic Site.

Weir Farm National Historic Site Forest Plot Tracking Form A

	Plot Data				
Plot	**Entry Type & Date** (Pap, DB, Part)	**Partial DB Data** Stand, Trees, ..., CWD	**Location** (TB-Thing #, Vehicle)	**Entered from Pap** Date/Initials/TB #	**Notes**
1					
2					
3					
4					
5					
	Pap=Paper datasheet **DB**= database **Part**=partially on Pap, partially in DB If **Part**, complete next column	Record tabs that were recorded partially on Pap, and partially in the DB	Record Toughbook # or if on paper, the vehicle where data are stored	Record date where data entered from datasheet to database, intials of enterer, and number of TB. Record a checkmark when data are checked.	Record notes such as missing or suspect data

Weir Farm National Historic Site Forest Plot Tracking Form B

	Photopoints			Unknown Plants	
Plot	**Camera**	**Date Downloaded**	**Backup** Date/Lacie #	**# Unknown Samples**	**Location** per sample
1					
2					
3					
4					
5					
	Record camera photos were taken with	Record date photos were downloaded from SD card	Record the date and Lacie drive photos were backed up		Record the vehicle samples are stored in, or Kate, or CB for Contract Botanist

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
2.00	September 2006	Geri Tierney Brian Mitchell	Reorganized information Emphasized importance of careful data collection and management, now require only one photocopy of datasheets in addition to original, included note that database and datasheet should match as closely as possible.	
2.01	December 2006	Geri Tierney Brian Mitchell	Removed requirement that Forest database be periodically printed, included requirement that forest database be periodically uploaded to NETN during field season.	
2.02	April 2007	Geri Tierney	Minor editorial changes	
2.03	November 2007	Geri Tierney Kate Miller Brian Mitchell	Clarified requirement that crew should upload database weekly, added that NETN staff check database for errors early in the season, added that field QA/QC should occur as close to the original sample date as possible.	
2.04	December 2007	Geri Tierney Kate Miller Brian Mitchell	Changed Data Verification and Integrity to Data Verification and Quality, removed NPS ftp site user name and password.	
2.5	May 2008	Kate Miller Brian Mitchell Jim Comiskey	Revised to serve as joint MIDN/NETN protocol.	
2.06	November 2008	Adam Kozlowski Kate Miller	Clarified the verification and validation procedures and who has the responsibility to implement them, added that data entry and error checking dates and initials should be written on datasheet, added that any modifications or remarks written on paper datasheets should be written in a different colored pencil, and indicated in the verification log found on the top of each datasheet, added Appendix I to summarize QAQC steps.	
2.07	December 2008	Kate Miller Adam Kozlowski	Clarified that prior to finishing data entry for a plot, the data technician must record their initials to indicate that they checked over each form in the database to ensure complete and accurate data, added an example of a potential logic error in data entry that may not be picked up by validations built into the database, added a transcription error rate at the 10% level that will require another 100% check.	
2.08	April 2008	Kate Miller	Minor editorial changes.	
2.09	May 2009	Sarah Lupis Kozlowski	Minor editorial changes, formatting.	Conform to NPS standards.

Revision History Log (continued)

Version	Date	Revised By	Changes	Justification
2.10	December 2009	Kate Miller Andrew Vincello Brian Mitchell	Minor editorial changes. Clarified appropriate staff combinations for field QA/QC sampling.	
2.11	January 2013	Kate Miller Adam Kozlowski	Clarified roles of QA/QC team and rules on order of sampling. Added procedures for importing soil data from lab into the database.	
2.12	March 2014	Kate Miller	Added information about the merge tool, including considerations for QA/QC. Clarified schedule of data management duties and provided an example of a tracking form.	Revision to match updated procedures.
2.13	December 2015	Kate Miller	Added the responsibility to photograph or scan datasheets at the end of each field day.	

SOP 5 - Site Selection, Plot Establishment and Remeasurement

Mid-Atlantic Network/Northeast Temperate Network

Version 3.10

Overview

This SOP provides instruction for establishing plots, resampling plots and collecting site information. Prior to the field season, plot locations will be selected using GIS and the GRTS sampling algorithm to provide a random, spatially balanced sample. Locations which present a safety hazard or do not fall within forest, woodland or plantation will be discarded. Figure S6.1 is the plot layout for parks in the Northeast Temperate Network (NETN), and Figure S6.2 illustrates Mid-Atlantic Network (MIDN) plot layout.

It is important for NETN and MIDN to ensure that plot marking procedures have been approved by the natural resource manager at each park prior to plot establishment. These procedures may vary by park in response to individual park requirements.

Definitions

Horizontal distance is the straight line distance between two objects. This contrasts with slope distance which is measured parallel to the ground. Slope distance and horizontal distance are equivalent on flat land. On sloped land, the horizontal distance between two objects is less than the slope distance.

True north is the direction of the North Pole relative to your position. This contrasts with magnetic north, which varies across the landscape and over time as the direction towards which your compass needle points when you are in the northern hemisphere. To find true north, use a magnetic declination chart or table to find the correct declination between true north and magnetic north for your position at the time you wish to navigate (such as at http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp). Then, adjust your compass by dialing this declination into the faceplate. All azimuths referred to herein are based on true north. For 2011, use the following degrees west declination for NETN parks: 17 at Acadia NP (ACAD); 15 at Minute Man NHP (MIMA) and Saint-Gaudens NHS (SAGA); 14 at Marsh-Billings-Rockefeller NHP (MABI), and Saratoga NHP (SARA); 13 at Morristown NHP (MORR), Roosevelt-Vanderbilt NHS (ROVA), and Weir Farm NHS (WEFA). For 2009, use the following degrees west declination for the MIDN parks: 13 at Valley Forge NHP (VAFO); 12 at Hopewell Furnace NHS (HOFU); 11 at Eisenhower NHS (EISE), Fredericksburg and Spotsylvania County Battlefields Memorial NMP (FRSP), Gettysburg NMP (GETT) and Richmond NBP (RICH); 10 at Appomattox Court House NHP (APCO) and Petersburg NB (PETE); and 8 at Booker T. Washington NM (BOWA).

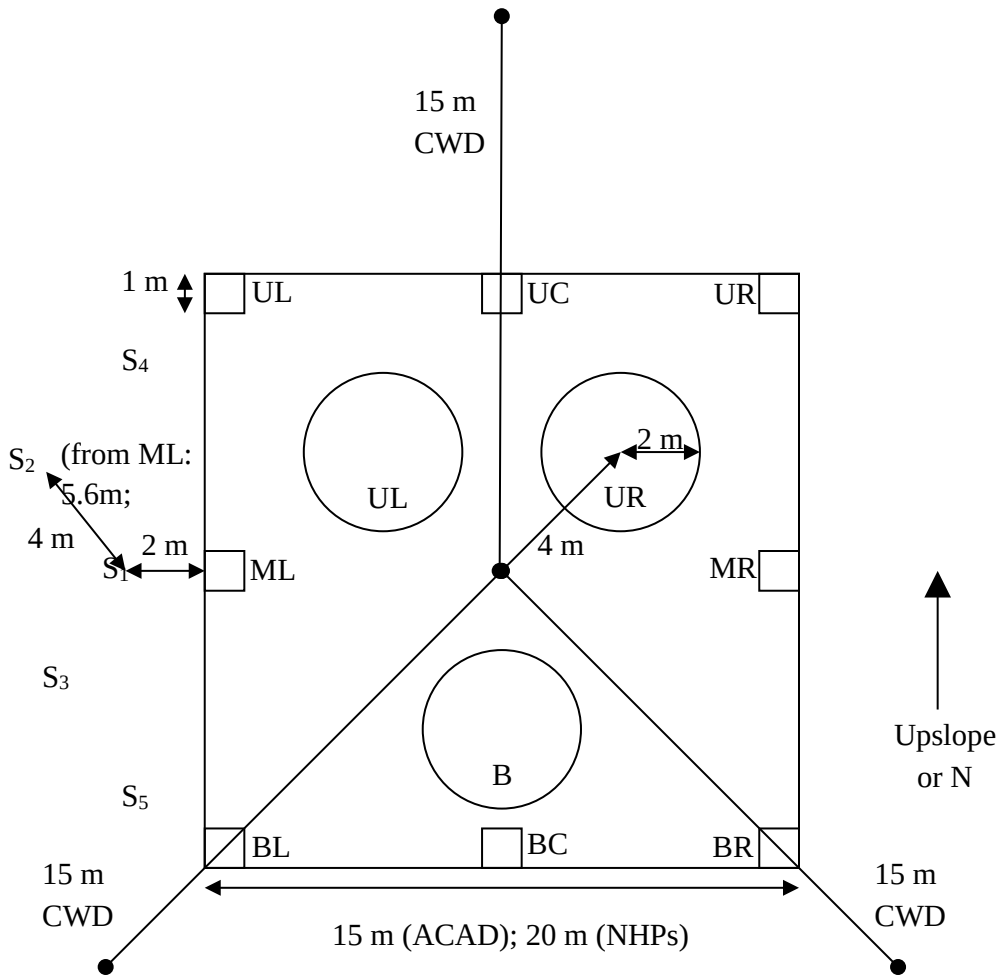


Figure S6.1. NETN plot layout showing square tree plot with three nested 2-m radius regeneration microplots, eight 1-m^2 vegetation quadrats, and three 15-m CWD transects. S_x is location of soil sample.

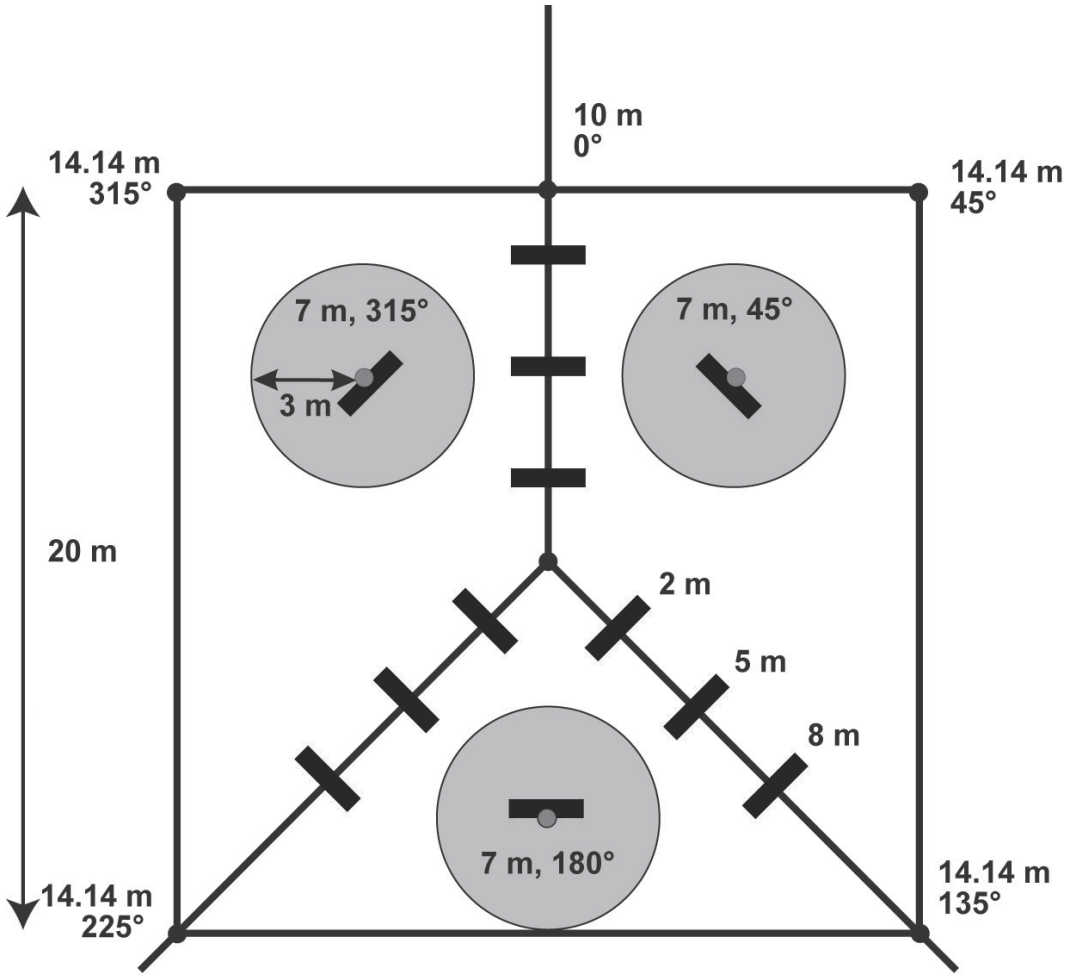


Figure S6.2. The MIDN plot layout showing square tree plot with three nested 3-m radius microplots, 12 one-m^2 vegetation quadrats, and three 15-m coarse woody debris (CWD) transects.

Plot size will be 15 x 15 m square plots at ACAD, and 20 x 20 m square plots at all the national historic sites and parks (NHPs) including all MIDN parks.

Procedure

Plot Establishment

Examine park topographic maps to determine the best route to preselected plot locations. Using GPS and compass, travel to a proposed plot location. The GPS and compass should be held sufficiently far apart to avoid the GPS influencing the compass needle. Do not take safety risks when traveling to plots—if off-trail topography becomes too steep or difficult, find an easier route to the plot location. If a safe route does not exist, discard the location and record the reason for doing so.

As you near the pre-selected location, use the following protocol to locate the plot—do not spend time trying to find the exact pre-selection location. As soon as the GPS indicates you are within 15 m of the pre-selected location, continue exactly 10 steady paces (20 steps) in the direction of the pre-selected location and stop. Do not veer off course to avoid obstacles. This is the location of the center of the plot.

Upon arrival at this plot location, visually examine the location to ensure it is primarily forested, succeeding to forest, a plantation or a woodland, and that plot center is ≥ 15 m from the park boundary, a road, a carriage road, a perennial stream, a water body, a mowed area, or any obstacle that would interfere with plot establishment. Taking care to examine the plot location will ensure that no part of the plot will fall outside the park boundary, and also that roads, carriage roads and water bodies will not fall within the plot. Abundant poison ivy, dense brambles, and location near or along a hiking trail are not appropriate reasons for excluding a plot. Plots should not be located on top of earthworks in cultural parks if the plot establishment and measurement disturb these cultural resources. In no instance should permanent markers, such as rebar, be installed in an earthwork. To qualify as woodland (ACAD only), the plot must have at least 25% tree canopy cover. Trees need not be 10 cm DBH to qualify as part of the tree canopy—smaller or stunted trees can contribute to this threshold. Early successional areas (NHPs only) that are succeeding to forest due to a change in land management should be measured regardless of canopy cover, as long as tree reproduction is evident or expected at the site. If unsure whether this is so, consult a supervisor. If the site is a forested wetland with standing water covering much or all of the plot, do not discard the site. Where feasible, postpone installation and measurement, and note that the plot should be revisited later in the season when water has receded. If the field schedule doesn't allow for postponing plot measurement, then sample the plot and take extra care not to trample the plot. If the plot does not meet the criteria listed herein, or if the plot presents a safety hazard such as extremely steep slopes (i.e., > 30 degree/ 60% slope) or unstable snags, discard the plot and record the reason in the forest database. Proceed to add the next backup location to the list of plot locations for establishment. Then proceed to the next nearest pre-selected location currently included in the annual sample.

For MIDN parks, plots may be moved if the initial location is not suitable. Temporarily mark the current plot center, and using the compass and rangefinder move 20 m north of the initial plot location and evaluate whether the new location meets the criteria outlined above. If this location is not suitable, return to the initial plot location and repeat the relocation process, this time moving east, then south, and finally west. If after checking each new location in all four cardinal directions it is determined that all points are unsuitable, then the site is discarded and the crew should proceed to the next backup location as outlined above.

If the plot meets all criteria listed above, set the GPS to average readings for a waypoint, and allow it to collect readings at plot center while the plot is being established (see SOP 3 - Using the Global Positioning System (GPS) for more detailed instructions). Install permanent markers as follows to establish the plot. The plot layout is shown above (Figure S6.1 for NETN, Figure S6.2 for MIDN). For NETN, install a #2 rebar stake with pre-marked survey cap at your current position—plot center. In ACAD attach a plastic research tag with the study number (#82) clearly written with permanent marker. For MIDN, a #6 rebar stake with pre-marked survey cap is installed.

If the plot center location is on a rock, an intermittent streambed, or some other obstacle, look for a suitable location to secure the rebar stake 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 no suitable location exists within a 2-m radius, return to the original position, and select a witness tree near plot center and record the tree number. Plot tags should be attached to the witness tree using a stainless steel nail at

ACAD, MORR, and SAGA and aluminum nails in MABI, MIMA, ROVA, SARA and WEFA; for MIDN the tag is attached using aluminum nails.

To find the plot corners, determine and record the upslope azimuth from your current position. When determining upslope azimuth, consider the slope at the scale of the plot. If the plot is in a flat location (i.e., ≤3 degrees or 5%), the first marker will be oriented toward true north. Measure the upslope azimuth using the TruPulse) and record this as the orientation of the plot If the plot orientation is not true North, then use the plot map in the database to determine the azimuths of the corners and midpoints for the rest of the plot.

For NETN parks, use the TruPulse to measure ½ the **horizontal distance** of a plot side (7.5 m at ACAD, 10 m at NHPs) along the upslope azimuth (Figure S6.3, step 1). This is the mid-point of the upper plot boundary—insert a fiberglass stake and record the up slope angle (VA). Along the same azimuth, locate the end point of the UC Coarse Woody Debris transect (15 m **slope distance** from plot center), place a survey flag at this point, and measure the slope angle (VA). Rotate the TruPulse in a clockwise direction, taking readings until the compass registers 45° past the plot orientation. Measure a **slope distance** of 4 m to mark the location of the UR microplot (Figure S6.3, step 2). Install a fiberglass stake. Using the same azimuth, measure a **horizontal distance** of 10.61 m (ACAD) or 14.14 m (NHPs) and install a bent rebar stake (Figure S6.3, step 3). Rotate the TruPulse in a clockwise direction, taking readings until the encoder registers 90° past the plot orientation, and measure a distance of 7.5 m (ACAD) or 10 m (NHPs), and install a fiberglass stake. Continue with steps five through 11 to install all corner, midpoint and microplot markers. Mark end points for CWD transects (lines 5 and 8) with survey flags, and record slope angle (VA) for each transect. Also record the down slope angle (VA) in step 7. Distances should be measured to within 10 cm error, and bearings and vertical angles should be sighted to within 1 degree error. Note that plots established prior to 2012 in NETN were marked entirely with fiberglass stakes, and between 2008 and 2010 in MIDN, all but plot center were marked with fiberglass stakes. Starting in 2012 in NETN, plot corners should be marked with #3 rebar that have a 90 degree bend on the top. Plot centers should be marked with #4 rebar with a pre-installed marked survey cap. In MIDN, all plot corners and microplot centers should be marked with #3 rebar that have a 90 degree bend on top.

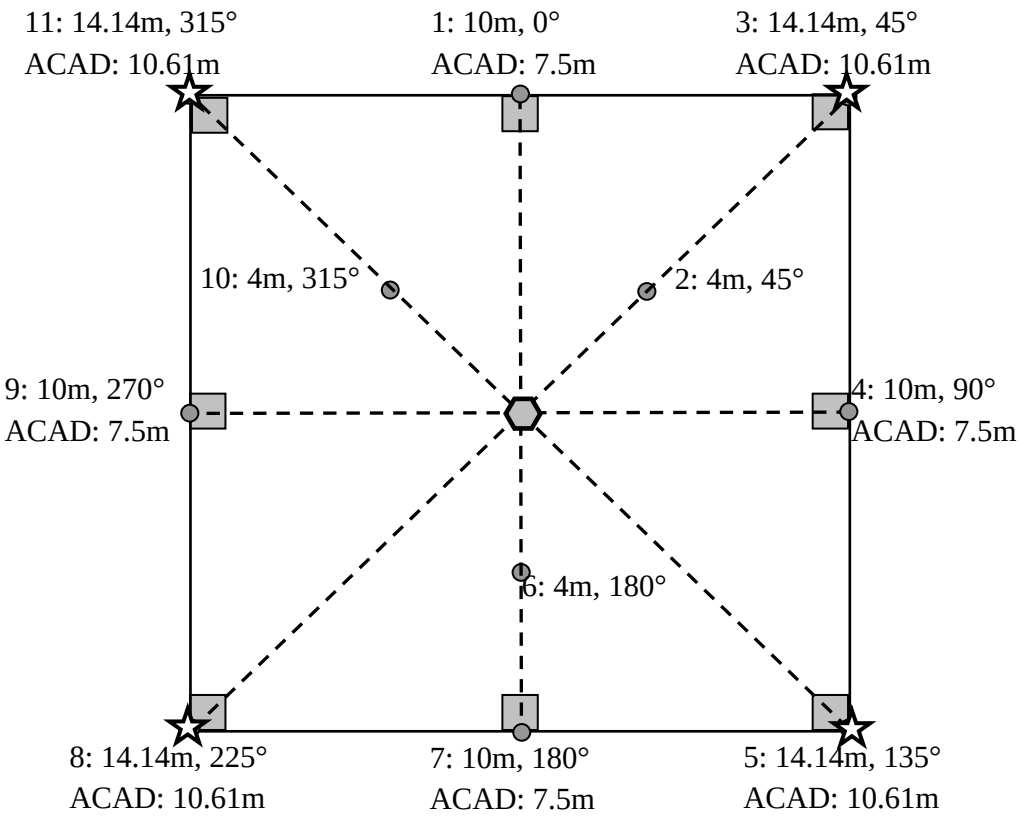


Figure S6.3. Sequential steps in setting up a forest vegetation monitoring plot in NETN parks. Step number is followed by the distance and azimuth for NHPs in NETN. Distances for ACAD are shown on the second line. Distance measurements are in a horizontal plane, except that steps 2, 6, and 10 are 4 meters slope distance. Bent rebar stakes are installed at plot corners (☆). A rebar stake with a pre-marked survey cap is installed as plot center (⬡). Plot midpoints and microplot centers are each marked with a fiberglass stake (●). Azimuths are relative to the orientation of the plot.

For MIDN parks, use the TruPulse to measure ½ the **horizontal distance** of a plot side (10 m at all parks) along the upslope azimuth (Figure S6.4, step 1). This is the mid-point of the upper plot boundary—insert a bent rebar stake and record the upslope angle (VA). Along the same azimuth, locate the end point of the UC Coarse Woody Debris transect (15 m **slope distance** from plot center), place a survey flag at this point, and measure the slope angle (VA). Rotate the TruPulse in a clockwise direction, taking readings until the TruPulse compass registers 45° past the plot orientation. Measure a **horizontal distance** of 7 m to mark the location of the microplot (Figure S6.4, step 2). Install a bent rebar stake. Using the same azimuth, measure a **horizontal distance** of 14.14 m and install a bent rebar stake (Figure S6.4, step 3). Rotate the TruPulse in a clockwise direction, taking readings until the compass registers 135° past the plot orientation and measure a distance of 14.14 m and install a bent rebar stake (Figure S6.4, step 4). Continue with steps 5 through 9 to install all corner and microplot markers. Mark end points for CWD transects (lines 4 and 7) with survey flags, and record slope angle (VA) for each transect. Also record the down slope angle (VA) in step 6. Distances should be measured to within 10 cm error, and bearings should be sighted to within 1 degree error.

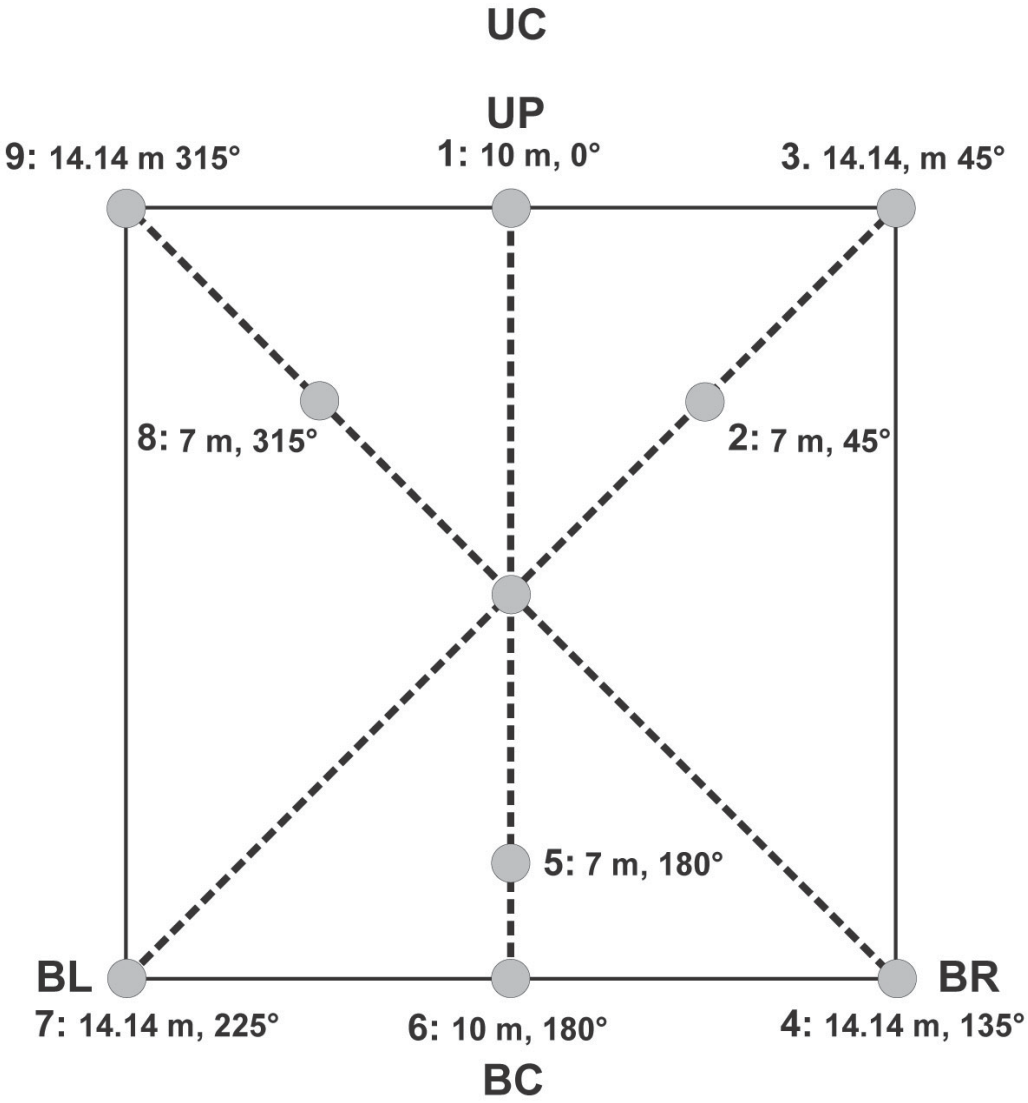


Figure S6.4. Sequential steps in setting up a forest vegetation monitoring plot in MIDN parks. Step number is followed by the distance and azimuth for all parks in MIDN. Distance measurements are in a horizontal plane. Azimuths are relative to the orientation of the plot.

If a TruPulse is not available or not operating correctly, the same steps can be followed using a surveyor's compass or forester's compass (i.e., a compass with a mirror for sighting and an adjustable declination), and a Sonin electronic distance measurer or measuring tape. **When sighting compass bearing, crew members must take care that metal objects such as survey flags do not affect the compass needle.**

Metal survey flags should not be carried by the crew member sighting the compass during plot setup. To **measure horizontal distance**, hold the measuring tape horizontally level rather than parallel to the slope, using a plumb bob if necessary. On slopes, this will result in the upslope tape end held low to the ground while the downslope end is held high. On steep slopes, it will be necessary to measure the horizontal distance in sequential short increments that can be held level.

Install rebar stakes flush to the ground. Install fiberglass stakes half-way into the ground unless the plot is visible from a major trail or visitor location in any park—in this case sink stakes more deeply with only 5 cm extending above ground. Use a mallet to ensure the stake is inserted firmly in the ground. Where soil is shallow to bedrock it may be necessary to use a shorter stake. If shallow soils or exposed bedrock prevent installation of some stakes, note which stakes were omitted, and select a witness tree to aid in relocating the plot corner/midpoint. For each witness tree, record species and DBH along with the bearing and horizontal distance from the tree to the plot corner/midpoint. The crew should temporarily mark stakes with bright-colored survey flags to make them more visible during measurement. It is important that these flags be collected and removed from the site after measurement.

In early successional plots within NHPs stakes will be hard to relocate so **additional plot marking** will be used if permission can be obtained from the natural resource manager at the given park. In this case, use flagging and paint as needed.

Plot Remeasurement

Read the directions and plot notes that were recorded during the original and all subsequent sampling events. Use the notes and field maps to find the safest and most efficient route to the plot.

Once at the plot, use the TruPulse to locate plot corners, midpoints, and microplot centers. In NETN install bent #3 rebar stakes in plot corners, and #4 rebar stake with pre-printed survey cap at plot center. If microplot or midpoint stakes are missing, replace them with fiberglass stakes. In MIDN, install #3 bent rebar stakes at every plot marker location. Use the TruPulse to reestablish any missing stakes, and record this in the notes. If a plot has been vandalized and/or multiple markers have been removed, reestablish the site using the TruPulse. If at all possible, find plot center and set up the plot from that point using the azimuth recorded from the original plot establishment. If plot center cannot be located, use existing plot markers to recreate plot center, and reestablish the plot from this point. If plot center can't be relocated or recreated, reestablish plot center following the same procedures as described in the plot establishment section (i.e., navigate with GPS and walk 10 paces to plot center when within 15m). In this case the plot number must be changed in the database (keep the same GRTS number) to reflect that this is essentially a new plot. Be sure to record thorough notes in all of these situations so future sampling and analyses can account for these issues. If possible, position tree tags and plot markers so they are facing away from a road or opening and are less conspicuous.

Once plots have been established, we will continue to monitor them in most situations, even if they do not meet the original guidelines for plot establishment. There are some rare cases that would lead to a plot being abandoned, based on the plot no longer fitting within the target population for monitoring. Plots will be abandoned if there is a change in park management that has resulted in permanent conversion of forest to open, non-forest habitat (e.g., open field, parking area) within the plot. Note that forestry activities (e.g., harvesting or even clear-cutting at MABI or GETT) are not a permanent conversion, nor is a one-time impingement of mowing into the plot. If a plot has been partially mowed or otherwise affected for two or more sampling events, contact the park resource manager to determine if there has been a permanent change in management for the location. If crew

is unsure of whether a disturbance is significant enough, or if it is permanent, they should contact their supervisor before deciding to abandon a plot.

Note: NETN plots in panel 1 and panel 2 were established manually with measuring tapes and compasses, and are likely to be less accurate (especially on steep slopes) than plots setup with the TruPulse. From 2016 on, only stakes that are off by >1m and/or >4 degrees (based on TruPulse), should be moved to the correct location. Before moving the stake, check notes from the previous survey to see if for some reason the stake was offset. Record stakes that are moved in the notes. Be sure to record all trees that were affected by adjustment of the plot boundary in the notes.

Once data collection is complete and before leaving the plot, the crew must perform several checks between the previous sampling event and the current sampling event. Crew must visually check all plot level data to ensure accuracy, and run the database check on tree, sapling and stand level data. If inconsistencies between the previous sampling event and current event are detected in the check, the crew must verify that the data collected in the current sampling event are correct, and record the inconsistency in the notes. Crew must NOT write over any data collected during previous sampling events.

Data Collection

Park

Record 4-letter park code (ACAD, MABI, MIMA, MORR, ROVA, VAMA, SAGA, SARA, or WEFA).

Plot Number

Record the plot identification number, unique within each park (unique for all MIDN plots).

GRTS Number

Record the GRTS order number.

UTMN

Record the GPS North Universal Transverse Mercator value of the plot center.

UTME

Record the GPS East Universal Transverse Mercator value of the plot center.

Accuracy

Record the positional accuracy of the UTMN and UTME coordinates, as determined by GPS.

Brief Description

Record a brief description of the plot cover and important geographic features. For example, early successional forest with high shrub cover or spruce/fir forest with rocky outcrops.

Slope

Record slope across plot to the nearest degree, using the TruPulse. During plot setup, record upslope in degrees (VA on the TruPulse) during step 1, and downslope in degrees (VA) during step 7 (NETN) or step 6 (MIDN). Observer 1 (with the TruPulse) should take care to sight on Observer 2 (with reflector) at the same height above ground as the TruPulse height.

Orientation

Record the orientation as the upslope (>2.86 degrees, or 5%) azimuth from plot center to UC to the nearest degree. True North will be used when a slope <2.86 degrees is detected.

Aspect

Record aspect in the general area of the plot (approximately 100-m radius) to the nearest 5°. Aspect is determined along the direction of slope for land surfaces with at least 5% (2.86 degrees) slope in a generally uniform direction. If slope is less than 5% (2.86 degrees), record 0 to signify no aspect. Aspect is measured downslope using a compass.

Physiographic Class

Record the physiographic class that best describes the plot area in terms of land form, topographic position and soil, using the codes below. **Xeric codes (11-19)** are for sites that are normally low or deficient in moisture available to support vigorous tree growth. These areas may receive adequate precipitation, but experience a rapid loss of available moisture due to runoff, percolation, evaporation, etc. **Mesic codes (21-29)** are for sites that have moderate but adequate moisture available to support vigorous tree growth except for periods of extended drought. These sites may be subjected to occasional flooding during periods of heavy or extended precipitation. **Hydric codes (31-39)** are for sites that generally have a year-round abundance or over-abundance of moisture. Hydric sites are very wet sites where excess water seriously limits both growth and species occurrence.

11 Dry Tops—Ridge tops with thin rock outcrops and considerable exposure to sun and wind.

12 Dry Slopes—Slopes with thin rock outcrops and considerable exposure to sun and wind. Includes most steep slopes with a southern or western exposure.

19 Other Xeric—All dry physiographic sites not already described

21 Flatwoods—Flat or fairly level sites outside flood plains. Excludes deep sands and wet, swampy sites.

22 Rolling Uplands—Hills and gently rolling, undulating terrain and associated small streams. Excludes deep sands, all hydric sites, and streams with associated flood plains.

23 Moist Slopes and Coves—Moist slopes and coves with relatively deep, fertile soils. Often these sites have a northern or eastern exposure and are partially shielded from wind and sun. Includes moist mountain tops and saddles.

26 Flood plains/Bottomlands—Flood plains and bottomlands along rivers and streams. These sites are normally well drained but are subjected to occasional flooding during periods of heavy or extended precipitation. This category includes associated levees, benches, and terraces, but excludes swamps, sloughs, and bogs with year-round water problems.

29 Other Mesic—All moderately moist physiographic sites not already described.

31 Swamps/Bogs—Low, wet, flat forested areas usually quite extensive that are flooded for long periods of time except during periods of extreme drought.

32 Small Drains—Narrow, stream-like, wet strands of forest land often without a well-defined stream channel. These areas are poorly drained or flooded throughout most of the year and drain the adjacent higher ground.

39 Other hydric—All other hydric physiographic sites.

Directions

Record directions for driving and walking to the plot, including landmarks, distances, and bearings. Include parking recommendations where applicable.

Plot Notes

Record any unusual plot features or problems encountered during plot setup, including the reason for discarding any pre-selected plot locations. Note any problem or irregularities inserting plot markers. Note any features which indicate plot history, including evidence of past agricultural, silvicultural or recreational use regardless of how long ago it may have been.

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
2.00	June 2006	Geri Tierney Brian Mitchell	Switched to GRTS sampling. Plot shape changed from circular to square. New plot size at ACAD, and larger at NHP. Changed decision rule for plot inclusion to prevent exclusion of woodlands. Plot layout based on true north, rather than magnetic north. Procedure included for pacing final steps to pre-selected plot location.	
2.01	September 2006	Geri Tierney Brian Mitchell	Clarified upslope determination should be at the scale of the plot. Now marking all edge midpoints with stakes. Included additional marking for early successional stands at NHP. Reinserted plot aspect measurement. Now record evidence of plot history in Plot Notes. Clarified and improved rule specifying minimum distance of plot to obstacle. Taller stakes now used at all corner, midpoint and other locations unless soil is shallow.	

Revision History Log (continued)

Version #	Date	Revised by	Changes	Justification
2.02	December 2006	Geri Tierney Brian Mitchell	Included acceptable error for plot establishment. Added additional guidance for finding plot center if ground is obstructed. Now record GPS accuracy.	
2.03	April 2007	Geri Tierney Kate Miller Brian Mitchell	Minor edit to rule for identifying obstacles within 15 m of proposed plot location. Added two additional regen microplots.	
2.04	November 2007	Geri Tierney Kate Miller Brian Mitchell	Added need to enter rejected plots into database. Changed procedure for locating plot center when stake can't be secured. Crew to attach research plot tags (study #82) in ACAD. Corrected error distance to 1m instead of 0.1 m. Included use of witness tree if fiberglass stake can't be secured at plot corner or midpoint. Added brief description of plot. Replaced Terrain position with Physiographic class.	
3.01	November 2008	Geri Tierney Kate Miller Jim Comiskey Brian Mitchell	Updated declination website. Changed rebar to fiberglass for 7 or 8 plot markers in MIDN plots.	
3.02	December 2008	Geri Tierney Kate Miller Jim Comiskey Brian Mitchell	Added that abundant poison ivy, dense brambles, and location near or along a hiking trail are not appropriate reasons for excluding a plot. Added the process for establishing 2 witness trees in NETN plots. Changed “rangefinder” to LAR. Minor editorial changes.	To aid in future relocation of plot center. To be consistent with Using the Laser Rangefinder SOP terminology.
3.03	April 2009	Kate Miller	Clarified that compasses used for plot establishment must have an adjustable declination and sighting mirror.	
3.04	May 2009	Sarah Lupis Kozlowski	Minor editorial changes, formatting.	Conform to NPS standards.

Revision History Log (continued)

Version #	Date	Revised by	Changes	Justification
3.05	December 2009	Kate Miller Andrew Vincello Brian Mitchell Jim Comiskey	Changed witness trees to only require a check box in trees form Added resampling section Changed SOP to allow plots with temporary standing water to be sampled. Minor editorial changes. Modifications to MIDN plot setup to include slope measurements	
3.06	October 2010	Kate Miller Jesse Wheeler	Clarified that once plots are established, we do not exclude them, unless a portion has been converted to open habitat by park management Changed plot tags to be attached using nails, when a stake at plot center won't work. Changed SOP name to Site Selection, Plot Establishment and Remeasurement Added that if plot center is missing crew should try to recreate plot center from existing plot markers. If this won't work, then crews should reestablish plot using GPS waypoint and 10 paces. Minor editorial changes	
3.07	March 2012	Kate Miller	Revised plot marking directions to use rebar instead of fiberglass stakes.	
3.08	March 2014	Kate Miller	Revised SOP to reflect replacement of LaserAce Rangefinder with TruPulse. Removed need to select and mark two witness trees in NETN plots	Change of equipment. Witness trees not needed when all trees are mapped.
3.09	November 2015	Jesse Wheeler	Revised tolerance level for plot boundary markers to no greater than 1m and or 4 degrees off based on the TruPulse	
3.10	December 2016	Camilla Seirup	Removed mention of witness trees.	

SOP 6 - Photopoint

Mid-Atlantic Network/Northeast Temperate Network

Version 2.06

Overview

This SOP documents the procedure for photographing plots. Photographs will be archived and used as visual reference for change in appearance of plots over time. Photographs should be taken shortly after plot setup in order to visually record the plot before significant field crew impacts occur.

Data Collection

Six scenes and the plot tag or marker are photographed at each plot—the first five scenes document the plot overall and the last is a close-up of the microplot in the upper right portion of the plot (UR). The first scene is photographed from plot center, facing the top of the plot and holding the camera vertically (portrait). For the rest of the scenes, hold the camera in a horizontal orientation (landscape). Continue standing at plot center, and rotate clockwise, photographing each of the corners of the plot in turn. The final scene is a close-up of the UR microplot ground cover, taken from a position standing over that microplot. After the scenes are photographed, a final picture is taken of the plot tag or survey marker using the macro (picture of a flower) photo function, clearly showing the plot number.

For every scene, the flag marking the stake of interest should be in the center of view. Photopoints should be taken while the crew members are setting up the plot. If the stake is not visible for the photo, a crew member should stand directly behind the stake with a reflector card or flag over the stake to help orient the photo.

Capture one digital photograph of each scene. Do not zoom-in on the scene. Allow the camera to automatically select the appropriate aperture for the given light conditions. Allow the camera to use flash if necessary for the microplot close-up, but do not use a flash for the overall plot scenes. Photos should be 24-bit color photographs, taken at the highest resolution available on the network camera (at least 1024 x 768 pixels). Photos should be compressed using the high-quality JPEG compression setting on the camera. If photos are accidentally taken in wrong order, are out of focus, taken with the flash on, etc., it is only acceptable to delete the flawed photos and start again if all photopoints from previous plots have already been downloaded and named. Otherwise, take a photo (e.g., photo with lens cap on, blank sheet of paper, back of hand, etc.) that makes it clear the photo sequence will start over after that photo.

In remeasured plots, field crew should examine photographs from previous visits and attempt to recreate the position and angle used.

Note: Only one plot level photo was taken from NETN plots in 2006 and 2007, and it was taken outside of the plot at ML facing plot center. Photopoints for these plots should be relocated using the

procedures described in SOP 7 – Photopoint. The regeneration photopoint location and procedures have not changed.

Camera

Use a designated network digital camera for all pictures. Record the brand and model number of this camera.

Photographer

Record the initials of the photographer.

Weather

Record the presence of sun, clouds, rain or fog.

Data Management

After field work is complete for the day, download the photos to the laptop plot photograph directory. View the photos, and rename the photos using the following format:

Four character park code + 3-digit plot code + Scene (UC, UR, BR, BL, UL, RN = Regeneration, ID = ID photo) + Date (YYYYMMDD), with each element separated by an underscore (_). So the UR photo at MABI plot 15, taken June 18, 2008 would be “MABI_015_UR_20080618.jpg”.

Use the Bulk Rename Utility to ensure consistency in file names using the steps below (Figure S7.1). This utility can be downloaded from http://www.bulkrenameutility.co.uk/Main_Intro.php

1. Navigate to the folder containing the files you wish to rename
2. Select the file(s) you wish to rename (SHIFT or CTRL + click to select more than one).
3. Set Filename to ‘Remove’.
4. Add the 4 letter park code, underscore separator, and 3 digit plot number code (e.g., ACAD_081)
5. Add an Auto Date
    a. Mode = Suffix
    b. Type = Taken (Original)
    c. Fmt = Custom
    d. Custom = %Y%m%d (Note the capital and lower case letters)
6. Add Numbering
    a. Mode = Insert
    b. Start = 1

   c. Pad = 2
   d. at = 8
   e. Incr. = 1
   f. Sep = _

7. Check that the photo names in the New Name Column are correct
8. Click the ‘Rename’ button
9. Open up Bulk_Rename_Utility_Step_2.bru with the following settings (Figure S7.2)
10. Navigate to the folder containing the files you wish to rename
11. Select the file(s) you wish to rename (SHIFT or CTRL + click to select more than one).
12. Set Filename to ‘Keep’.

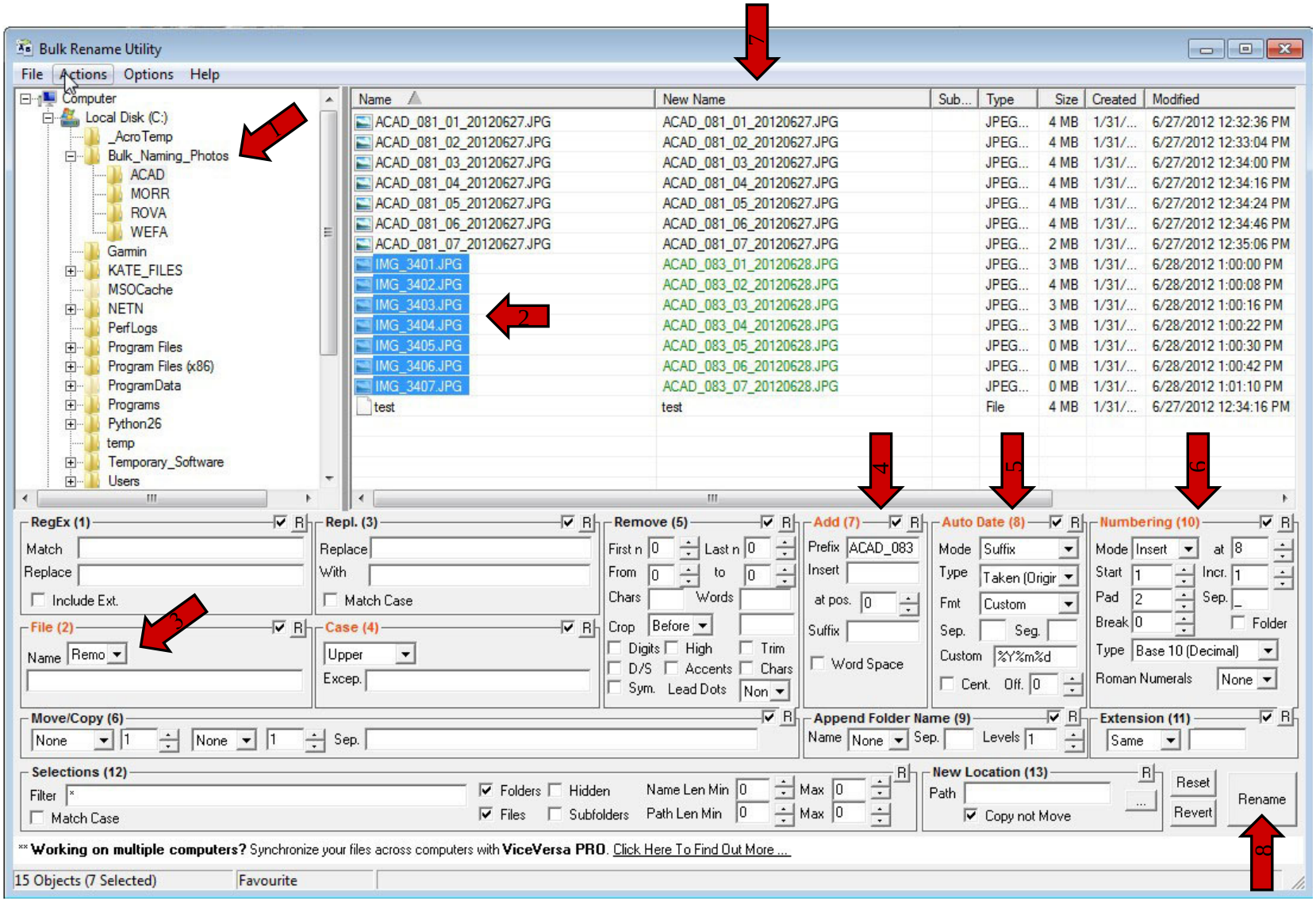


Figure S7.1. Bulk File Rename Utility screen

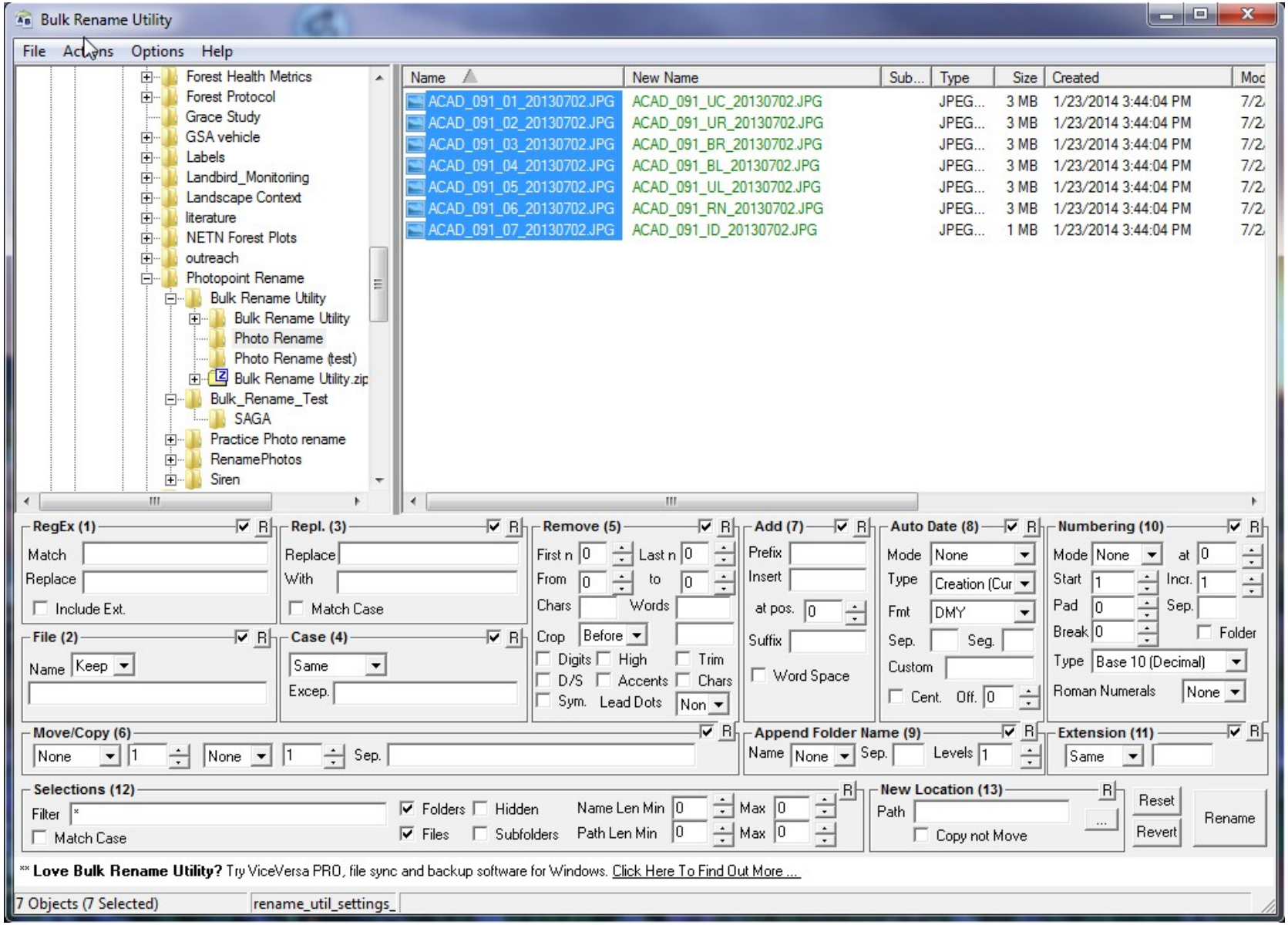


Figure S7.2. Bulk File Rename Utility screen

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
1.01	June 2006	Geri Tierney and Brian Mitchell	Added instructions not to zoom camera.	
1.02	September 2006	Geri Tierney and Brian Mitchell	Added instructions to use camera date stamp if available.	
1.03	December 2006	Geri Tierney and Brian Mitchell	Plot photograph should be taken from 2 m beyond the plot edge.	
1.04	April 2007	Geri Tierney, Kate Miller, and Brian Mitchell	Specified that the regeneration (regen) photo is taken in the UR regen microplot.	
1.05	November 2007	Geri Tierney, Kate Miller, and Brian Mitchell	Clarified instructions for ID card.	
2.00	May 2008		Changed to MIDN methods to produce joint SOP. No need to record date and time of photograph, since this is recorded elsewhere. Record photographer's initials. Added rain to weather conditions. Added data management section with file naming conventions. No ID card or date/time stamp.	Instead of one overall scene per plot (from left or upper left of the plot), five photos are taken from the plot center.
2.01	November 2008	Geri Tierney, Kate Miller, and Brian Mitchell	Only one photo per scene is taken.	Rather than two.
2.02	May 2009	Sarah Lupis Kozlowski	Minor editorial changes, formatting.	Conform to NPS standards.
2.03	December 2009	Kate Miller Andrew Vincello Jim Comiskey	Removed MIDN's old photopoint file naming Added note about change in NETN photopoint locations for plots sampled in 2006 and 2007.	
2.04	October 2010	Jesse Wheeler	Clarified that macro setting should be used for the plot ID photo.	
2.05	January 2013	Kate Miller	Clarified that photopoints should center the plot stake in the view to maintain consistency. Added instructions for bulk file rename utility.	
2.06	March 2014	Jesse Wheeler	Added Figure S7.2 and steps necessary to add photopoint scene code to file name.	Update procedures.

SOP 7 - Stand and Site Measurements

Mid-Atlantic Network/Northeast Temperate Network

Version 3.17

Overview

This SOP collects stand-level and site measurements. These data will allow proper interpretation of other measures, and will be used to assess stand structure and disturbance. This SOP is designed to be used only during the leaf-on period of the summer months (about June 1 to August 31 for NETN and September 30 for MIDN).

The crew should temporarily enhance plot markers with bright-colored survey flags to make them more visible during measurement. It is important that these flags be collected and removed from the site after measurement.

When canopy closure and cover class are assessed, notice the exact breakpoints (e.g., 25%) are not included in any class. Classes are either above or below each breakpoint. This is not a mistake—it is to encourage the crew not to waste time trying to decide if the correct value is exactly 25%. The most suitable class should be rapidly assessed and recorded.

Data Collection

Stand Structure

Record the basic stand structure in the plot using these codes:

1. Even-aged: A succeeding stand dominated by a single cohort of closely competing trees of relatively uniform size and height with a closed tree canopy (≥ 60% tree canopy cover). Smaller trees are typically stressed or overtopped and have fallen behind their associates. Regeneration and/or tall relics from a previous stand may be present.

2. Multi-aged: A later-successional or mature stand characterized by a distinct canopy with typical regeneration below including trees of may sizes and heights. Canopy trees vary in age and diameter. Typically has a closed tree canopy (≥ 60% tree canopy) but gap dynamics may be evident.

3. Mosaic: Plot contains at least two distinct structural classes each covering at least 25% of the stand.

4. Early-successional: A succeeding stand without a closed tree canopy (< 60% canopy – cover). The stand may be dominated by a mix of trees, saplings, shrubs and herbaceous vegetation.

5. Woodland: A stand with at least 25% but less than 60% canopy tree cover, giving the area an open appearance. Trees are open-grown, or growing in small groups interspersed with shrub or herbaceous cover or bare rock. Do not use this code for early-successional plots

apparently succeeding to forest, or a forested plot that currently has < 60% canopy cover due to gap dynamics. This category only occurs in Acadia NP (ACAD).

Note: In ACAD, plots that could be classified as either woodland or multi-aged (or any other class) should be recorded as woodland. Woodland plots are treated differently in analyses, and it is important that these plots are recorded correctly in the database.

Stunted Woodland

Record 1 if the stand is a stunted woodland (otherwise record 0). A stunted woodland will have a discontinuous canopy of stunted and/or twisted trees generally ≤10 m tall. This habitat will only be found in ACAD.

Crown Closure

Estimate % of plot area covered by live tree crowns directly overhead and record appropriate code. If foliage is not present due to seasonal variation or temporary defoliation, visualize the amount of live crown that would normally be present. Do not visualize foliage that formerly existed on dead branches. Notice that the exact breakpoints (e.g., 25%) are not included in either class. This is not a typo—it is to encourage the crew not to waste time trying to decide if crown closure is exactly 25%. Note the instructions in the overview about breakpoints.

1	< 10%
2	10 to 25%
3	25 to 50%
4	50 to 75%
5	> 75 %

% Vascular Cover by Layer

Estimate the total cover of vascular plant foliage by layer within the plot. A rapid cover estimate is made, ignoring overlap among species. It may help to visualize cover by collapsing each layer into a 2-dimensional space, ignoring normal spaces occurring between leaves. Estimate total cover for each layer: Ground, < 0.5 m above ground; Mid-understory, 0.5-2 m above ground; and High-understory, 2-5 m above ground. Use these canopy cover classes: 0, 1-5, 5-25, 25-50, 50-75, 75-95, 95-100%. Note the instructions in the overview about breakpoints.

% Bryophyte Ground Cover

Estimate the total cover of non-vascular plant foliage within the plot in the ground layer only. A rapid cover estimate is made, ignoring overlap among species. Use these canopy cover classes: 0, 1-5, 5-25, 25-50, 50-75, 75-95, 95-100%.

Deer Browse Index

Visually inspect the plot and record the level of deer impact observed (adapted from Brose et al. 2008). Use the following codes and criteria for all parks except ACAD:

1 Very low impact: No observed browse. Found only inside well maintained, deer-exclosure fences.

2 Low impact: No observed browse. Browse-preferred regeneration (Table S8.1) is abundant and of varying heights. Browse-preferred herbaceous plants (Table S8.2) are present and able to flower and fruit. Stump sprouts are present and have minimal evidence of browse.

3 Moderate impact: Browse evidence is observed but not common. Browse-preferred regeneration is present but with little variability in height. There are no stump sprouts, or stump sprouts are browsed. Nonpreferred browse and browse-resistant plant species (Table S8.3), including beech root suckers, are common and widespread.

Table S8.1. Preferred browse regeneration species.

Scientific Name	Common Name
Acer rubrum	red maple
Acer saccharum	sugar maple
Cornus florida	flowering dogwood
Liriodendron tulipifera	tulip poplar
Magnolia acuminata	cucumbertree
Prunus pensylvanica	pin cherry
Sassafras albidum	sassafras
Sorbus americana	mountain ash
Thuja occidentalis	northern white cedar
Tilia americana	basswood
Tsuga canadensis	Eastern hemlock

Table S8.2. Preferred browse herbaceous plant species.

Scientific Name	Common Name
Aralia nudicaulis	wild sarsaparilla
Arisaema triphyllum	Jack in the pulpit
Clintonia borealis	blue bead lily
Eurybia divaricata	white wood aster
Impatiens capensis	jewelweed
Laportea canadensis	Canadian woodnettle
Maianthemum (Smilacina) spp. (racemosum, stellatum)	false Solomon's seal
Medeola virginiana	Indian cucumber
Polygonatum spp. (biflorum, pubescens)	smooth Solomon's seal
Sanguinaria canadensis	bloodroot
Trillium spp. (cernum, erectum, grandiflorum, undulatum)	trillium
Uvularia spp. (grandiflora, perfoliata, sessifolia)	bellwort

Table S8.3. Nonpreferred/browse resilient regeneration and herbaceous plant species.

Species Type	Scientific Name	Common Name
Regeneration	*Abies balsamea*	balsam fir
	Acer pensylvanicum	striped maple
	Fagus grandifolia	American beech
	Pinus resinosa	red pine
	Pinus rigida	pitch pine
	Pinus strobus	white pine
	Pinus sylvestris	Scotch pine
Herbaceous	*Ageratina altissima* var *altissima*	white snakeroot
	Carex spp.	Sedges
	Dennstaedtia punctilobula	hay-scented fern
	Juncaceae (includes *Luzula* spp.)	rushes (includes wood rushes)
	Poaceae	grasses
	Podophyllum peltatum	Mayapple
	Polystichum acrostichoides	Christmas fern
	Thelypteris noveboracensis	New York fern

4 High impact: Browse evidence is common, or browse-preferred regeneration is rare to absent. Nonpreferred and browse-resilient vegetation is limited in height growth by deer browsing.

5 Very high impact: Browse evidence is omnipresent, or browse-preferred regeneration is absent. The abundance of nonpreferred vegetation is reduced by browsing. Browse-resilient plants show signs of heavy repeated browsing and a browse line is evident.

In ACAD use the following codes and criteria:

1 Very low impact: No observed browse. Found only inside well maintained, deer-exclosure fences.

2 Low impact: No observed browse. If browse-preferred (Table S8.1) regeneration or stump sprouts are present, there is no evidence of browse. In some cases browse preferred regeneration or stump sprouts are not present on a plot in ACAD for reasons other than deer browse. In these situations, crew should record 2 unless there are other signs of deer activity on the plot, including a deer trail, deer scat and/or browse of any plant species on the plot. Be sure to distinguish between hare and deer browse. Hare browse is low to the ground and is a clean, angled cut on the twig (i.e., looks like it was cut by scissors). Deer browse appears more ragged and can occur at varying heights

3 Moderate impact: Browse evidence is observed but not common in browse-preferred regeneration or stump sprouts. Other signs of deer activity are observed on the plot, including a deer trail, deer tracks and/or deer scat.

4 High impact: Browse evidence is common. Nonpreferred and browse-resilient regeneration shows signs of browse and browse preferred species are absent.

5 Very high impact: Browse evidence is omnipresent. Browse-resilient regeneration shows signs of heavy repeated browsing and a browse line is evident.

Disturbance Code

Record up to three disturbance codes from most to least important based on visual inspection of the plot. To be recorded, a disturbance must cause "significant threshold" damage equivalent to either 1) 25% of trees in a plot, 2) 50% of an individual tree species' count (but must include at least two trees in or near the plot), or 3) disturbance to at least 25% of the soil surface or understory vegetation. Minor foliage or bole damage to trees on the plot does not qualify as a disturbance. Only record disturbances which appear to have occurred since the previous inventory or within the last four years. If you record an unknown disturbance, attempt to capture a picture illustrating the disturbance.

00 None—no observable disturbance
10 Insect damage
11 insect damage to understory vegetation
12 insect damage to trees, including seedlings and saplings
20 Disease damage
21 disease damage to understory vegetation
22 disease damage to trees, including seedlings and saplings
30 Fire—prescribed or natural
40 Animal damage
41 beaver damage to vegetation
42 porcupine
43 deer/ungulate
44 bear
45 rabbit
46 domestic animal/livestock including grazing
47 flooding caused by beaver
50 Weather damage
51 ice/snow
52 wind including hurricane, tornado
53 flooding caused by weather
54 drought
55 earth movement/avalanches
60 Vegetation—suppression, competition, or vines
70 Unknown/not sure/other. Describe in Notes and take photo.
80 Human-caused damage—other than described in these codes. Describe in Notes.

90 Silvicultural treatment
91 Overstory removal—removal of all or most of the canopy trees
92 Selective cutting—removal of one or more trees from a stand (but see 91)
93 Site preparation—clearing, slash burning, chopping, disking, bedding, or other practice to prepare site for regeneration.
94 Artificial regeneration
95 Other silvicultural treatment—use of fertilizers, herbicides, girdling, pruning, or other activities to improve the commercial value of the stand. Describe in Notes.

Disturbance Threshold

For each disturbance recorded above, record which threshold was triggered: 1) damage to 25% of trees in a plot, 2) damage to 50% of an individual tree species'count, or 3) disturbance to at least 25% of the soil surface or understory vegetation. Note that minor foliage or bole damage to trees on the plot does not qualify as a disturbance.

Disturbance % Class

For each disturbance recorded above, record an approximate disturbance percentage to the nearest 10%. If the recorded disturbance was triggered by threshold 1, record the approximate % of trees in the plot damaged by that disturbance. If triggered by threshold 2, record the approximate % of an individual tree species' count damaged by that disturbance. If triggered by threshold 3, record the % of the soil surface or understory affected by that disturbance.

% Trampled

Record the percentage of the plot showing evidence of trampling by humans, wildlife or livestock. Trampling is assessed relative to the conditions of adjacent undisturbed soil. Include area occupied by established or unofficial trails traversing the plot, and record type of trail in plot notes. Estimate the percentage as: 0, 1-5, 5-25, 25-50, 50-75, 75-95 or 95-100 %. Note the instructions in the overview about breakpoints.

% Cover Bare Soil

Record the percentage of the plot covered by bare soil as: 0, 1-5, 5-25, 25-50, 50-75, 75-95 or 95-100 %. Include bare soil area beneath water drainage channels. Bare soil is defined as exposed mineral soil with no leaf litter or duff layer (i.e., O horizon) present. Note the instructions in the overview about breakpoints.

% Cover Rock

Record the percentage of the plot covered by exposed bedrock or large rocks (> 10 cm) as: 0, 1-5, 5-25, 25-50, 50-75, 75-95 or 95-100 %. Note the instructions in the overview about breakpoints. Except for crustose lichens that are 2-dimensional, rock does not include lichen cover.

% Surface Water Cover

Estimate the total cover of surface water in the plot (can be temporary or permanent). Use these cover classes: 0, 1-5, 5-25, 25-50, 50-75, 75-95, 95-100%.

Microtopography

Microtopography is small-scale variation in the soil surface caused by tree tip-ups which create a pit and mound undulation. Microtopography is eliminated when a site is plowed, and recovers over time once an area is reforested. Record presence (1) or absence (0) of pit and mound microtopography on the plot. If pit and mound topography is suggested but not clear, or reduced due to natural features such as exposed bedrock or thin soil, record (9). Only record microtopography as absent (0) when it appears that plowing or other human disturbance has created an unnaturally flat soil surface. Earthworks do not count as microtopography.

Water on Plot

Record the water source having the greatest impact on the plot using codes below. This information will be recorded during the first visit, and verified or updated on subsequent visits. It will be necessary to re-examine the plot for temporary water sources during each visit.

0	None—no water sources on plot
1	Permanent streams or ponds
2	Permanent water in the form of deep swamps, bogs, marshes
3	Ditch/canal—human-made channels such as for irrigation or drainage
4	Temporary streams
5	Flood zones—evidence of flooding when bodies of water exceed their natural banks
6	Vernal pool
7	Other water—specify in Plot Notes

Stand Height

It will not be possible to measure stand height in early successional plots without a distinct canopy—omit this measurement in those plots. Within the plot, select three co-dominant trees and three intermediate trees of typical height and with a canopy visible from the ground. To measure, move to a position as far from the base of the tree as possible along minimal slope while still allowing sufficient view of the tree canopy. In all parks except ACAD, stand height must be measured at least 15m from the tree. In ACAD, stand height must be measured at least 10m from the tree. Do not select a location upslope or downslope from the tree. Determine height to the top of each co-dominant tree using the TruPulse according to SOP 4 - Using the LTI TruPulse 360°R. Sight the base of your chosen tree using the TruPulse, and record the vertical angle (VA) and horizontal distance (HD). Then, sight the top of the tree and record the vertical angle (VA). If a TruPulse is not available, measure HD using a measuring tape or Sonin electronic distance measurer, and the VA with a clinometer. Record which trees were used to measure stand height.

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
2.00	June 2006	Geri Tierney Brian Mitchell	Added stunted woodland yes/no. Changed height strata for % cover by layer. Added estimate of disturbance % class. Field assessment of ecosystem removed from protocol. Adjusted terrain position code requirement on minimal slope. Added code for rabbit/hare damage added to disturbance codes. Clarified at least 2 trees must be affected to trigger disturbance threshold 2	
3.00	September 2006	Geri Tierney Brian Mitchell	Added microtop and % cover trampled, bare soil and rock from Forest Floor SOP. Included definition of microtopography. Reinserted instructions for stand height measured by triangulation. Modified stunted woodland ≤10 m tall No longer measure stand height in early successional plots without closed canopy Revised and better defined stand structure codes, dropped Two-storied code. Added temporary flags. Changed rabbit damage code from 48 to 45 to match FIA. Added disturbance code to distinguish clearcut from selective cut	.
3.01	December 2006	Geri Tierney Brian Mitchell	Included clarification regarding breakpoints and cover classes. Included option to use electronic clinometer for stand height as directed by supervisor.	
3.02	April 2007	Geri Tierney Kate Miller Brian Mitchell	Minor editorial changes.	
3.03	August 2007	Geri Tierney Kate Miller Brian Mitchell	Clarified that % cover by layer includes vascular plants only. Added % non-vascular ground cover measure.	
3.04	November 2007	Geri Tierney Kate Miller Brian Mitchell	Added that stunted woodlands will only be found in ACAD. Clarified % Bare Soil measurement to include exposed mineral soil only.	
3.05	April 2008	Geri Tierney Kate Miller Brian Mitchell	Clarified woodland and other definitions in stand structure measure.	

Revision History Log (continued)

Version #	Date	Revised by	Changes	Justification
3.06	May 2008	Geri Tierney Kate Miller Jim Comiskey Brian Mitchell	Incorporated MIDN methods into the SOP (noted duration of summer “leaf-on” in overview). Stand height is now calculated with the LAR.	
3.07	December 2008	Geri Tierney Kate Miller Jim Comiskey Brian Mitchell	Clarified Microtopographyr ratings. Changed % Non-Vascular Cover to % Bryophyte Cover to match the database and datasheet term.	
3.08	April 2009	Kate Miller	Clarified that the Early Successional category in Stand Structure has < 60% canopy cover.	
3.09	May 2009	Kate Miller Sarah Lupis Kozlowski	Changed stand height measurement to measure three trees instead of one. Replaced browseline with deer browse index used by Eastern Rivers and Mountains Network, and added a table of browse preferred and nonpreferred species. Minor editorial changes, formatting.	
3.10	December 2009	Kate Miller Andrew Vincello Brian Mitchell Jim Comiskey	Added % water on plot Revised a deer browse index for ACAD and added MIDN browse species Clarified that minor foliage damage does not qualify as a disturbance. Clarified that earthworks do not count as microtopography	
3.11	October 2010	Kate Miller Jesse Wheeler	Clarified that plots that could either be classed woodland or multi-aged should be recorded as woodland. Changed lowest percent cover class for %cover by strata and substrate from <1 to 0. Clarified that% cover rock doesn’t include lichen cover (except crustose). Added that trees used to measure stand height should be recorded.	
3.12	January 2013	Kate Miller	Added three intermediate trees to the stand height tally.	
3.13	March 2014	Kate Miller	Revised SOP to use TruPulse instead of LAR	Change of equipment.

SOP 8 - Tree Measurements

Mid-Atlantic Network/Northeast Temperate Network

Version 3.16

Overview

This SOP details how to measure species, diameter, and condition of all live and standing dead trees ≥ 10 cm diameter-at-breast-height (DBH) within each forest plot, or alternatively each tree ≥ 10 cm diameter-at-root-crown (DRC) in stunted woodland plots. These data will yield information on tree growth, mortality and condition, and stand structure and composition.

Caution

Dead trees can be a safety hazard. Crews must exercise caution – trees that are deemed unsafe to measure should be estimated but not touched.

The use of any tree tags or nails other than aluminum at parks which undergo silvicultural management or tree cutting will pose a safety hazard to loggers during subsequent tree cutting. **Never use stainless steel tags or nails at Marsh-Billings-Rockefeller NHP (MABI), Minute Man NHP (MIMA), Roosevelt Vanderbilt NHS (ROVA), Saratoga NHP (SARA) or Weir Farm NHS (WEFA)**. Nylon cable ties attached with a single staple are safe to use at all parks.

Definitions

Diameter-at-breast-height (DBH) is measured at 1.37 m above the ground line on the uphill side of the tree.

Diameter-at-root-crown (DRC) is measured at the base of the tree just above the point where the base flares or the ground, whichever is higher.

A stunted woodland will have a discontinuous canopy of stunted and/or twisted trees generally ≤10 m tall.

Live trees are trees with any living parts (leaves, buds, cambium) present at or above DBH, including trees that have been temporarily defoliated.

Dead standing trees are dead trees that lean < 45 degrees from vertical. They need not be self-supported. Once included, dead trees are tracked until they no longer qualify as standing dead.

Recruits are trees that have reached the minimum diameter since the last census.

Standing trees are free standing and less than 30° from vertical.

Leaning trees are trees leaning more than 30° from vertical.

Fallen trees are those with the main stem more than 45° from vertical.

Broken trees are trees whose main stem or branch is broken or missing.

Cut trees occur in instances where previously tallied trees were actively removed from the plot, for example, health cuts in Gettysburg National Military Park, or exotic tree species removal by the exotic plant management teams.

Forks are stems that branch out from the main stem below DBH. In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45 degrees or less. Stems that branch out more than 45 degrees from vertical of the main stem are considered branches and not measured. Forks originate at the point on the bole where the piths intersect. Once a stem is tallied as a fork that originated from a pith intersection between 0.3 m (1 foot) and 1.37m (4.5 feet), do not recognize any additional forks that may occur above that stem.

Procedure

Delineate the plot by placing temporary survey flags at plot corners and mid-points and connecting plot corners with measuring tapes or kite string. **Begin tallying trees from the center-up position and continue clockwise through the plot.**

A tree which occurs on the plot boundary will be included only if the center of the stem base lies directly on or within the boundary. A tree which occurs in a corner of the plot boundary is included if the center of the stem lies directly on or within the boundary. In this situation, the tree notes should estimate percent of stem that is actually in the plot.

As you work through the plot, attach a pre-printed tag consistently to each tallied tree at a location about 10 cm below breast-height (20 cm above in the MIDN parks). When resampling plots that have already been established, crew only needs to tag recruits and trees with missing tags. Tree tags should face plot center if possible, unless the plot is visible from a nearby trail or road. In that case, tags should face away from the trail or road. **Use aluminum tree tags at MABI, MIMA, ROVA, SARA, and WEFA** and stainless steel tree tags at Acadia NP (ACAD), MORR, Saint-Gudens NHS (SAGA), and all Mid-Atlantic Network (MIDN) parks. In Northeast Temperate Network (NETN) parks, tree tags were originally attached using 30-cm UV-stabilized nylon cable ties and a 14 mm staple. Starting in 2010, all tree tags will be attached using nails (**use aluminum tree nails at MABI, MIMA, ROVA, SARA and WEFA** and **galvanized steel tree nails at ACAD, MORR and SAGA**). In MIDN parks, always use aluminum nails.

To attach a tag using a tree nail, insert nail with the nail head slanted slightly downward and leave at least 4 cm of nail protruding to allow the tag to slide down. This will reduce the chance that the tag will be enveloped by the tree as the tree grows. Select a location on the trunk about 10 cm below breast-height and preferably facing plot center. Avoid locations with decay or peeling bark. If there is no good location facing plot center, find a suitable location on another side of the tree—it is more important that the tag be attached securely than facing plot center. Attach the tag to the tree with a single nail making sure that the numbered side of the tag faces out. The nail must reach through the bark to wood to be secured.

Do not tag snags that sway when touched in order to ensure no snags are knocked down. Also do not tag a snag if the tag cannot be securely attached because the wood is too soft and decayed. Note in Tree Notes that the snag was not tagged, and proceed to record data as usual. Be careful to skip the numbered tag corresponding to the un-tagged snag as you proceed through the plot.

Tags should be checked at every remeasurement. Nailed tags which are in danger of being enveloped by bark should be gently released by pulling the nail back, or the nail and tag should be removed and the tag reattached. Cabled tags which are in danger of being enveloped should be removed by cutting the cable, and the tag should be reattached with a nail. If a tree tag has been removed between surveys, reattach a tag using a nail (follow instructions about stainless steel versus aluminum nails).

Keep unused tree tags organized. In NETN parks, hang unused tags at the end of the set. Use a permanent marker to record both the park and plot where each tree tag set has been used on the back of last unused tree tag, so that the set can be easily found for future measurement cycles. Store unused tree tags in a box and clearly label it based on the park and group of plots to which it applies. Crews should carry the corresponding tree tag set with them when resampling the plot. A spare set with all 1-50, 51-75 or pre-stamped, numbered tags should also be carried to replace tags that are missing from trees (i.e., keep 1's, 2's, 3's and so on, stored in bundles for easy replacement). This is not needed in MIDN parks, since consecutive numbers are used throughout the network—tree numbers are unique for the entire network, not just within a park.

Data Collection

Tree Number

Record the tree tag number which uniquely and permanently identifies each tree on the plot.

Distance

Record the horizontal distance from the center of the plot to the center of the side of the tree stem using the TruPulse. The distance is rounded to the nearest tenth of a meter (0.1 m).

Azimuth

Record the azimuth from the center of the plot to the front center of the tree stem using the TruPulse. The azimuth is rounded to the nearest digit.

Species Code

Record species code using the first three letters each of genus and species. If species cannot be determined in the field, bring a twig sample with foliage, buds, cones, or flowers, and/or a photograph to your supervisor for identification. If possible, collect samples outside the plot from similar specimens and make a note to correct the species code later. Record genus or family if known, or use "Unk Con" for unknown conifer, "Unk Har" for unknown hardwood or "Unk" for unknown tree; this is often the case with standing dead trees on newly established plots. Use Ace sac3 for *Acer saccharum* (sugar maple), and Ace sac2 for *Acer saccharinum* (silver maple).

DBH

Measure tree diameter at breast-height (1.37 m) above ground line on uphill side of tree. Do not measure from a pit or atop a mound or emergent rock. Make sure the DBH tape is straight and not

twisted, perpendicular to the bole axis, and not caught on any twigs or irregularities. In stunted woodlands, measure DRC instead (see below). Use a PVC pole cut to 1.37 m to find breast-height. **Round measurement down to the last 0.1 cm.**

In MIDN and NETN parks, all trees are marked at the point of measurement using green spray paint. Ensure that the mark is facing the same direction as the tag, and that it consists of a short thin horizontal line, precisely where the DBH measurement was taken. When encountering **unusual DBH situations** described below, check the box in the database denoting an unusual DBH measurement and describe the location of measurement in Tree Notes, using distances and landmarks found on the tree. During re-measurement, trees with an existing paint mark should be measured at that exact location, even if the location does not follow current procedures for locating DBH.

,

Irregularities at DBH

On trees with swellings, bumps, depressions, and branches at DBH, measure diameter immediately above or below the irregularity at the place it ceases to affect normal stem form.

Missing Wood or Bark

Do not reconstruct the DBH of a tree that is missing wood or bark. Record diameter of the wood and bark still attached to the tree, and note in Tree Notes.

Curved Bole

Find the point equivalent to breast-height (1.37 m) by measuring along the curvature of the bole on the upper surface (i.e., the short side) of the tree as shown in Figure S9.1.

Leaning Tree

Find the point equivalent to breast-height (1.37 m) by measuring along the underside (i.e., the short side) of the tree; measure diameter perpendicular to the bole as shown in Figure S9.2. Always paint mark DBH on leaning trees.

Live Windthrown Tree

Find the point equivalent to breast-height (1.37 m) by measuring from the top of the root collar along the bole, as shown in Figure S9.3.

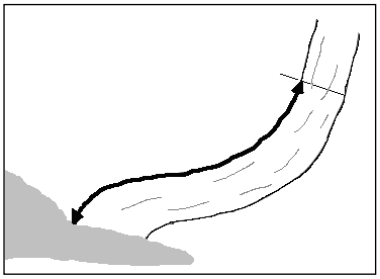


Figure S9.1. Measuring DBH on tree with a curved bole.

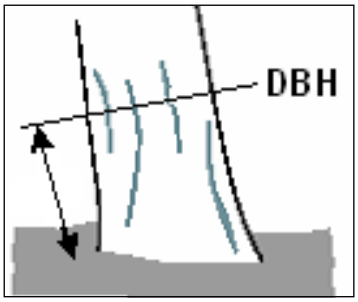


Figure S9.2. Measuring DBH on a leaning tree.

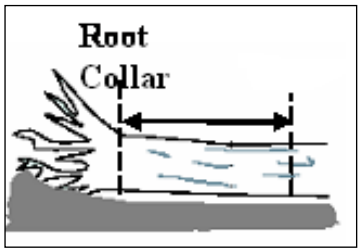


Figure S9.3. Measuring DBH on a live windthrown tree.

Independent Trees That Grow Together

If two or more previously independent stems have grown together at or above the point of DBH, continue to treat them as separate trees. Estimate the diameter of each, and explain the situation in Tree Notes.

Forked Tree

Trees which fork at or above breast-height are tallied and measured as one tree. Diameter should be measured below the point at which forking affects DBH (Figure S9.4A). This point should be marked and recorded in Tree Notes.

In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45 degrees or less. Stems that branch more than 45 degrees from the axis of the main stem are considered branches and not measured. Forks originate at the point on the bole where the piths intersect. Multiple forks can be tallied per tree if the first fork originates below 0.3 m (Figure S9.5A), or if multiple stems originate from roughly the same place on the stem (Figure S9.5B). Once a stem has a tallied fork that originates (based on pith intersection) between 0.3 m and 1.37 m, do not recognize any additional forks that occur above that point (Figure S9.5B).

Trees which fork below breast-height are tallied and measured as multiple trees. The diameter of each fork ≥ 10 cm DBH should be measured at breast-height unless the fork occurs within 0.5 m of breast-height (i.e., above 0.87 m height). In this case, the diameter of each stem ≥ 10 cm at the point of measurement should be measured at a position 0.5 m above the fork (Figure S9.4B). This point should be recorded in Tree Notes, and this tree should be recorded as an unusual DBH. Multiple stems should be recorded in clockwise order, or from front to back when one stem lies directly in front of another. Use the “Fork” field in the database to identify the stems that emerge from a common base. All stems from the same base should be assigned the same letter. For example, if stems four and five are the first forked tree on the plot, enter an “A” in the “Fork” field; stems from the next forked tree would be assigned the letter “B”.

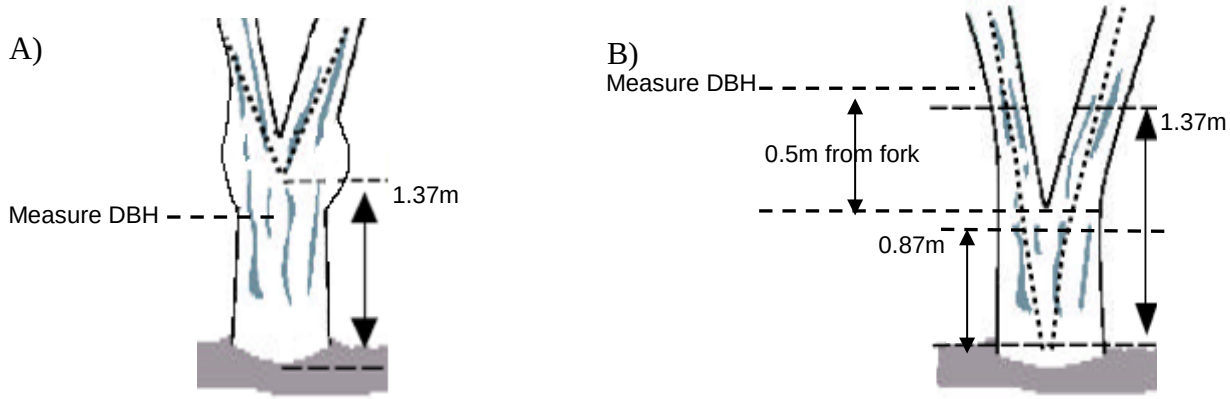


Figure S9.4. Measuring DBH on a tree that A) forks above breast-height, and B) measuring DBH on a tree that forks below breast-height.

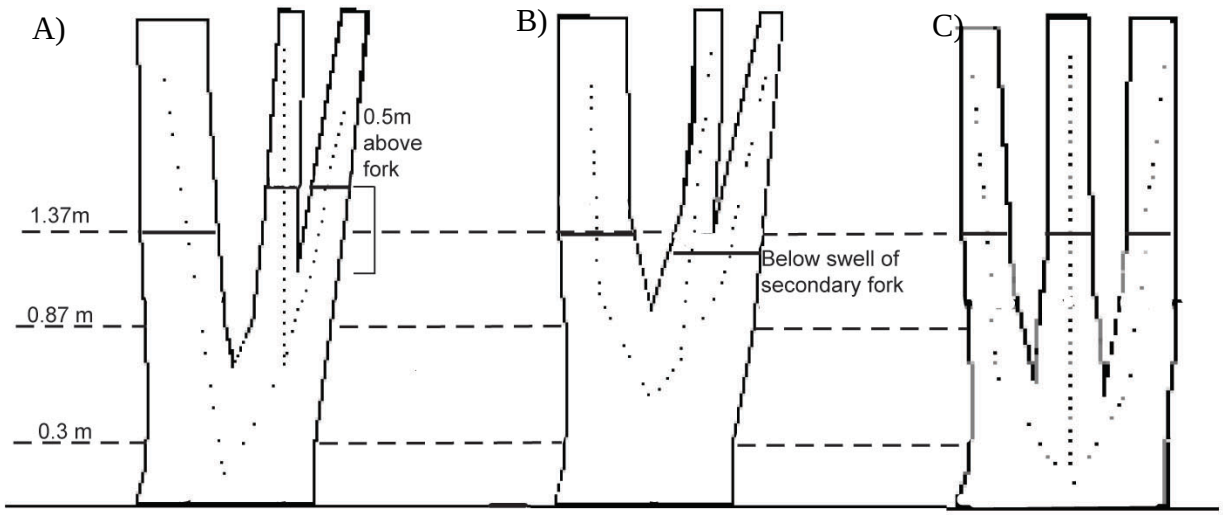
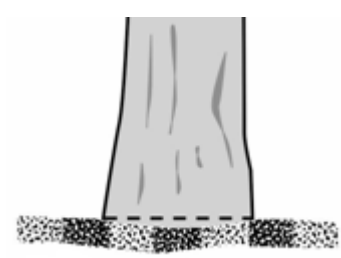


Figure S9.5. Measuring DBH on A) a tree with a fork that originates below 0.3 m, based on the intersection of the pith, and second fork that originates between 0.3 and 1.37m, B) a tree with a fork that originates above 0.3 m, with a secondary fork that isn't tallied and C) a tree with three forks that intersect at roughly the same place on the stem.

DRC

In stunted woodlands (ACAD), measure diameter-at-root-crown (DRC) instead of DBH. Round measurement down to the last 0.1 cm. Wrap diameter tape around base of tree at the ground, as shown in Figure S9.6, or just above the location at which the base flares with root growth as shown in Figure S9.7. Another option for measuring DRC is to use calipers. When using calipers, take 2 measurements that are perpendicular, and average the measurements. Avoid knobs or irregularities in the stem. For trees with bent stems, measure DRC at the lowest suitable location above the bend, taking care to wrap the tape straight across. For clumps of stems sharing a common base above ground, record as a single tree.



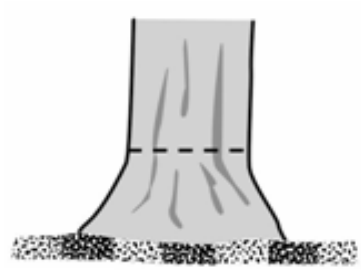


Figure S9.6. For stunted woodlands, measure diameter-at-root-crown, by wrapping the tape around the base of the tree at the ground.

ve location for
ıt-root-crown, just
which the base
ı.

Tree Status

Record a status code for each tree to track status over time. Tree status codes are based on two letter codes (Table S9.1). The first letter designates whether the tree is alive (A), dead (D), or is a new recruit (tree that has reached the minimum DBH since previous census) (R). The second letter designates whether the tree is standing (S), leaning (L), broken (B), or fallen (F). For example, “AS” indicates a live standing tree. Not located (NL) is used for trees that were not found in a subsequent census, dead cut (DC) for trees that were cut and removed from plot, missed alive (AM) and missed dead (DM) are used where trees are > 12cm DBH indicating that they were missed during the previous census. Excluded trees are previously tallied trees that have been removed from the sample. The excluded shrank status (XS) is for live trees that shrank below 10 cm DBH. If a dead tree shrinks below 10 cm DBH, record it as DF even if it is still standing. This indicates that the individual no longer meets the requirements for a tree as defined in this protocol and will not be measured in the future. The XP status is for a tree that is excluded because it is outside of the plot. The XO status is for a tree that is excluded for a reason other than XS and XP. In the rare occasion that a tree status is recorded as "XO", crews must explain in the tree notes why the tree was excluded from the sample. When encountering a previously labeled XP tree that appears to be in the plot, continue to exclude the tree. Likewise, a tallied tree from a previous visit should continue to be measured, even if the tree appears to be outside of the plot.

Table S9.1. Tree status codes.

	Alive	**Dead**	**Recruit**
Standing	AS	DS	RS
Leaning	AL	DL	RL
Fallen	AF	DF	RF
Broken	AB	DB	RB
Cut	-	DC	-
Missed	AM	DM	
Not located	NL	NL	-
Excluded-Shrank	XS	-	-
Excluded-Not in Plot	XP	XP	
Excluded-Other	XO	XO	

Crown Class

Assign code describing tree crown position in canopy relative to immediate neighbors (Figure S9.8).

1 Open-grown—Crown has received full sunlight from above and all sides through much of its life, particularly during early development, as seen by well-developed lower branches. Lower branches may currently be devoid of leaves.

2 Dominant—Crown extends above canopy. Taller than the average tree in stand and has well-developed crown.

3 Co-dominant—Crown is at the general level of the canopy. Typically, co-dominant trees have medium-sized crowns and are crowded on the sides; in dense stands, co-dominant trees have small crowns.
4 Intermediate—Tree is shorter than co-dominant trees but with a crown that extends into the general canopy. Tree has small crown and is very crowded from the sides.
5 Sub-canopy—Crown is entirely below the general level of the canopy.
6 Gap-exploiter—Tree is of intermediate or sub-canopy height, but is exploiting a gap within otherwise closed canopy forest and receives direct light from above.

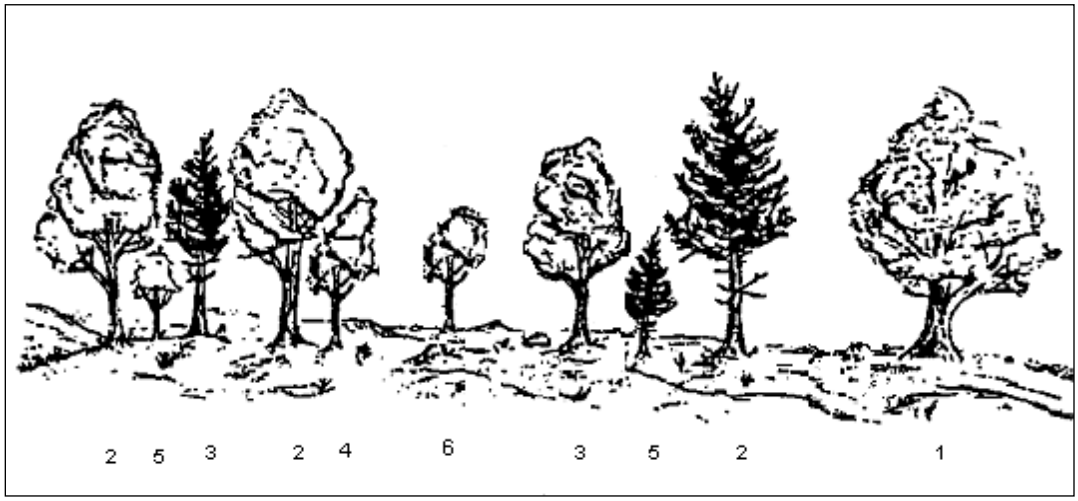


Figure S9.8. Illustration of crown classes in a forest canopy.

Tree Condition

Record the presence of any of the following: Advanced decay (AD including fungal infection), Asian longhorned beetle (ALB), balsam woolly adelgid (BWA; not found in MIDN), beech bark disease (BBD; record degree of severity using codes below), burl/gall (G), butternut canker (BC), dogwood anthracnose (DOG), emerald ash borer (EAB), epicormic branching (EB), gypsy moth (GM), hemlock woolly adelgid (HWA; record degree of severity using codes below), elongate hemlock scale (EHS), insect damage (ID; record in notes if insect is known), large dead branches (DBT; in canopy, including broken or dead top), open wounds (CW; includes cankers), sirex wood wasp (SW), spruce budworm (SB), sudden oak death (SOD), vines in crown (VIN; record species), other damage (OTH; describe in notes), small cavity (CAVS), large cavity (CAVL). If none of these conditions exist, record “healthy”.

Note that small and large cavities are the only conditions recorded for both live and dead trees. To qualify as a cavity the walls of the opening must be approximately cylindrical shaped and penetrate the inner bole of the tree. The cavity does not have to penetrate the heartwood, but it must appear at least as deep as the opening is wide. Foraging excavations by woodpeckers do not qualify as cavities. Small cavities are 3 to 5 cm diameter, and large cavities are over 5 cm diameter.

Record BBD severity for all American beech (*Fagus grandifolia*) trees using the following scale:

1—No sign of BBD

2—Scale insect present, some cracks in bark, 75% canopy remains
3—Heavily cracked bark, Nectria cankers present, some limb loss, 25-75% canopy remains
4—Severe bark cracking, large girdling cankers present, < 25% canopy remains. For trees that have grown in post invasion, tree crown is stunted and not reaching into the canopy

Record HWA/EHS severity for all eastern hemlock (*Tsuga canadensis*) using the following scale:

1—No sign of HWA or EHS
2—HWA and/or EHS scale insect present. Foliage appears healthy (< 10% of foliage appears to be effected).
3—HWA and/or EHS scale insect present and 10-25% of needles have chlorosis and/or necrosis
4—Severe impact. Greater than 25% of total foliage has needle loss on fine twigs, chlorosis and/or necrosis.

Foliage Condition

Visually assess **canopy** foliage and record up to three problems as chlorosis (C), necrosis (N), holes (H), small leaves (S), wilting (W), leaf loss (L), or other (O—describe in Tree Notes). Chlorosis is yellowing of leaves associated with loss of chlorophyll. Foliage necrosis is dead leaves or dead patches on leaves. Only record leaf loss (L) for needle loss if fine twigs in the canopy are affected—disregard lower branches and large dead branches. If no foliage conditions are observed, select none (NO).

Foliage Percentage

Estimate the total percentage of leaves affected by foliage conditions and the percentage of leaves affected by each foliage condition using the following classes: 1-10, 10-50, 50-90, 90-100%. Estimate using the number of leaves affected. For example, if approximately 20% of leaves are affected but only a small amount of surface area of each leaf is affected, choose class 2 (10 – 20%) for foliage percentage. Notice the exact breakpoints (e.g., 10%) are not included in any class. Classes are either above or below each breakpoint. This is not a mistake—it is to encourage the crew not to waste time trying to decide if the correct value is exactly 10%. The most suitable class should be rapidly assessed and recorded.

Percentage of Leaf Area

For the chlorosis (C), necrosis (N), and holes (H), estimate the percent of the leaf area that is affected by each specific foliage condition. For example, if approximately 20% of leaves are affected, but only about 5% of the area of each of these leaves are affected, then choose class 1 (1 – 10%) for percentage of leave area.

Decay Class

For each standing dead tree, record code indicating the tree's stage of decay (Table S9.2). Note that snags in decay class V are rarely, if ever, encountered.

Tree Notes

Record any unusual tree features or notes required above, including location of diameter measurement if not measured at breast-height.

Table S9.2. Decay class definitions for standing dead trees.

Class	Bark	Branches and Twigs	Wood Condition
I	Firmly attached	Branches retain many small twigs	Sound wood covered by intact bark
II	If present, decayed, faded, and not firmly attached	Branches and small twigs may be present	Hard wood—impenetrable with fingernail or pen point, may be case hardened with powder wood beneath.
III	Generally absent, except in *Betula* and *Prunus*	Branch stubs present but no twigs	Soft wood—will spring back if compressed and can be penetrated with fingernail or pen point.
IV	Generally absent	Some branch stubs may remain but no twigs	Spongy wood -responds to finger pressure and may exude moisture—and powder wood—flows through fingers like coarse sawdust.
V	Absent	No branch stubs or twigs	Powder wood

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
2.00	June 2006	Geri Tierney Brian Mitchell	Added tree tagging procedure using cable ties. Adjusted foliage condition classes to be similar to SHEN. Added alternative root-crown-diameter measurement in stunted woodlands. Added balsam woolly adelgid to tree condition measurement. Changed decay classes—now adapted from Pyle and Brown (1998) for eastern trees. Added caution not to tag snags which sway when touched.	
3.00	September 2006	Geri Tierney Brian Mitchell	Added status code for fallen dead tree. Emphasized need to mark trees and record note for trees with special DBH situations Clarified DRC measurement and provided 2 figures. Included tree health codes, and record absence of problem as NONE Added BBD disease scale. Clarified DBH measurement must not occur from atop a mound or down in a pit. Labeled figures and removed English units. Renamed ‘overtopped’ canopy class to be ‘sub-canopy’. Changed "overtopped" crown class to "sub-canopy.” Modified “advanced decay” to substantial decay” under tree condition	

Version #	Date	Revised by	Changes	Justification
			Changed names of lower quarters (L) to bottom (B) to avoid confusion with left (L).	

Revision History Log (continued)

Version #	Date	Revised by	Changes	Justification
3.01	December 2006	Geri Tierney Brian Mitchell	Included instruction that tree tags face plot center unless plot is visible from road or trail.	
3.02	April 2007	Geri Tierney Kate Miller Brian Mitchell	Added crown classification for short tree in gap. Added other canker/gall (CG) to TREE CONDITION. Clarified use of aluminum tags/nails at ROVA, WEFA, steel at MORR. Clarified snag decay classes. Included text to ensure good DBH measurement.	
3.03	November 2007	Kate Miller Geri Tierney Brian Mitchell	Clarified boundary tree inclusion rules. Revised directions for recording unusual DBH measurements. Clarified open grown and Gap-exploiter crown classes. Refined tree condition categories. Added definitions of chlorosis and necrosis to foliage condition. Clarified foliage percentage estimation.	
3.04	December 2007	Brian Mitchell Kate Miller Geri Tierney	Added figures S9.4 and S9.5 to illustrate location of DBH on forked trees.	
3.05	May 2008	Kate Miller Jim Comiskey Brian Mitchell Geri Tierney	Incorporate MIDN methods into SOP.	
3.06	December 2008	Kate Miller Jim Comiskey Brian Mitchell Geri Tierney	Clarified that standing dead trees should not be tagged if the tag cannot be secured due to soft, decayed wood. Changed crown condition to only consider relative height in canopy, and not light availability. Added figure and table captions. Added illustration of a gap exploiter to Figure S9.8.	
3.07	April 2009	Kate Miller	Minor editorial changes based on external review.	
3.08	May 2009	Sarah Lupis Kozlowski	Minor editorial changes, formatting.	Conform to NPS standards.
3.09	December 2009	Kate Miller Brian Mitchell Jim Comiskey	Clarified when a tree is considered in a plot Added that species of vines in canopy be recorded for NETN too. NETN adopted MIDN's tree status codes and tree mapping procedures. Added a index for HWA/EHS severity.	
3.10	October 2010	Kate Miller Jesse Wheeler	Changed all tree tags to be attached using a nail instead of cable tie.	

Revision History Log (continued)

Version #	Date	Revised by	Changes	Justification
			Added that tree tags that have been removed between surveys should be reattached with a nail. Added that trees >40cm DBH should get paint marked at DBH Added that all leaning trees should have a paint mark at DBH Added that once a tree has a paint mark for DBH, that location should never be moved. Added option to use calipers for DRC. Added that all DRC measurements should be paint marked. Added Dogwood anthracnose to priority pest list. Clarified that trees that shrink below 10cm (e.g., snags) should be given the EX status with "shrank" in notes.	
3.11	April 2011	Kate Miller Jesse Wheeler	Corrected the definition of fallen as greater than 45° from vertical.	
3.12	March 2012	Kate Miller	Added small and large cavities to tree condition	Park (MABI) request
3.13	January 2013	Kate Miller	Added new fork tally rules to be consistent with FIA procedures.	
3.14	March 2014	Jesse Wheeler	Revised what the crew needs for replacement tree tags in NETN plots. Replace references to LAR with TruPulse.	Updated procedure. Change in equipment.
3.15	December 2014	Kate Miller	Added XS and XP tree status codes, and replaced EX with XO to ensure that common reasons for tree exclusions are documented consistently.	
3.16	November 2015	Jesse Wheeler	Added that Foliage Condition would also include % of foliage area affected in addition to % of leaves. Revised language for unusual DBH situations. Clarified that trees near plot boundary should continue to have the same status as they did last visit, as long as the tree is still measureable.	Foliage area assessment informs us on annual tree health Plot boundaries should no longer be adjusted.
3.17	December 2016	Camilla Seirup	Clarified that the XS tree status code is only for live trees.	

SOP 9 - Microplot

Mid-Atlantic Network/Northeast Temperate Network

Version 3.09

Overview

This SOP quantifies live saplings, established seedlings, and shrubs by species on three 2-m radius circular microplots for Northeast Temperate Network (NETN) parks. Seedlings are also quantified by size class. These data yield information on advance regeneration, future cover, and the effects of deer browsing. For Mid-Atlantic Network (MIDN), three 3-m radius circular plots are used to quantify live saplings and shrubs by species; seedlings are quantified in the quadrats.

Definitions

Saplings are defined as juvenile trees with diameter-at-breast-height (DBH) at least 1 cm but less than 10 cm in forest plots, or diameter-at-root-crown (DRC) at least 1 cm but less than 10 cm in stunted woodland plots (Acadia NP).

Established seedlings are defined as live juvenile trees that are at least 15 cm tall with at least two true leaves and no cotyledons present, and are smaller than saplings (i.e., less than 1 cm DBH). Any juvenile tree ≥ 15 cm tall but less than 1 cm diameter at breast height (1.37 m tall) is considered a seedling.

Shrubs are woody, sub-canopy species (includes vine species). To qualify for counting in this protocol, shrubs must be at least 30 cm tall. When determining shrub height, do not measure along the stem; instead determine the highest point the shrub reaches in its natural position. Do not straighten or otherwise manipulate the individual. Vines are only measured up to 2 m tall. All shrubs are measured by % cover.

Horizontal distance is the straight line distance between two objects. This contrasts with slope distance which is measured parallel to the ground. Slope distance and horizontal distance are equivalent on flat land. On sloped land, the horizontal distance between two objects is less than the slope distance.

Height of seedlings or shrubs is defined as the distance from the root crown to the top of the terminal bud, or to the top of the tallest fork. Do not include leaves or needles in this measurement. To measure height, gently align seedling or shrub along a ruler. Realign the ruler along any curves present to account for additional height masked by a curved stem.

Data Collection

The microplot centers are marked by stakes located 4 m slope distance (NETN) and 7 m horizontal distance (MIDN) from the full plot center, in the direction of the upper plot corners and the lower boundary midpoint. The microplots are circular plots of 2-m radius horizontal distance (3-m radius

for MIDN). To identify saplings, established seedlings or shrubs within the microplot, one crew member holds a tape at the microplot center, while a second crew member stretches the tape a

horizontal distance of 2 m toward plot center (3 m for MIDN). The second crew member then slowly circles clockwise at this fixed distance from microplot center. In NETN parks, both crew members examine the ground for all saplings, established seedlings and shrubs that fall within the 2-m radius; in MIDN parks, the crew members measure all saplings and some shrubs within the 3-m radius. In MIDN parks, all saplings and shrubs that are measured are marked and tagged.

Microplot Code

Specify in which microplot each sapling, seedling and shrub measurement has been observed as UR (upper right), UL (upper left) or BC (bottom center).

Unknown Species Code

If an unknown species occurs throughout the plot, and it is easily distinguishable from other species, record every occurrence of that species as “Unk type 1” in the database and on the sample bag. If there are multiple commonly occurring and distinguishable unknown species, use consecutive numbers for each separate species. Otherwise, record "Unk type" and a consecutive number for each specimen on the sample bag and in the database. Type refers to hardwood, conifer, shrub, etc. Do not carry over unknown names and numbers to other forest plots. Store unknown specimens with different numbers (denoting different species) in separate bags.

Sapling Species Code

Record species code using the first three letters each of the genus and species. If species cannot be determined in the field, bring a twig sample or photograph to your supervisor for identification. If possible, collect samples outside the entire tree plot from similar specimens and make a note to correct the species code later. Record genus or family if known, or use “Unk Con” for unknown conifer and “Unk Har” for unknown hardwood.

Sapling Diameter

Measure DBH at 1.37 m above ground line on the uphill side of each sapling. Round the measurement down to the last 0.1 cm. See instructions for measuring DBH in unusual situations in SOP 9 - Tree Measurements. In stunted woodlands (Acadia NP), measure sapling diameter as diameter-root-collar (DRC) rather than DBH. See instructions for DRC in SOP 9 - Tree Measurements. All saplings > 4 cm and < 10 cm in diameter are measured using a DBH tape, and in MIDN these saplings are tagged with a nail. All saplings with a diameter < 4 cm are measured using calipers, and in MIDN parks these saplings are tagged with a cable tie, thus minimizing injury to smaller individuals when using nails. If the shape of a sapling that is < 4 cm DBH is not round, take the average of the largest and smallest caliper measurement, and round down. In addition, the cable ties also serve to indicate that the measurement was taken with calipers. Saplings are not tagged in NETN parks, but they should be paint-marked at DBH.

Saplings that fork from a tree must originate below DBH, be at least 1/3 the diameter of the tree, and be less than 45 degrees from the main stem of the tree to be tallied as a sapling. Forks originate at the point on the bole where the piths intersect. Multiple forks can be tallied per sapling if the first fork originates below 0.3 m, or if multiple stems originate from roughly the same place on the stem. Once a stem has a tallied fork that originates (based on pith intersection) between 0.3 m and 1.37 m, do not recognize any additional forks that occur above that stem (See SOP 9 – Tree Measurements).

In NETN plots with a dense sapling component, only the first 10 saplings of a species encountered per microplot should be measured for DBH. The remaining saplings in the microplot should be tallied by species, and paint-marked at DBH to indicate which saplings were included in the count for that microplot.

Sapling Status

For MIDN only, record a status code for each sapling to track status over time. Sapling status codes are the same as those used for SOP 9 – Tree Measurements, with the exception that alive missed (AM) saplings are > 2 cm DBH.

Sapling Notes

Record any unusual sapling features, including if sapling is sprouting from a stump.

Seedling Count

NOTE: seedling count for MIDN parks is conducted in the quadrats instead of the microplots (SOP 13 – Quadrat Measurements).

Within each microplot (quadrat for MIDN parks), record the number of live, established tree seedlings by species within each height class: 5-15 cm (VAFO only), 15-30 cm, 30-100 cm, 1-1.5 m, > 1.5 m. Do not recount saplings. Count up to five individuals per species and height class (in MIDN all tree seedlings are counted; see SOP 13 – Quadrat Measurements for more details). Estimate the total count by five if there are more than five individuals of any species in any class.

Multiple “suckers” that originate from a common base are considered one seedling. Do not count stump sprouts from a live tree; however do count stump sprouts from a dead bole, counting all sprouts from a common base as one seedling. Do not count “layers”—undetached branches partially or completely covered by soil, usually at the base.

Seedling Species Code

Record species code using the first three letters each of the genus and species. If species cannot be determined in the field, record genus or family if known, or use “Unk Con” for unknown conifer and “Unk Har” for unknown hardwood. Bring a sample collected from outside the microplot or photograph to your supervisor for identification. If possible, collect samples from outside the entire tree plot from similar specimens and make a note to correct the species code later.

Shrub Species Code

For each shrub species encountered on the microplot, record species code using the first three letters each of the genus and species. If species cannot be determined in the field, tally the shrub and bring a twig sample or photograph to your supervisor for identification. If possible, collect samples outside the entire tree plot from similar specimens and make a note to correct the species code later. Record genus or family if known, or use “Unk” for unknown shrub.

Shrub % Cover

Estimate % shrub cover by species using the following classes: 0, < 1, 1-5, 5-10, 10-25, 25-50, 50-75, 75-95, 95-100% (Table S10.1). Notice the exact breakpoints (e.g., 25%) are not included in any class. Classes are either above or below each breakpoint. This is not a mistake—it is to encourage the

crew not to waste time trying to decide if the correct value is exactly 25%. The most suitable class should be rapidly assessed and recorded. Shrubs must be ≥ 30 cm length to be included in the cover estimate. Only estimate cover of vines up to 2m in height.

Table S10.1. Area in square meters for each microplot cover class breakpoint.

	NETN	MIDN
< 1%	present	present
1%	0.126 (~35 x 35 cm)	0.283 (~50 x 50 cm)
5%	0.628 (~80 x 80 cm)	1.414 (~1.2 x 1.2 m)
10%	1.257 (~1.1 x 1.1 m)	2.827 (~1.7 x 1.7 m)
25%	3.142 (~1.8 x 1.8 m)	7.069 (~2.7 x 2.7 m)
50%	6.283 (~2.5 x 2.5 m)	14.137 (~3.8 x 3.8 m)
75%	9.425 (~3.1 x 3.1 m)	21.206 (~4.6 x 4.6)
100%	12.566	28.274

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
1.01	September 2006	Geri Tierney Brian Mitchell	Included alternative measure of shrub cover in early successional stands. Included description of microplot procedure. Clarified established seedling definition. Clarified instruction to estimate seedlings and shrubs counts by multiples of 5.	
1.02	December 2006	Geri Tierney Brian Mitchell	Clarified that the radius of the regeneration plot must be measured as horizontal distance. Included clarification regarding breakpoints and cover classes. Improved criteria for using shrub cover measurement rather than shrub count.	
2.00	April 2007	Geri Tierney Brian Mitchell	Minor editorial changes. Added 2 additional regen microplots.	
2.01	November 2007	Geri Tierney Kate Miller	Minor editorial changes.	
3.00	May 2008	Brian Mitchell Jim Comiskey Kate Miller	Incorporated MIDN methods.	
3.01	November 2008	Kate Miller Jim Comiskey Brian Mitchell	Adjusted saplings section to only require first 10 saplings per microplot to require a DBH measurement.	

Revision History Log (continued)

Version #	Date	Revised by	Changes	Justification
3.02	December 2008	Kate Miller Jim Comiskey	Changed SOP title from Regeneration to Microplot Added rule that calipers will not be used to measure DBH of saplings > 4 cm and < 10 cm.	More accurately reflects NETN and MIDN protocols.
3.03	May 2009	Sarah Lupis Kozlowski	Minor editorial changes, formatting.	Conform to NPS standards.
3.04	December 2009	Kate Miller Andrew Vincello Jim Comiskey Brian Mitchell	Changed shrub tally to shrub percent cover Clarified that vines are considered shrubs Clarified how to document unknown species Added the 5-15 cm seedling class for VAFO	
3.05	October 2010	Kate Miller Jesse Wheeler Jim Comiskey	Clarified that vine cover is estimated up to 2m MIDN has stopped measuring DRC of shrubs. All shrubs that previously had a DRC measurement are now included in cover estimates only.	
3.06	January 2013	Kate Miller Jesse Wheeler	Clarified that small saplings that aren't round should be measured as the average of the largest and smallest caliper measurement. Added new fork tally rules to be more consistent with FIA procedures. Added sapling status for MIDN.	
3.07	March 2014	Jesse Wheeler	Simplified sapling and shrub methods for MIDN so that woody species are either saplings or shrubs. All shrub species are estimated for % cover, and all saplings are measured for DBH.	3.07
3.08	December 2014	Kate Miller	Added that saplings should be paint-marked at DBH to improve consistency across sample cycles.	
3.09	December 2016	Camilla Seirup	Clarified the procedure for measuring shrub height.	

SOP 10 - Coarse Woody Debris

Mid-Atlantic Network/Northeast Temperate Network

Version 3.07

Overview

This SOP quantifies coarse woody debris using line intersect sampling along three, 15-m transects at each plot. These data yield information on forest structural diversity, and the availability of habitat for wildlife and fungi.

Definitions

Coarse woody debris (CWD) includes down, dead tree and shrub boles, large limbs, and other woody pieces that are ≥ 10 cm diameter and ≥ 1 m long, are separated greater than 50% from a live tree or a snag, and are touching the ground at some point along the piece. Coarse woody debris includes dead trees leaning > 45 degrees from vertical. Very decomposed logs reduced to slightly elevated 'humps' on the ground without structural integrity are not tallied as CWD. Do not tally CWD pieces that are completely suspended above the ground.

Horizontal distance is the straight line distance between two objects. This contrasts with slope distance which is measured parallel to the ground. Slope distance and horizontal distance are equivalent on flat land. On sloped land, the horizontal distance between two objects is less than the slope distance.

Data Collection

Coarse woody debris transects extend 15 m slope distance from plot center. Transect UP extends upslope or North, parallel to plot sides and extending through the upper boundary midpoint. Transect BL extends through the bottom left plot corner. Transect BR extends through the bottom right plot corner. Transects must be laid out along a straight line to avoid biasing the selection of pieces.

Transect slope should be measured during plot setup. Using the TruPulse, record to the nearest degree the average slope along each CWD transect.

Tally Rules for CWD

Most CWD will be lying on the ground. To be tallied by this protocol, the point of intersection between the transect and the central longitudinal axis of the piece must occur above the ground, and the piece must meet the minimum diameter criteria (≥ 10 cm) at the point of intersection, as shown in Figure S11.1.

All snags leaning > 45º from horizontal should be tallied regardless of height off the ground, as long as the piece is touching the ground at some point along its length (even if the part touching the ground is <10 cm diameter). If the snag is too high to reach, record this fact and estimate diameter and length.

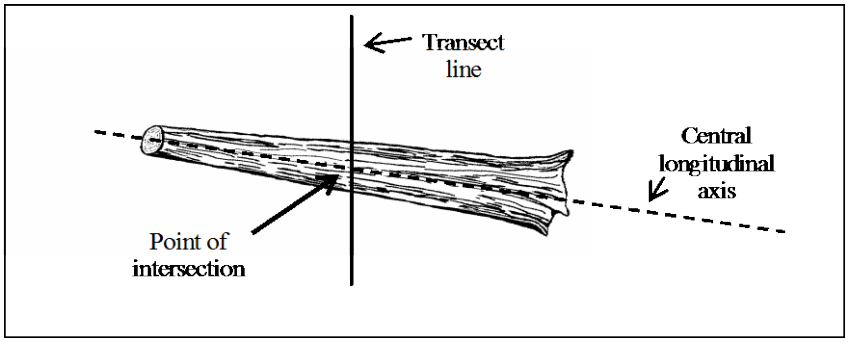


Figure S11.1. Diagram showing the point of intersection along the transect where diameter of the coarse woody debris is measured.

If a piece intersects a transect line more than once or intersects two transect lines, tally the piece each time it intersects and record the same letter for each record of the same piece in the database.

For each piece of CWD to be tallied, record the following:

- **Transect—**Record the letters indicating the transect on which the piece is sampled: transect UP runs upslope or North from the plot center, transect BL runs through the bottom left plot corner, and transect BR runs through the bottom right plot corner.
- **Distance**—Record the slope distance from plot center to the point of intersection to nearest 0.1m.
- **Type**—Record if the piece is coniferous (CON), deciduous (DEC), or unknown (UNK).
- **Species Code**—If species can be quickly and confidently assessed (for example if the piece has a tree tag or is in decay class 1, record species using the first three letters each of the genus and species. If it is not possible to identify the species, record “UNK” for unknown. Do not spend time trying to identify CWD if species is not obvious.
- **Decay Class**—Record the code indicating the predominant decay class (> 50% of the piece) along the length of the pieces as determined from Table S11.1. If no single class dominates, average the decay classes present. For example, a log with sections totaling 15% class 2, 40% class 3, 40% class 4, and 5% class 5 would be classified as Decay Class 3.
- **Diameter at Intersection**—Record the piece's diameter, to the nearest cm, at the point where the transect intersects the longitudinal center of the piece. Take care to measure diameter perpendicular to the piece’s length (not along the line of the transect). Diameter of CWD is typically measured by holding a metal tape or ruler above the log. To avoid parallax error, position your eyes directly over each end of the tape in sequence. Other methods include wrapping a tape around the bole (if possible) and using large calipers. If the piece is not round in cross-section, take the average of the smallest and largest diameter measurements to get an accurate diameter of the piece.

- **Multiple Cross**— If a piece crosses the same transect more than once, or crosses multiple transects, record the same letter for each record of the same CWD piece in the multiple cross column. For example if one piece is intercepted twice by the UC transect, record “A” in the multiple column both times it is measured. Likewise if on the same plot another piece crosses both BL and BR transects, record “B” in the multiple column both times it is measured.

- **CWD Length**—Record the length of the piece that qualifies as CWD to the nearest 0.5 m. From the small end, begin measurement at the point that diameter is at least 10 cm and above ground, and measure to the point that the log either ends, goes underground or deteriorates to less than 10 cm diameter. For curved logs, measure along the curve. For forked pieces, consider the main fork to be that with the largest diameter at the fork. For the main fork, length should include the entire length of the piece. For minor forks, length should be measured only to the point of attachment with the main fork. Minor forks do not count as a multiple cross with the major fork. The minimum length recorded by this protocol is 1 m.

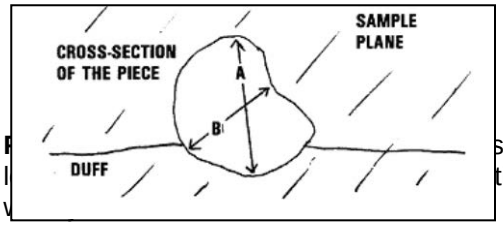
- **Hollow**—Record whether piece is hollow (Y) or not (N). A piece is considered hollow if a cavity extends at least 0.5 m along the central longitudinal axis of the piece, and the cavity entrance is at least 1/4 the diameter of the piece.

For each CWD piece that is measured, paint the location that the piece crosses the transect and where the diameter is measured with tree paint.

For pieces that are not round in cross-section because of missing chunks or “settling” due to decay, measure the diameter in two directions and average. Estimate the longest and shortest axis of the cross-section (as shown in Figure S11.2) and record the average value.

Table S11.1. Coarse woody debris decay class definitions, adapted from Pyle and Brown (1998).

Class			Bark	Log Shape and Integrity	Wood Condition
I			Firmly attached	Round and solid	Sound wood covered by intact bark
II			If present, decayed, faded, and not firmly attached	Round and firm	Hard wood—impenetrable with fingernail or pen point, may be case hardened with powder wood beneath
III			Generally absent, except in *Betula* and *Prunus*	Round	Softwood—will spring back if compressed and easily penetrated with fingernail or pen point
IV			Generally absent	Oval or flattened, no longer a solid piece though some hard chunks remain	Very spongy wood—responds to finger pressure and may exude moisture—and powder wood—flows through fingers like coarse sawdust
V	Absent	Quite flat or flat with some rounding	Loosely aggregated powder wood		



stimate the
tion of coarse

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	June 2006	Geri Tierney Brian Mitchell	Changed decay classes, increased CWD transect length to 45 m per plot, added measurement of distance from plot center to CWD piece.	Decay classes now adapted from Pyle and Brown 1998 for eastern trees.
2.00	September 2006	Geri Tierney Brian Mitchell	Increased CWD minimum size threshold to 10 cm diameter, adjusted transect names from lower (L) to bottom (B) to match quads, clarified CWD length measurement.	
2.01	April 2007	Geri Tierney Kate Miller Brian Mitchell	Minor editorial changes, added measurement of multiple intersection on a single transect, clarified measurement of length for forked pieces, clarified CWD classes.	
3.00	May 2008	Kate Miller Brian Mitchell	Specified that CWD slopes are taken during plot setup, with the laser rangefinder.	CWD slopes are now measured in degrees, not percent slope.
3.01	December 2008	Kate Miller	Added MIDN to SOP title, added figure and table titles to be consistent with SOP format, minor editorial changes.	
3.02	May 2009	Sarah Lupis Kozlowski	Minor editorial changes, formatting.	Conform to NPS standards.
3.03	December 2009	Kate Miller Andrew Vincello Jim Comiskey	Changed method for dealing with a CWD piece that crosses the same transect more than once or multiple transects.	
3.04	October 2010	Kate Miller	Minor editorial changes	

Revision History Log (continued)

Version	Date	Revised By	Changes	Justification
3.05	January 2013	Kate Miller	Clarified that for pieces that aren't round, crews should take an average of the largest and smallest measurement for diameter. Changed CWD tally rules to exclude pieces that are completely suspended above the ground. Added that a dead branches attached to a snag or live tree only count as CWD if they are >50% severed from the snag/tree.	QA/QC suggested that suspended CWD was often missed. These methods are also more consistent with FIA.
3.06	March 2014	Kate Miller	Replaced LAR with TruPulse	Equipment change.
3.07	December 2016	Camilla Seirup	Added calipers as a diameter measurement option. Added that CWD pieces should be painted at the location where the piece crosses the transect to improve repeatability.	

SOP 11 - Soil Measurements and Sampling

Mid-Atlantic Network/Northeast Temperate Network

Version 4.05~~4~~

Overview

This SOP will be used to characterize soil depth and chemistry within the rooting zone and provide information on the effects of atmospheric deposition upon the ability of these soils to support forested ecosystems. Soil samples will be shipped to designated facilities for soil chemistry analysis. This SOP also includes a rapid assessment of earthworm presence, used to characterize the spatial extent of earthworms across the network.

Regulations Governing Sample Collection

The National Historic Preservation Act of 1966 (as amended) provides for the protection of historical and cultural artifacts. Due to the random placement of plots, a soil sampling site may be located on a site of prehistoric or historical significance. Park archeologists or cultural resource specialists must be contacted prior to field visits in order to obtain permission to sample. However, if cultural artifacts are encountered at a plot where permission to sample has been granted, do not take a soil sample. Code the site as not sampled and record a note explaining why a soil sample was not taken.

Definitions

Horizons are layers which develop in the soil under the influence of climate, living organisms and other soil forming factors. Major horizons from top to bottom include the O (organic) horizon, A, E (eluviated), B and C horizons.

Forest floor is the top layer of organic matter overlying the mineral soil, consisting of intact and partially decomposed litter and humus, otherwise known as the O (organic) horizon. This protocol will collect forest floor as the consolidated litter and the humus layer only, without unconsolidated litter.

Litter is undecomposed or partially decomposed organic material that can be readily identified as plant leaves, twigs, etc. The upper part of the litter layer is typically unconsolidated and is easily brushed aside. Beneath is a layer of older, compressed litter which has been consolidated.

Peat is partially decomposed organic matter that can accumulate in wet areas under acidic conditions.

Mineral soil is a soil consisting predominantly of products derived from the weathering of rocks (e.g., sands, silts, and clays). As soil develops under the influence of climate, living organisms and other soil forming factors, it typically develops layers or horizons. Typical mineral soil horizons include the A, E and B horizons.

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.

Data Collection

Measurements will be taken at the annual soil sampling location. The first time a plot is sampled, the soil measurement location can be found as described here and diagrammed in Figure S12.1. From a position facing upslope at the plot center, turn to face left and travel in a direction parallel to the upper and lower plot boundaries to reach the midpoint of the plot edge, and continue in that same direction 2 m past the plot edge. The first soil sampling location lies within a 2-m radius circle surrounding this point.

During subsequent visits, soil measurement locations will be at 4-m intervals alternating in a diagonal fashion on opposite sides of soil measurement site #1, as shown below in Figure S12.1. To locate the S2 location, stand at ML and face S1. S2 is 5.6 m from ML at 30 degrees (when facing S1).

If the soil cannot be measured or sampled within the designated sampling location due to obstruction (e.g., boulder, tree, standing water), move to the corresponding location off the opposite (right) side of the plot, and attempt to obtain a sample there within a 2-m radius. Note the alternate sampling location in Soil Notes.

Earthworms

Visually assess and record the presence (1) or absence (0) of earthworm casts and burrows at the soil sampling location for the current year. To do so, gently brush aside unconsolidated litter to view casts and burrows at the soil surface. Examine up to three locations within an area approximately equivalent to the 2-m radius available for the soil sample. If examination is inconclusive, record 9, and record a brief note explaining why in Soil Notes.

Soil Sample

Soil samples will be separated and collected by layer whenever possible (Table S12.1). When soil layers are not evident, samples will be separated and collected by depth (Table S12.2 and S12.3). Differences in soils between Acadia NP (ACAD) and the National Historical Parks (NHP) require different methods.

Tables S12.1-S12.3 highlight the methods and data to be recorded in different situations. Detailed procedures follow the tables.

At each plot, sampling of soil in the rooting zone will occur at three places within the current year's sampling location (a 2-m radius circle); samples from the three places will be composited by soil

layer or depth to yield composite samples. Procedures for collecting samples at ACAD differ from **procedures used at the NHPs, as described herein.**

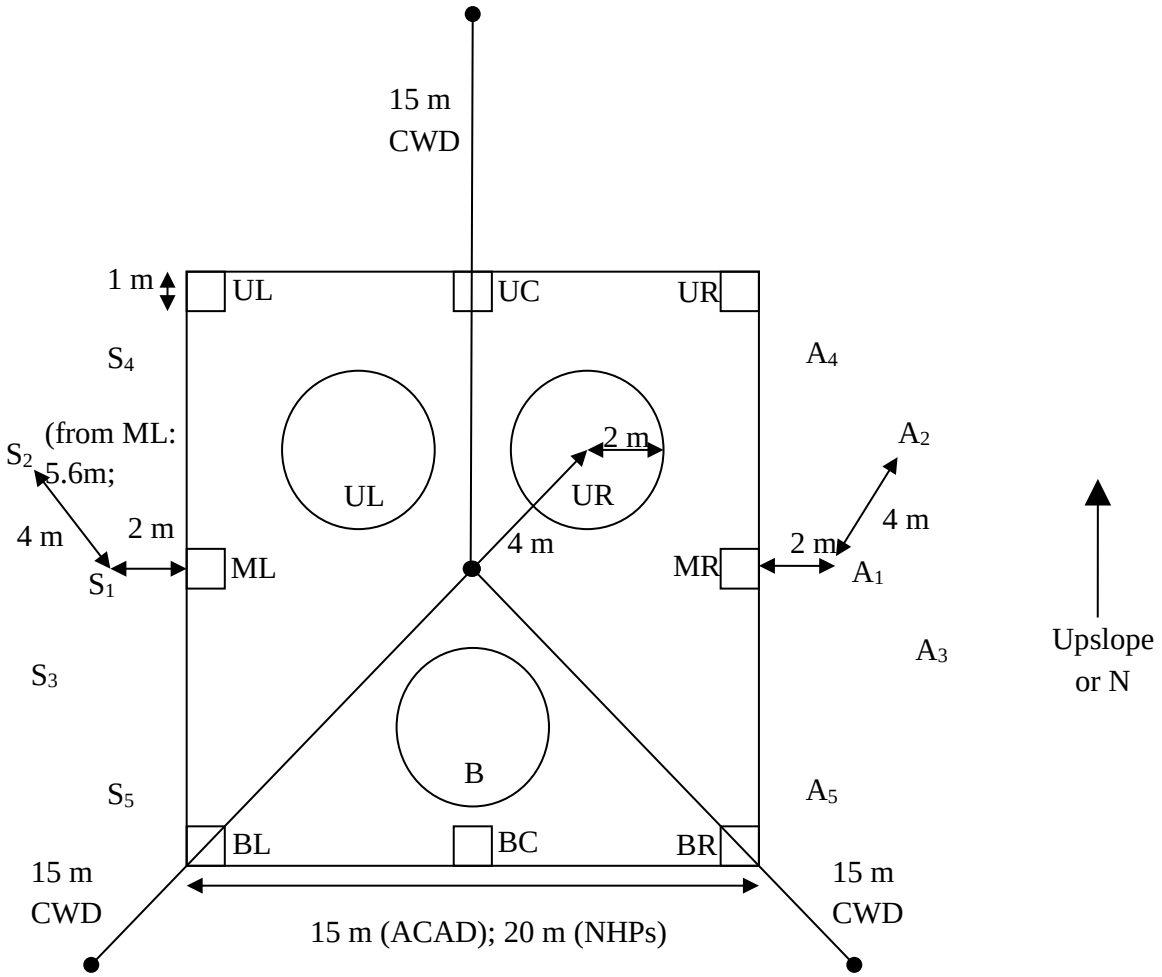


Figure S12.1. Soil sampling location relative to plot. S1 shows location of soil sample during first visit, S2 shows location of soil sample during second visit, etc. (added the alternate soil sample sites to figure on a trial basis).

Table S12.1. Soil sample procedures by horizon.

Soil Layer	ACAD	NHPs
Unconsolidated Litter	Measure depth at two points on frame and remove	Measure depth in core hole
Forest Floor	Excavate using frame and record depth	Collect using core and record layer length in core
A Horizon	Excavate using frame and record total depth. Do not exceed 20 cm total depth of excavation.	Collect using core and record total length of core. Do not exceed 20 cm total length of core.

Table S12.2. No detectable horizons, sample by depth[1].

Soil Layer	ACAD	NHP's
Unconsolidated Litter	Measure depth at two points on frame and remove	Measure depth in core hole
No detectable horizons	Excavate using frame to bottom of fine root penetration or max depth of 10 cm, and record total depth	Collect using core to bottom of fine root penetration or max depth of 10 cm, and record total length of core

[1] In the event of a thick peat layer, exclude litter measurement (record "thick peat" in notes).

TableS12.3. No detectable mineral horizons, hybrid sample

Soil Layer	ACAD	NHP's
Unconsolidated Litter	Measure depth at two points on frame and remove	Measure depth in core hole
Forest Floor	Excavate using frame and record depth	Collect using core and record layer length in core
Mineral soil (no mineral horizons evident)	Excavate up to 10 cm using frame and record total depth. Do not exceed 20 cm total depth of excavation.	Collect up to 10 cm using core and record total core length. Do not exceed 20 cm total length of core.

Begin by visually examining the soil sampling location designated for the current year of measurement. The first sampling place should be the centerpoint of the 2-m radius soil sampling location. If rocks, roots or other obstructions prevent soil sampling at that point, select another location within the 2-m radius circle. If, after 5 attempts, no suitable location exists within that 2-m radius, note this fact in Soil Notes, and move to the corresponding location off the opposite (right) side of the plot and attempt to obtain a sample there.

National Historical Parks and MIDN

Soil will be collected using a soil corer. Gently remove any unconsolidated litter from the soil surface, and drive the soil corer at least 5 cm into the ground. If the core strikes a rock or obstruction before reaching this depth, remove the core and select another location with a radius of 2 m of the original sampling location. The maximum collection depth is 10 cm for an individual sample by depth, and 20 cm for the total excavation. Collect and composite three cores from within this area as follows.

Once a core is exposed, carefully examine the core to identify boundaries between the forest floor, A horizon, and any underlying horizons. The boundary between the **forest floor** and mineral soil can be detected by soil texture and weight. **Forest floor**, comprised of organic matter, will be light in weight and have a greasy feel. Underlying mineral soil may be lighter in color or have a similar dark color to the forest floor, but will contain a mix of organic and mineral particles which will be heavier in weight and may feel gritty. A boundary between the A **horizon** and underlying soil may be identified as the lower extent of fine root penetration, or by changes in soil color or texture. If present, an E horizon would be relatively narrow band that is markedly lighter in color than the overlying A or underlying B horizons.

Use a ruler to measure the thickness of the forest floor (excluding unconsolidated litter), and thickness of the A horizon (up to a total combined thickness of 20 cm). Then, use a knife to separate

the forest floor and A horizon from each other and any underlying horizons. Carefully collect the forest floor (excluding unconsolidated litter), and A horizon in separate plastic bags, clearly labeled with Date of collection, Park, Plot number, and Horizon.

Finally, use a ruler to record the thickness of unconsolidated litter adjacent to the core hole.

If no horizons can be distinguished, use a ruler to measure a) the entire thickness of soil removed, and b) the depth to which fine roots penetrate the core. Then collect soil to the depth of fine root penetration (up to 10 cm) in a plastic bag clearly labeled with Date of collection, Park, and Plot number.

In this manner, collect and composite three cores from this location. Composite corresponding layers (e.g., forest floor) from all three cores into a single bag. This will yield two soil samples per plot (one composite forest floor layer and one composite A horizon); or one undifferentiated sample per plot if no horizons can be distinguished.

Acadia National Park

Soil will be collected using a frame. Place the 10 x 10 cm sampling frame on the ground at the first sampling place carefully to avoid compacting the forest floor. Use small survey flags to mark the approximate midpoints of the upper and lower edges of the frame, and remove the frame. Use a ruler to measure the depth of unconsolidated litter at each flag, to the nearest cm. Some areas may have thick organic layers comprised of peat—partially decomposed organic matter. In this case, omit the litter measurement and note "thick peat" in Soil Notes.

Replace the sampling frame. Using a pair of clippers, carefully remove all live vegetation from the sample area. Living mosses should be clipped at the base of the green, photosynthetic material. Then brush aside all unconsolidated litter (leaves, bark, wood fragments, etc.) and deposit this material outside the sample frame (it may help to clear litter 3-5 cm around the outside of the quad to keep litter from falling into the quad while excavating). Unconsolidated litter will easily be brushed aside by hand. Consolidated litter (leaves, etc.) which has begun to compress and decompose should not be removed, as it is part of the forest floor layer. The maximum collection depth is 20 cm total excavation, and 10 cm for a single sample of undifferentiated soil sampled by depth.

Next, collect the forest floor as follows. Use a sharp knife or keyhole saw and a pair of clippers to carefully cut through the forest floor along the inner surface of the frame to separate it from the surrounding soil. Using inward scooping motions, carefully collect and bag the forest floor layer (excluding unconsolidated litter) within the sampling frame to the depth at which mineral soil is detected. Discard all recognizable woody debris including pine cones, large pieces of bark, and decomposed wood, and any rocks or pebbles. The boundary between the forest floor and the underlying mineral soil can be detected by soil texture and weight as described above. In the case of a thick organic layer comprised of peat, collect to a maximum depth of 10 cm. Collect material in a plastic bag, clearly labeled with Date of collection, Park, Plot number, and Horizon. Now, record the thickness of the forest floor layer (excluding unconsolidated litter) as the distance from the top of the consolidated litter to the bottom of the excavation so far.

After the forest floor layer is collected, identify and collect the A horizon as follows. Expose a soil profile along the inside edge of the frame using a trowel or by taking a soil core just outside the frame. Examine the profile to find the point at which fine roots penetrate no further into the soil, and look for any distinct changes in soil texture and color as described above.

If an A horizon is apparent, carefully collect the A horizon within the sampling frame into a plastic bag (to a maximum total excavation depth of 20 cm). Clearly label the bag with Date of collection, Park, Plot number and Horizon (A). Now, record the total depth reached as the distance from the top of the consolidated litter to the bottom of the excavation.

If the boundary between the forest floor and A layer is difficult to determine or no horizons can be differentiated, collect soil within the sampling frame to the depth of fine root penetration (up to a maximum of 10 cm) in a plastic bag clearly labeled with Date of collection, Park, and Plot number. Record the depth of soil collected.

Alternatively**, if a forest floor layer has been collected but no mineral horizons can be differentiated**, collect mineral soil within the sampling frame to the depth of fine root penetration (up to a maximum of 10 cm for this sample and 20 cm for the entire excavation) in a plastic bag clearly labeled with Date of collection, Park, and Plot number. Record the total depth reached as the distance from the top of the adjacent consolidated litter to the bottom of the excavation.

Next, repeat this entire procedure at two additional places within this year's soil sampling location (2-m radius circle). All three samples should be composited by soil layer (forest floor or A horizon) to yield a total of one or two samples per plot.

Unconsolidated Litter Thickness

Measure the depth of unconsolidated litter to the nearest cm as described above. Gently pat down (do not compress) the litter prior to measurement so that the litter is the same height it was before it was disturbed. Be sure that you are only measuring the unconsolidated litter (i.e., do not sink the ruler into the consolidated litter). Some areas may have thick (> 20 cm) organic layers comprised of peat—partially decomposed organic matter. In this case, omit the litter measurement and write “thick peat” in the soil notes.

Forest Floor Depth

Record to the nearest cm the thickness of the forest floor collected (excluding unconsolidated litter). If the lower boundary cannot be discerned, omit this measurement.

Total Depth Collected

At ACAD, record to the nearest cm the total depth collected (up to 20 cm) as the distance from the top of the consolidated litter to the bottom of the excavation. In the NHPs, record the total length of the core collected (up to 20 cm).

A Thickness

At the NHPs only, measure and record to the nearest centimeter the thickness of A horizon collected. If no distinct A horizon is evident, omit this measurement.

Soil Notes

Note which, if any distinct horizons were evident at this site. If it was difficult to find a suitable soil location, note that here, record the reason, and note if it was necessary to sample on the alternate side of the plot. Record any unusual soil features.

Sample Drying

Upon return from the field, leave soil sample bags open to air-dry in a safe location until soil no longer appears moist. To do so, gently squeeze the soil from the outside of the bag to break up clumps, and arrange the sample so it has maximum exposure to the air (fold back the lip of the bag, move soil out of the corners of the bag, and let the sample lay as flat as possible). In order for this to work properly, soil sampling bags should be flexible plastic bags that are wider at the opening than they are long. Soil sample bags should always be open, unless in transit or completely dry. Bags closed for extended periods of time may grow mold or other fungi, and may impact soil analyses. As the soil dries, **check and mix the sample daily** by gently squeezing from outside the bag. During the soil drying process, do not handle the soils with bare hands or allow contact with any other potential contaminant.

If a **drying oven** is available (such as at ACAD and FRSP), place open sample bags in oven set to 30-35° C (85-95° F) until dry. Arrange sample bags and check as described above for air-drying. Clearly mark the outside of the oven with a note identifying the date, a crew member's name and contact information, and the temperature at which the oven must remain. **If more samples need drying than can fit in the drying oven, keep the extra samples open, and in a safe, dry place.** Monitor samples in the oven and in the alternate location daily.

Record the date each sample finishes drying. Once samples are dried, seal bags and store them in a labeled box until your supervisor directs you to send the set of samples to a designated soil chemistry lab for analysis.

Prior to sending samples to the lab, **prepare a master list of sample information**. Assign each sample a unique number from 1 to n, mark this number prominently on the bag (using a different color ink than other info on the bag and circle this number), and create a list identifying which sample number corresponds to which park, plot number, soil horizon or depth increment, date collected and date finished drying. Print a copy of this list for NETN, and include a copy with the samples when shipped or delivered to the lab.

Sample Analysis

Dried samples should be sent to a designated soil chemistry lab for analysis. The designated lab should have experience analyzing forest soils. Several soil laboratories have sufficient capabilities, including the Analytical Lab at the University of Maine (http://anlab.umesci.maine.edu, contact Sue Erich at erich@maine.edu).

The lab should prepare samples by passing each through a 2 mm sieve to remove larger particles. Analysis must include:

- Total carbon and total nitrogen by dry combustion
- NH_4Cl extractable ions including Ca and Al

Soil Archiving

Once soil samples are returned from the analytical lab, samples may be archived to allow for future analyses. Original soil samples (≥10g) should be archived in 4 mil sealable plastic bags (6” X 6”), filling bag no more than approximately 2/3 full. If original sample is not available, then use the sieved/pulverized sample found in the small Whirl-Paks that were returned from the lab. Remaining soil from the analyzed samples should either be discarded or stored in an additional sample bag. Soil sample labels should be printed on acid-free paper using a pencil and contain: Sample (UMO) number, Park, Plot, Layer, Date collected, Date dry, and Sample Type. Sample type refers to whether the sample is the original unsieved/pulverized sample (label as "original") or the sieved/pulverized sample (label as "sieved"). Labels should be inserted into small (2” X 3”, 2 mL) plastic bags. Label and soil bags should both be kept in 6”X6” bags and stored in an acid-free cardboard box.

Original Sample Type

The original soil sampled in pure form, containing consolidated litter of the organic layer, and/or aggregates of varying size from the A-layer.

Sieved/Pulverized Sample Type

Soil that has been sorted with larger particle sizes removed, or pulverized to create uniform soil particle size. The analytical lab encloses these samples in small Whirl-Paks.

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
2.00	June 2006	Geri Tierney Brian Mitchell	Changed soil sample to a composite sample, separated by horizon.	
3.00	September 2006	Geri Tierney Brian Mitchell	Added earthworm and humus measurements from Forest Floor SOP. Included instructions for drying samples. Included specifications for soil analysis. Added soil notes. Revised instructions to separate by depth if soil layers are not identifiable.	
3.01	December 2006	Geri Tierney Brian Mitchell	Altered instructions for separating soil horizons and collecting sample	

Revision History Log (continued)

Version #	Date	Revised by	Changes	Justification
4.00	November 2007	Geri Tierney Kate Miller Brian Mitchell	Clarified need to sample soil from the rooting zone only. Revised instructions for collecting soil in NHPs to use soil corer. Clarified instructions for sites without clear horizons.	
4.01	May 2008	Geri Tierney Kate Miller Brian Mitchell	Clarified litter depth measurement to refer to unconsolidated litter. When using the frame, clear unconsolidated litter for several cm around the frame. Humus thickness excludes unconsolidated litter. Total depth excludes unconsolidated litter. Litter thickness is unconsolidated litter (previously was consolidated + unconsolidated. Specified that litter can be patted down if it has been disturbed. Clarified and simplified terminology for layers. Clarified sample depths and added tables summarizing procedures and depths.	
4.02	December 2008	Geri Tierney Kate Miller Brian Mitchell	Clarified that soil sample bags should always be open, unless in transit or completely dry. Clarified that soil samples should not be handled with bare hands post collection.	
4.03	December 2009	Kate Miller Andrew Vincello	Added location of S2. Clarified unconsolidated leaf litter measurement	
4.04	October 2010	Kate Miller Jesse Wheeler	Added MIDN to National Historic Parks section Added instructions for archiving soil samples Minor editorial changes	
4.05	November 2017	Kate Miller	Clarified labeling for archived soils	

SOP 12 - Quadrat Measurements

Mid-Atlantic Network/Northeast Temperate Network

Version 4.09

Overview

This SOP measures the composition and abundance of understory vascular plants. Lichen genera are also recorded if possible. In Northeast Temperate Network (NETN) parks, species percent cover data are collected in eight 1-m^2 quadrats nested within each plot; in Mid-Atlantic Network (MIDN) parks, the data are collected on twelve 2 x 0.5-m^2 quadrats. This SOP is designed to be conducted by two people, one of which must be a vegetation specialist or crew member familiar with vegetation at the sampled park. This protocol should be used only during the summer months (about June 1 to August 31 in NETN parks, and to September 30 in MIDN parks).

Percent cover classes used for this protocol are: 0, < 1, 1-2, 2-5, 5-10, 10-25, 25-50, 50-75, 75-95, 95-100%.

Notice the exact breakpoints (e.g., 25%) are not included in any class. Classes are either above or below each breakpoint. This is not a mistake—it is to encourage the crew not to waste time trying to decide if the correct value is exactly 25%. The most suitable class should be rapidly assessed and recorded.

Data Collection

In NETN parks, quadrats are nested within each of the four corners of the plot and at the midpoints of each plot edge, for a total of eight quadrats. At plot corners, anchor the quadrat with the corner stake and align the quadrat along plot edges. At midpoints, align the quad edge with the plot edge so that the plot midpoint stake also demarks the midpoint of that aligned quad edge.

In MIDN parks, three quadrats are located at 2 m, 5 m, and 8 m along each of the three coarse woody debris (CWD) transects, and one quadrat is at the center of each microplot. For the quadrats located along these transects, the bottom of the quadrat is placed at the defined distance with half the quadrat stretching to either side of the transect. The top of the quadrat will therefore be located at 2.5 m, 5.5 m, and 8.5 m respectively. For the microplot quadrats, the quadrat base is placed at the middle of the microplot and oriented so the quadrat sides face the plot center (Figure S13.1). The top of the quadrat will therefore be located at 6.5 m from the plot center. MIDN quadrats should be sampled as soon as plot setup is complete to minimize trampling.

A useful quadrat frame can be made from PVC pipe and pipe joints—the joints are detachable to improve maneuverability. The quadrat should be placed so that it follows the contour of the ground. Level the quadrat, if necessary, by propping up the quadrat corners. In areas of thick vegetation, quadrat sides should be slid through the vegetation. Carefully mark the midpoints of each quadrat frame edge with a permanent marker in order to accurately line up the quad frame with plot markers.

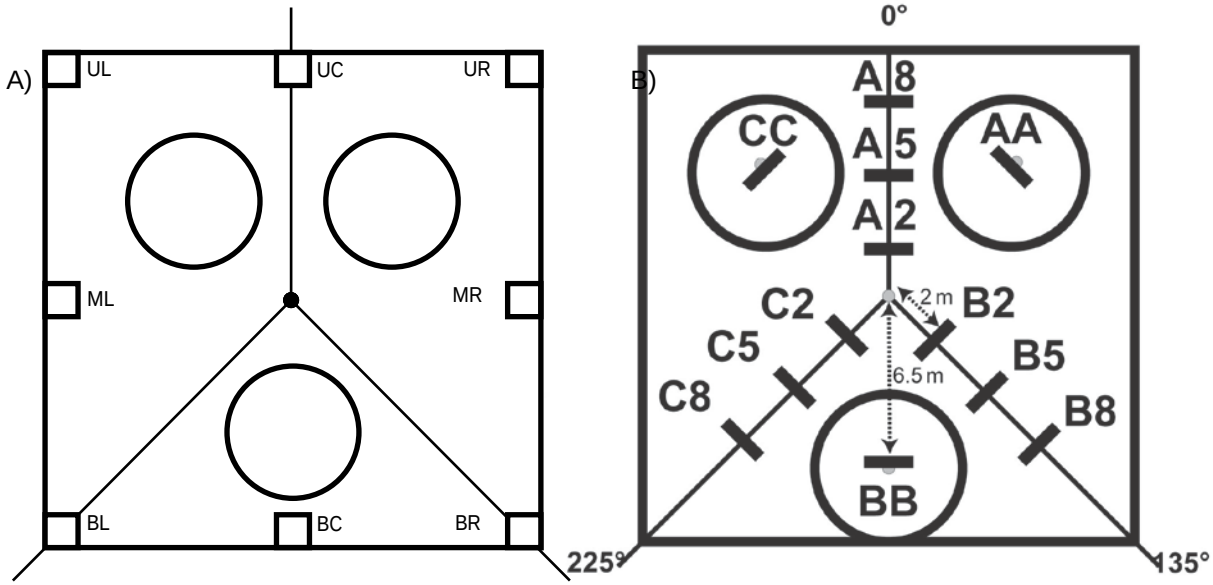


Figure S13.1. Layout and naming of quadrats in A) NETN parks, and B) MIDN parks.

Quadrat Code

Record the code(s) corresponding to each quadrat within which the species was found: Codes in NETN are upper-center (UC), upper-right (UR), mid-right (MR), bottom-right (BR), bottom-center (BC), bottom-left (BL), mid-left (ML), and upper-left (UL). For the MIDN the quadrat codes are shown in Figure S13.1.

Quadrat Sampling Status

Record whether each quadrat was sampled (1) or not (0). If a quadrat was not sampled, record the reason in Quad Notes. This might occur if no vascular plants are rooted in or overhanging the plot, or if a safety hazard exists.

Quadrat Trampling

Examine each quadrat prior to sampling and record "1" if more than 10% of the ground surface of any quadrat appears trampled. If not, record "0". Trampling is defined as damage to plants or disturbance of the ground layer by humans, livestock, or wildlife. Include trampling caused by the field crew, and note this in Quad Notes.

<u>The next six measurements of Quadrat Characteristics are made to determine the % of quadrat area unavailable to vascular plants.</u> Note that distinguishing between wood and stem are less important than making sure the same non-plant area is only included in one cover estimate.

% Stem

Record % cover of vertical (less than 45 degrees from vertical) woody stem ≥ 1 cm DRC within the quad using the cover classes listed above.

% Wood

Record % cover of live or undecomposed dead wood (large root or coarse woody debris ≥ 5 cm diameter) within the quad using the cover classes listed above. Wood suspended above the ground should not be included in this estimate. Wood is greater than 45 degrees from vertical.

% Rock

Record % cover of exposed rock within the quad using the cover classes listed above. If rock is visible beneath unconsolidated litter include that area as rock. If consolidated (aggregated) litter, moss or non-crustose lichens cover the rock surface, do not include that area as rock.

% Cover Bare Soil

Record % cover of bare soil within the quad using the classes listed above. Bare soil is defined as exposed mineral soil with no leaf litter or duff layer (i.e., O horizon) present.

% Sphagnum

Record % cover of sphagnum moss within the quad using the cover classes listed above.

% NS Bryophyte

Record % cover of non-sphagnum bryophytes within the quad using the cover classes listed above.

% Lichen

Record % cover of lichens "rooted" in the substrate within the quad using the cover classes listed above. Lichens that have fallen from the canopy or are attached to recently fallen branches should not be included in the % cover estimation.

Quadrat Species—NETN

Each quadrat is examined for vascular plant species found rooted in or overhanging within 1.5 m above the ground by a team of two people, one of which must be familiar with vegetation at this park (i.e., a crew member familiar with flora of that park or a contract botanist). A list of species is recorded, including vines and epiphytes as long as they are vascular plants and are overhanging within 1.5 m above the ground. Then, % cover of the foliage of each species is jointly estimated and recorded by the team of two people. Use the cover classes listed above. Cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between leaves, up to a maximum height of 1.5 m. The 1.5 m height should follow the contour of the ground.

New germinants of woody species receive special treatment because cover of these germinants fluctuates greatly within and among years. For each woody species, record and estimate cover of this year's germinants separately from more established specimens. Specify records for germinants by checking the "germinant" box in the database. The germinant category only refers to seedlings that have germinated from seed within the current growing season. These seedlings typically are very small (< 5 cm tall), and will display cotyledons (rudimentary seed leaves) and possibly one-two true leaves or a single whorl of fine needles.

If a plant cannot be identified to species quickly and confidently, assign the species a specimen number, record genus or family, if possible, and give a short descriptive name. If the unknown plant

is not locally sparse, collect a specimen away from the quadrat as described below. Do not collect any plants that are represented by five or fewer individuals (i.e., locally sparse) in the general vicinity of the plot. Do not collect if plant occupies less than 1% canopy cover on subplot *and* no mature foliage or reproductive parts are present; these plants would be too difficult to identify. Any time it is not possible to collect a specimen, collect a photograph. Place a ruler in the photograph for scale, and allow the camera to automatically select the appropriate aperture for the given light conditions. Close-up photos should be taken using the macro lens setting. Photos should be downloaded at the end of the field day to a folder devoted to photos of unknowns and be named using the following format (UNK# is the name in database/ datasheet):

4-character park code _3-digit plot code _UNK#_Date (YYYYMMDD)

Example: ACAD_121_001_20100713.jpg

If lichen genus is known, record percent cover of genus that is “rooted” in the plot substrate (e.g., rock, soil, CWD, or tree stem). Lichens that have fallen from the canopy or are attached to recently fallen branches should not be included in the % cover estimation. If lichens are present, but genus is unknown, record total % lichen cover in quadrat characteristics section only.

Quadrat Species—MIDN

A similar process is used in the MIDN parks with the following differences. A select group of herbaceous species are targeted for estimation of % cover in the quadrat. These include invasive exotics and some native species (TableS13.1). For other herbaceous species in the quadrat, their total cover is estimated and recorded as a single value.

Tree seedlings are measured using the protocols outlined for the regeneration plots in SOP 10 - Microplot; seedlings are identified and assigned to a height class category. For each tree seedling species the total cover within the quadrat, including seedlings rooted outside with foliage overhanging inside the quadrat, are also estimated. For seedlings that are smaller than 15 cm (5 cm in VAFO), no height measurement is taken, but the total cover within the quadrat is estimated. Starting in 2017, deer browse is assessed for each tree seedling that is >15cm (>5cm VAFO) tall and rooted in the quadrat. Browse is recorded as a tally of browsed seedlings by species per quadrat. The presence of deer browse is only recorded if the browse is determined to have occurred within the last four years. Pay careful attention to differentiate between deer and rabbit browse (see SOP 8 Stand and Site Measurements: Deer Browse Index).

Plot Species

In NETN parks, a time-constrained search for additional species is conducted on the whole plot by the vegetation specialist or crew member familiar with vegetation at this park. Record all additional species rooted within or overhanging the plot, searching for no more than 15 minutes (not including time spent identifying or looking up species). If portions of the plot are wet, only emergent plants are recorded. Epiphytes and vines are recorded as best as possible as seen from the ground level. For MIDN parks, the time constrained search is limited to the presence of target species that were not found in the quadrats.

Quad Notes

Record any note-worthy observations, including reason quadrat was not sampled, or trampling of quadrat by the field crew.

Plant Collection

Do not collect any plant that is locally sparse as described above. Use a digging tool to extract the entire plant, including any underground portions, flowers, fruits, and leaves. 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. It is essential that each specimen be assigned a number to allow accurate matching of identified species with field measurements. Promptly identify collected plants, present plants to your supervisor for identification, or press specimens for later identification.

Table S13.1. List of targeted herbaceous species measured in the quadrats in MIDN parks. The list is consistent with protocols used by the National Capital Region Network.

Species	Common Name	Comments
Exotic Species		
Akebia quinata	Five-leaved akebia	
Alliaria petiolata	Garlic mustard	
Ampelopsis brevipedunculata	Porcelain berry	
Berberis thunbergii	Japanese barberry	
Celastrus orbiculatus	Oriental bittersweet	
Cardamine impatiens	Narrowleaf bittercress	
Centaurea biebersteinii	Spotted knapweed	
Cirsium arvense	Canada thistle	
Clematis ternifolia	Yam-leaf clematis	
Duchesnea indica	Mock strawberry	
Euonymus fortunei	Creeping euonymus	
Glechoma hederacea	Ground ivy	
Hedera helix	English ivy	
Hemerocallis fulva	Common daylily	
Lespedeza cuneata	Chinese lespedeza	*Sericea Lespedeza*
Ligustrum spp.[2]	Privet	
Lonicera japonica	Japanese honeysuckle	
Lonicera spp.	Bush honeysuckles	
Microstegium vimineum	Japanese stiltgrass	
Oplismenus hirtellus spp. *Undulatifolius*[2]	Wavy-leafed basketgrass	
Polygonum caespitosum[2]	Oriental lady's thumb	
Polygonum cuspidatum	Japanese knotweed	
Polygonum perfoliatum	Mile-a-minute	
Pueraria montana	Kudzu	
Ranunculus ficaria	Lesser celandine	
Rosa multiflora	Multi-flora rose	
Rubus phoenicolasius	Wineberry	
Vinca minor	Periwinkle	
Wisteria sinensis[2]	Wisteria vine	
Native Species		
Aralia nudicaulis[1]	wild sarsaparilla	
Arisaema triphyllum[1]	Jack in the pulpit	
Cyperaceae	sedges	As a group

Table S13.1. List of targeted herbaceous species measured in the quadrats in MIDN parks. The list is consistent with protocols used by the National Capital Region Network (continued).

Species	Common Name	Comments
Native Species		
Aralia nudicaulis[1]	wild sarsaparilla	
Dennstaedtia punctilobula[1]	Hayscented fern	
Eurybia divaricata[1]	white wood aster	
Ferns (not including those below)		As a group
Gaylussacia spp.	huckleberry	
Impatiens capensis[1]	jewelweed	
Arisaema triphyllum[1]	Jack in the pulpit	
Cyperaceae	sedges	As a group
Dennstaedtia punctilobula[1]	Hayscented fern	
Eurybia divaricata[1]	white wood aster	
Ferns (not including those below)		As a group
Gaylussacia spp.	huckleberry	
Impatiens capensis[1]	jewelweed	
Laportea canadensis[1]	Canadian woodnettle	
Lilies		As a group
Maianthemum racemosum	False Solomon's seal	*Smilacina racemosa*
Medeola virginiana[1]	Indian cucumber	
Orchids		As a group
Poaceae	grasses	As a group
Podophyllum peltatum	Mayapple	
Polygonatum biflorum[1]	smooth Solomon's seal	
Polystichum acrostichoides	Christmas fern	
Sanguinaria canadensis[3]	bloodroot	
Thelypteris noveboracensis	New York fern	
Trillium spp.		By species
Uvularia perfoliata[1]	perfoliate bellwort	
Uvularia sessilifolia[1]	Wild oats; Sessile-leaf bellwort	
Vaccinium spp.		As a group except *V. corymbosum* and *V. stamineum*
Vines		
Campsis radicans	Trumpet creeper	
Parthenocissus quinquefolia	Virginia creeper	
Smilax glauca[2]	Cat greenbrier	
Smilax rotundifolia[2]	Common greenbrier	
Smilax spp.[1]	Greenbrier	Other; as a group
Toxicodendron radicans	Poison ivy	
Vitis spp	Grape vine	

[1] Species added in 2008

[2] Species added in 2009.

[3] Species added in 2010.

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
2.00	June 2006	Geri Tierney Brian Mitchell	Number of quads per plot increased to eight. Percent cover class of species is now recorded in quads. % cover class of ground unavailable for plants is now recorded in quads by category. % cover class of both sphagnum and non-sphagnum bryophytes now recorded in quads. Upper boundary for veg quad sampling decreased from 2 m to 1 m.	
3.00	September 2006	Geri Tierney Brian Mitchell	Added additional stakes to mark all veg quads. Use team of 2 people to assess veg quads. Adjusted upper height boundary of veg quad sampling from 1 m to 1.5 m. Emphasized proper labeling and numbering of unknown plants collected. Included trampling by field crew in trampling measurement. Changed names of lower quads (L) to bottom (B). Clarified reason for % rock, wood, and stem measurement in quads . Added quad notes.	To avoid confusion with left (L).
3.01	December 2006	Geri Tierney Brian Mitchell	Included clarification regarding breakpoints and cover classes. Clarified epiphytes and vines are included only if vascular and overhanging quad within 1.5 m.	
3.02	April 2007	Geri Tierney	Minor editorial changes.	
3.03	November 2007	Kate Miller Geri Tierney Brian Mitchell	Noted that quad frame midpoints must be marked with permanent marker for accuracy. Changed % Stem DRC cutoff to 1 cm. Changed % Wood diameter cutoff to 5 cm. Minor editorial changes. Revised lichen % cover. Added separate woody germinant record.	

Revision History Log (continued)

Version #	Date	Revised by	Changes	Justification
4.00	May 2008	Brian Mitchell Jim Comiskey Kate Miller Geri Tierney	Incorporated MIDN procedures.	
4.01	December 2008	Kate Miller Jim Comiskey Brian Mitchell Geri Tierney	Changed name of SOP from Vegetation Diversity to Quadrat Measurements Added % Lichen to the Quadrat Characteristics section. Updated list of target species in Table S13.1. Minor editorial changes.	Instead of recording Lichen in the quadrat species section. If lichen genus is known, it will be included in the quadrat species section. Added notation to track when species was included for monitoring.
4.02	April 2009	Kate Miller	Minor editorial changes.	
4.03	May 2009	Sarah Lupis Kozlowski	Minor editorial changes, formatting.	Conform to NPS standards.
4.04	December 2009	Kate Miller Jim Comiskey Brian Mitchell	Clarified that the quadrat should follow the contour of the ground. Added that % wood only includes wood on the ground. Clarified MIDN microplot location Added bare soil definition Minor editorial changes Addition and modification to MIDN target species list	
4.05	October 2010	Kate Miller Jesse Wheeler	Clarified that seedling percent cover in MIDN is estimated for seedlings rooting or overhanging. Clarified that % rock doesn't include non-crustose lichens. Minor editorial changes	
4.06	January 2013	Kate Miller	Added that quadrats in MIDN should be sampled as soon as plot setup is complete to minimize trampling. Clarified that the 15min. plot search does not include time spent keying or looking up plants.	
4.07	March 2014	Jesse Wheeler	Split Vaccinium spp. and Gaylussacia spp. on the indicator species list.	
4.08	February 2016	Aaron Weed	Updated deer browse monitoring for MIDN seedlings.	
4.09	January 2017	Camilla Seirup	Updated deer browse monitoring protocol to reflect 2017 implementation.	

SOP 13 – Collecting and Aging Tree Cores

Mid-Atlantic Network/ Northeast Temperate Network

Version 1.00

Overview

This SOP details the process of collecting and reading tree core samples. Many of the methods are adapted without citation from Maeglin (1979), which is a U.S. Forest Service technical report that details methods for collecting and processing tree cores.

Definitions

Increment borer is used to core trees, and consists of a handle, auger and extractor (Figure S14.1).

Pith is the central core of the tree.

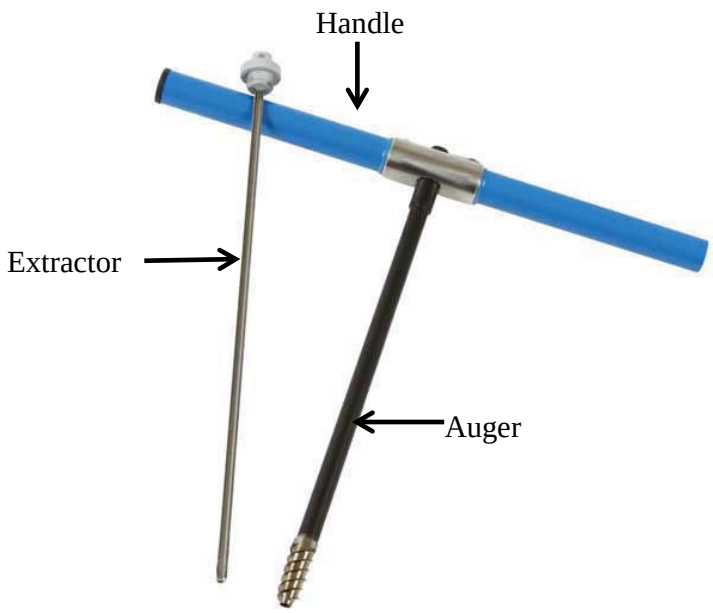


Figure S14.1. Parts of the increment borer.

Procedure

Coring the Tree

At each plot, select two co-dominant and two intermediate trees outside the plot and within 10 m of the boundary. Selected trees should be as representative of the trees in the plot as possible. For example, core only species that are well-represented in the plot.

Select an area on the bole that is at DBH, is free of wounds, branch stubs, unusual swellings, etc. If possible, collect the core along the longest bole radius to the pith, as this will minimize anomalies such as missed rings (Figure S14.2).

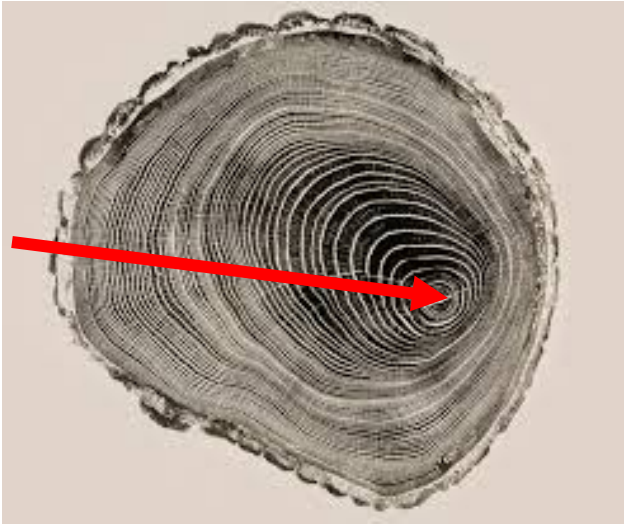


Figure S14.2. Cross section of tree bole to show arrangement of borer along the longest axis (red line).

Align the borer as straight as possible, and make every effort to hold the borer auger steady. Allowing the borer auger to wobble upon penetration will cause the tip of the core sample to break into many pieces.

1. Use the smallest borer that will reach the pith as possible, and check that the borer you are using will reach the pith by lining up the extractor. A smaller borer will allow for better leverage and easier penetration into the tree.

2. Borer starters may also be used in order to steady the borer shaft. Starters consist of a plate that is pressed against one's chest, which allows for both hands to rotate the borer and stabilizes the pivot points of the barrel.

3. If a borer starter is not used, begin coring by steadying the threaded tip end with one hand and rotating the borer clockwise with the other hand. Once the threaded bit has fully penetrated the wood, use both hands to rotate the borer.

Pay special attention to the alignment of the borer to ensure it is heading into the pith of the tree, otherwise multiple annual rings may be missed. Although the pith is not always located directly in the geometric center of the tree, this is generally the best location to aim. Branch stubs point towards the pith of the tree, and can also be helpful for aligning the borer. To estimate if the center of the tree has been reached, hold the core extractor next to the borer. The borer and extractor are similar lengths, and thus the end of the extractor provides a good estimate of where the end of the borer is in the stem. Notable situations include:

1. Forked trees, which are crowded on one side, and add more wood to the opposite side. This causes the pith to be shifted toward the fork. Avoid coring forked trees.

2. Leaning trees form “reaction wood” which is difficult to interpret and not representative of the true age. If possible, do not bore leaning trees. If you must, take the core along the contour of the slope (i.e. neither on the upslope nor downslope side of the tree).

When the pith is reached, gently insert the core extractor inside the borer. Rotate the borer two full turns in a counter-clockwise direction and remove the extractor and the core. Be particularly careful removing the extractor so the core is not dropped. Discard cores that are rotten at the center or are broken in more than two pieces from the pith to the outside of the core, and select another tree to core. Repeat this process until you have four good cores, but do not core more than eight trees total for a plot.

Store the core sample in a slotted plastic tray, and be consistent with the direction you store the bark end of the core. Store the tray in a zipper-locked plastic bag inside a metal clipboard to protect it.

Immediately after the core is completed, remove the borer from the tree by turning it in a counter-clockwise direction. Compressed wood surrounding the auger will rebound and cause the borer to become stuck if left in the tree for long. Once the borer is removed, check that the tip is clear; often a small piece of core will remain jammed in the tip of the borer. To dislodge this piece, use a small hardwood peg or dowel. Center the peg on the jammed wood, and gently tap it out with a rubber mallet. If possible, avoid hammering the core out with a metal tool, as this will inevitably chip the cutting edge of the borer. Do not plug the hole in the stem left by the core.

For each core collected, record:

1. Plot #
2. Core tray #
3. Core slot #
4. Tree species
5. Crown class (co-dominant or intermediate)
6. DBH
7. Corer initials
8. Notes

Increment Borer Maintenance

Common issues such as broken, ragged, and stained cores can be easily minimized by following basic maintenance procedures to keep the increment borer in good condition.

<u>Cleaning the Borer</u>

Wrap a piece of tissue paper or cloth patch around the extractor tip, and spray with WD-40. Rub the paper along the inside of the borer. Spray WD-40 directly onto the borer barrel and extractor and wipe clean. Alternatively, a .22 caliber gun cleaning kit also works well.

<u>Sharpening the Borer</u>

Sharpening the borer will require a flat sharpening stone, a round sharpening stone, and cleaning oil. Begin by adding a few drops of oil to the flat stone and place the tip of the cutting edge on the stone

at a 45° angle. Move the cutting edge up and down along the stone, while rotating the tip continuously clockwise and counter-clockwise between your fingers. Continue until the cutting edge appears sharp. Next, add a drop of oil to the rounded stone, and insert about three-fourths of the way into the cutting edge hole. Align the stone until it is in contact with the inside wall of the hole. Rotate the borer shaft a few times until sharp.

In general, a borer that is cleaned more often will require sharpening less often, because keeping the cutting edge clean will reduce rust and corrosion. Avoid metal-to-metal contact with the tip of the borer. Such preventative care will keep the borer in better condition for a longer period.

Analyzing Tree Cores

Preparation

Allow cores to air dry outside the plastic bag for 1 or 2 days before attempting to sand. If possible, orient the cores so the xylem vessels are facing vertically. The xylem vessels are small vertical tubes in the wood that are important for water transport along the stem, and appear as small oval to circular-shaped holes in the core. Sand the core by hand using progressively finer grits, finishing with at least a 320 grit. Dampen a paper cloth with water and rub along the length of the core in order to remove the sawdust clogging the vesicles. As an alternative, buffing the core with a lamb's wool pad may achieve the same result.

Distinguishing rings can be particularly difficult for diffuse-porous hardwoods (especially aspens). Several staining methods are available, though they vary in effectiveness and some involve using hazardous chemicals. Fehling's Solution, which is a solution of copper sulfate, potassium sodium tartrate, and sodium hydroxide, is a common staining option for distinguishing between heartwood and sapwood, but may not help distinguish early and late wood within rings (Asherin and Mata 2001). Fluorescent markers may help distinguish early and late wood, especially if a black light is available. Phloroglucinol may be most effective but is also most hazardous, as the process involves soaking the core in 50% HCl solution (Maeglin 1979).

Reading

Rings can be counted using a 10x dissecting microscope. The use of a dissecting needle is beneficial for keeping track of counted rings.

Because specific annual rings are not being assigned specific years, and because only living trees are being cored, the process of cross dating is not necessary for the purpose of this SOP. Simple ring counting will generally provide a reasonably accurate stand age. QA/QC procedures should be implemented in order to assess the reliability of ring counts, such that a random sample of 10% of the cores should be counted by a second person. QA/QC counts that are within 5% of the original count are considered acceptable.

In some situations, the core may not include the pith of the tree, either because the core was too short, or because it was taken at an improper angle. If a core was taken at an improper angle, and the arcs of the inner rings are visible, it may be possible to estimate the distance to the missing pith and estimate the number of missing rings. There are numerous geometric and graphical methods for

achieving this estimation. A pith locator designed by Applequist (1958) is a commonly used method, particularly for research designed to simply determine general stand age. At the risk of being slightly less precise than other methods, a pith locator is far more time efficient while still giving a good estimate of the missing number of rings.

The pith locator is designed as a series of concentric half-circles of various widths that are printed on transparent film (Figure S14.2). For example, circles can be arranged every 1mm, 2mm, 3mm, etc. To use, match one of the half-circles with the ring width of the inner arc of the core. Superimpose the locator over a similar ring on the core, so that multiple rings match. When an adequate match is found, the location of the pith is indicated, and the number of missing rings can be easily counted. This method assumes a constant growth rate between the rings near the center of the pith and the missing rings at the pith. If the 10 innermost rings near the center of the pith are not roughly equal in thickness, then this method will be less accurate.

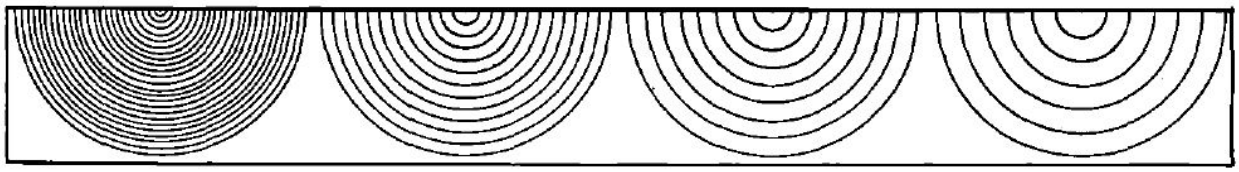


Figure S14.2. Example of a pith locator from Applequist 1958.

References

Applequist, M. B. "A simple pith locator for use with off-center increment cores." Journal of Forestry 56.2 (1958): 141.

Asherin, Lance A., and Stephen A. Mata. "Basic tree-ring sample preparation techniques for aging aspen." Sustaining Aspen in Western Landscapes, Proceedings RMRS-P-18. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO (2001): 347-351.

Maeglin, R.R. 1979. Increment Cores: How to collect, handle and use them. U.S. Department of Agriculture Forest Service General Technical Report FPL-25. http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr25.pdf

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
1.0	March 2014	Patrick Curtin Jesse Wheeler Kate Miller	New SOP	

SOP 14 – Limiting Exotic Species Transport (LEST)

Mid-Atlantic Network/ Northeast Temperate Network

Version 1.0

Overview

This SOP provides instructions for cleaning clothing and field equipment in order to limit the spread of exotic species by the vegetation monitoring crew members. The introduction and spread of exotic insects, diseases, and plants is a serious threat to the parks' vegetation and other natural resources. Therefore, crew members shall be responsible for taking reasonable actions to limit the spread of exotic species between plots and especially between parks.

When to Implement LEST

The crew is always encouraged to limit species transport in the parks, but certain situations will require following the LEST protocol. These situations include:

- Any time an early detection species is encountered that is setting seed or has probably set seed in previous years.
- After leaving a site with any abundant invasive species that is currently dispersing seed.
- Before leaving a park, boots and equipment must be cleaned and clothing must be washed before starting work at a new park.
- Before the start of the work week, if one has been hiking in other places over the weekend.

Materials Needed

- 5-gallon drywall bucket
- Wire brushes
- Coarse fibered brushes

These materials will be stored in the field vehicle for use after visiting a site where exotic species or their propagules were present.

Removing Exotic Species

After leaving a site that requires following LEST protocol, the crew shall return to the vehicle and remove the 5-gallon drywall bucket. Use the coarse fibered brush to brush any seeds off of pants and boots and into the bucket. Remove any material that is stuck in treads of boots with the wire brushes and drop it into the bucket. It may be necessary to unlace and clean out seeds that are trapped under boot laces.

Field equipment that is contaminated should also be cleaned into the bucket using the brushes. Equipment that needs to be cleaned includes, but is not limited to: packs, soil trowel, DBH tape, and any other potentially contaminated equipment.

The contents of the bucket should be placed into a plastic bag and thrown into the trash. If large quantities of material are being collected in the bucket, the crew should investigate safe manners in which to burn the material once it is dried.

If there is a possibility that a forest pest or pathogen that is not already widespread within the park has been in contact with your clothing, your clothes must be washed at the end of the day.

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 2014	Doug Manning	Initial version. Adopted from ISED Protocol	.

SOP 15 - Landscape Context

Mid-Atlantic Network/ Northeast Temperate Network

Version 3.05

Overview

This SOP describes procedures for calculating landscape context metrics. These landscape metrics are indicative of the influence of adjacent landuse and stressors on the ecological condition of the plot. Change over time will be monitored using Digital Orthophoto Quarter-Quadrangles (DOQQs) or alternatively the USGS National Land Cover Database.

This SOP is specific to the landscape condition of forested plots; the Northeast Temperate Network (NETN) will develop metrics for overall Landscape Dynamics as a separate protocol. However, it may be most efficient to bundle an analysis of forest plot landscape condition together with the large Landscape Dynamics analysis.

Sources of Spatial Data

Vegetation maps of NETN parks are being developed as one of the Inventory and Monitoring (IM) base inventories by the U.S. Geological Survey (USGS)/NPS Vegetation Mapping Program (http://biology.usgs.gov/npsveg/) and distributed in digital and paper format. These maps will show National Vegetation Classification (NVC) vegetation communities within and surrounding each park using a minimum mapping unit of 0.5 ha. The NVC polygons can be grouped to show NatureServe Ecological Systems. These maps also designate human land use and cultural vegetation areas to standard land use/land cover (LUC) classification Level II.

While these USGS/NPS Vegetation maps provide a useful starting point for analysis, new spatial data will be needed for reassessment of landscape metrics. NETN should monitor change over time by periodically acquiring and analyzing high-resolution Digital Orthophoto Quarter-Quadrangles (DOQQs)—digital images of aerial photographs that have been rectified to remove distortion from terrain and filming. A standard DOQQ is a grayscale or color-infrared image with 1-meter ground resolution, covering an area 3.75’ longitude by 3.75’ latitude—an area equivalent to one-quarter of a USGS quadrangle—plus 50 to 300 meters additional edge to facilitate mosaicing of adjacent images. DOQQs should be referenced to the North American Datum of 1983 (NAD83) and cast on the Universal Transverse Mercator (UTM) projection. For this analysis, we recommend color infrared images be used, and that imagery be photographed during the growing season when leaves are on trees.

Every 10 years, NETN should acquire recent (< 5 years old) DOQQs. High resolution DOQQs may be available from the 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/). If updated DOQQs photographed during the growing season are not available from these sources every 10 years, NETN may need to contract to have DOQQs created.

Acquisition of DOQQs should be done in conjunction with NETNs Landscape Dynamics protocol.If DOQQs are unavailable, it may be possible to use the USGS National Land Cover Database (NLCD) for some analysis. In addition, periodically updated digital spatial data showing the location of roads, carriage roads and trails will be needed. These data can be acquired directly from the parks in some cases. For parks that do not maintain GIS data, road data should be available from state GIS clearinghouses.

Spatial Analysis

The forest patch size analysis is performed at the scale of the park, while the anthropogenic land use analysis is performed separately for each plot. This analysis will be performed only on forest plots that have already been established, and not the pre-selected plot locations. Spatial analysis should be performed using ArcGIS 9.x, FRAGSTATS, or a program with similar capabilities. It may not be possible to identify woodland patches and neighborhood cover for woodland plots using DOQQs; however, woodland plots only occur at ACAD and are a small percentage of total plots there.

Forest Patch Size

Calculate average size in hectares of the forested patches within each park as described below. When patches extend beyond the park boundary, use the actual area rather than clipping patches to the park boundary. Patch size should be digitized at the 1:6,000 scale or finer, and patch size should be at least 0.5 ha.

Step 1: Identifying a Patch

For this analysis, a patch is considered to be an area of continuous medium to high-canopy (≥ 8 m height) forest vegetation or plantation. The area should have at least 60% canopy closure overall to qualify as forest rather than woodland. Examine recent DOQQs and establish polygons representing continuous patches of forest vegetation including plantations. Adjacent natural areas lacking forest (e.g., shrub wetlands or early successional areas, open woodlands) are not included. It may be helpful to first delineate the patch at a broader scale, such as 1:8,000. Once patch is delineated, zoom in to a finer scale (1:6,000 or finer) to check that the polygon is accurate.

NOTE: "Continuous" forest or plantation vegetation still needs to be defined. As a first cut, if two regions are separated by more than 30 m, with a connecting corridor less than 30 m, they may be separate patches (among other things, this would be simple to implement in FRAGSTATS with the NLCD). The literature should be consulted regarding how far "edge" typically extends into a forest patch to help make this judgment call. Another option would be to use a visible break in the orthophotography (for any feature, not just roads). For a narrow or small connection, we still need a defined breakpoint—30 m or 50 m width may be too low.

Step 2: Roads as Breaks

Roads wide enough to register on orthophotography as a visible break in the tree canopy present a barrier to many organisms living within a forested patch. Overlay road data upon polygons created in Step 1, and compare road data with aerial photography to identify areas where roads cause a break in the tree canopy. Bisect polygons along these breaks accordingly.

Step 3: Record Area

Record the size to the nearest 1/10 hectare of each forest polygon in the park, and calculate the average polygon area.

Alternative Calculation Method

An alternative calculation method based on the NLCD would use FRAGSTATS to calculate the average area of forested patches within the park.

- Prepare the layer by reclassifying forest habitat types so that they all have the same value (1), and classifying all other types to a different value (0).
- Clip the NLCD to the park (taking care to include forested patches that extend beyond the park boundary; this will require digitizing an appropriate boundary to use in the clipping operation).
- Rasterize the park roads layer, assigning roads a value of 0 and the rest of the grid a value of 1.
- Multiply the road and modified NLCD layers (forest will retain a value of 1, and roads will be assigned a value of 0, while non-forest remains 0).
- Calculate patch area statistics using FRAGSTATS.

Neighborhood Anthropogenic Land Use

Calculate the percentage of anthropogenic land use found in the specified buffer (Table S16.1) surrounding each plot center. Examine recent DOQQs to determine presence of recognizable anthropogenic land use on a pixel-by-pixel basis or delineated polygon basis within this circle. Polygons should be delineated at the 1:6,000 scale or finer.

Table S16.1. Buffer radius for neighborhood anthropogenic land use calculations for each park.

Park	Buffer (m)
ACAD	400
ELRO/HOFR	200
MABI	200
MIMA	200
MORR	200
SAGA	100
SARA	200
WEFA	100
VAMA	100

Plantations of exotic species and active agricultural lands should be considered anthropogenic land use. Designation of native species plantations and early-successional areas should consider current management; actively managed areas (e.g., mowed fields, new plantations) should be considered anthropogenic land use, but areas which are no longer actively managed (e.g., old fields, older, unmanaged native plantations) should be considered natural land use.

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
1.01	Sept 2006	Geri Tierney Brian Mitchell	Minor text edits	To reflect larger changes to overall protocol.
1.02	Dec 2006	Geri Tierney Brian Mitchell	Included possibility of using USGS NLCD if DOQQs are unavailable. Changed interior forest patch size to forest patch size (unbuffered).	
2.00	June 2007	Brian Mitchell Geri Tierney	Adjusted rule for determining if polygon is bisected by road. Adjusted size of window for neighborhood landuse calculations. Clarified height and closure criteria for closed canopy forest. Clarified anthropogenic landuse status of exotic plantations and agricultural fields.	
2.01	August 2007	Brian Mitchell Geri Tierney	Clarified natural landuse status of native plantations and early-successional areas.	
3.00	May 2008	Geri Tierney Kate Miller Brian Mitchell	Changed the forest patch size metric, and included methods for calculating this metric based on DOQ's and based on the NLCD (using FRAGSTATS).	The original metric (area of patch that plot resides in) was subject to positive bias due to multiple plots occurring in the same large patch. For example, if there is a 1,000 and a 100 ha patch in a park, with 10 plots in the first patch and one in the second, average patch size was 918 ha using the original metric. The new metric will produce an average patch size of 550 ha.
3.01	Jan 2009	Kate Miller Jim Comiskey Brian Mitchell	Removed reference to ArcView GIS. Added note about the need for criteria to assess "continuous" cover. Clarified this analysis will be done every 10 years Added NAIP as source of DOQQS.	
3.02	April 2009	Kate Miller	Clarified that the spatial analysis will only take place on plots that have already been established. Minor editorial changes.	
3.03	May 2009	Sarah Lupis Kozlowski	Minor editorial changes.	Conform to NPS standards.
3.04	Oct 2010	Kate Miller Jesse Wheeler	Clarified that polygons be digitized at 1:6,000 or finer scale Clarified that the minimum patch size is 0.5ha. Added that it may be useful to digitize at a coarser scale, then to check at 1:6,000 or finer. Added table of buffer distances to match EI metric calculations	
3.05	March 2014	Kate Miller	Changed SOP number; added MIDN to SOP	

SOP 16 - Analyzing and Reporting Ecological Integrity

Northeast Temperate Network

Version 3.11

Overview

This SOP describes how ecological integrity is assessed and reported from field data collected by the NETN forest protocol. NETN will use data, models and expert opinion from the scientific literature to evaluate levels of ecological integrity as “Good”, “Caution” or “Significant concern” for specific metrics of forest structure, composition and function based on assessment points derived from natural or historic ranges of variation for each metric. The interpretation of ecological integrity is a useful but developing conservation application, and ratings should be reviewed and updated as new information becomes available. A scorecard format will be used to clearly and concisely report the integrity of NETN forests to multiple audiences including park managers and decision-makers.

Ecological Integrity

The concept of “ecological integrity” is increasingly being used as a measuring tool to assess the state of ecosystems and the effectiveness of land management actions upon those ecosystems. Building upon the related concepts of biological integrity and ecological health, ecological integrity is a broader and more useful conceptual endpoint for ecological assessment and reporting (Czech 2004). “Integrity” is defined as the quality of being unimpaired, sound, whole or complete. To have integrity, an ecosystem should be relatively unimpaired and complete across a range of characteristics and scales (DeLeo and Levin 1997). “Ecological integrity” has been defined as a measure of the composition, structure and function of an ecosystem in relation to the system’s natural or historical range of variation and the perturbations imposed upon it by natural or anthropogenic agents of change (Karr and Dudley 1981, Parrish et al. 2003).

Assessment of ecological integrity is a challenging undertaking (NAS 2000). One promising approach builds upon the well-known Index of Biological Integrity (IBI). The original IBI interpreted stream integrity from twelve metrics reflecting the health, reproduction, composition and abundance of fish species (Karr 1981). Each metric was rated by comparing measured values with values expected under relatively unimpaired conditions, and the ratings were aggregated into a total score. Related biotic indices have sought to assess the integrity of other aquatic and wetland ecosystems primarily using faunal assemblages. Building upon this foundation, others have suggested interpreting the ecological integrity of ecosystems by developing suites of indicators or metrics comprising key biological, physical and functional attributes of those ecosystems (Andreasen et al. 2001). The Nature Conservancy has developed this approach into a framework for measuring conservation effectiveness upon targeted ecosystems (Parrish et al. 2003). This approach is well-suited to the needs of the NPS Vital Signs Monitoring Program, which seeks to improve understanding of the condition of park ecosystems by monitoring the status and trends of a selected group of indicators.

Selecting Metrics

The first step in determining ecological integrity is identifying a limited number of key attributes or metrics of an ecosystem that best distinguish a highly impacted, degraded or depauperate state from a relatively unimpaired, complete and functioning state. Key attributes may be properties that typify a particular ecosystem (Keddy and Drummond 1996, Parrish et al. 2003) or attributes that change predictably in response to anthropogenic stress (Karr and Chu 1999). The suite of attributes selected should be comprehensive enough to incorporate composition, structure and function of an ecosystem across a range of spatial scales (Andreasen et al. 2001).

A conceptual ecological model delineating linkages between key ecosystem attributes and known stressors or agents of change is a useful tool in identifying and interpreting metrics. NETN developed a simple conceptual model identifying important stressors and agents of change acting upon terrestrial ecosystems in NETN parks, and identifying key attributes of these systems. This model is presented within the Conceptual Ecological Model Appendix of the NETN Vital Signs Monitoring Plan (Mitchell et al. 2006). Key stressors acting upon NETN forested ecosystems include climate change, atmospheric deposition, ozone pollution, invasive exotic species including forest pests and pathogens, overbrowsing by white-tailed deer (*Odocoileus virginianus*), landscape change including fragmentation, visitor use, and on-site land management including agriculture and silviculture. Justification for the selection of each metric is included below within the Metrics and Ratings section.

Rating Metrics

A second step in determining ecological integrity is determining assessment points for each metric that distinguish acceptable or expected conditions from undesired conditions which warrant concern, further evaluation or management action (Bennetts et al. 2007). Assessment points for rating ecological integrity will be 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 recognizing the inherent natural variation in ecosystems across space, time, and stages of ecological succession (Landres 1999).

Of course, current knowledge of historic or natural conditions is limited. Insight into natural or historic conditions comes from historical studies and records, paleoecological reconstructions of past conditions, current studies of relatively pristine ecosystems, and efforts to model ecosystem dynamics. While all these efforts provide useful insight, our understanding of historic or natural conditions in many ecosystems relies on a limited number of key studies, and care must be taken when applying data from these studies to other sites. For these reasons, ratings should be reviewed and updated as our knowledge of the historic or natural variation and ecosystem response to perturbation increases over time.

Following the NPS national Vital Signs rating system, three ratings are used – Good, Caution and Significant Concern. “Good” represents acceptable or expected conditions; “Caution” indicates a problem may exist; “Significant Concern” indicates undesired conditions that may need management correction. For several metrics, we have not defined conditions that merit “Significant Concern” because current knowledge is insufficient to justify this rating.

Scorecard

NETN will use a 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 stake-holders (Harwell et al. 1999).

We have developed a scorecard reporting framework to visually convey status and trends in each metric of forest integrity using the NPS "stoplight" symbology. This symbology uses color to convey integrity rating—Good, Caution and Significant Concern are conveyed respectively as green, yellow or red circles—and uses an embedded arrow to convey the direction of trend observed across sampling intervals (increasing, stable or decreasing). For transparency, actual data values will be reported in addition to ratings. An example Forest Integrity Scorecard based on data collected in 2005 is shown in Appendix D.

Some ecological integrity reporting efforts have developed simple or elaborate point-based indexes to aggregate information describing integrity of individual metrics into overall scores for the ecosystem (Karr 1981). Successful aggregation of individual metrics will require an understanding of the relative importance of individual metrics in determining the overall integrity of an ecosystem. Such an approach relies on a subjective understanding of what is important in a particular ecosystem, and can unintentionally "hide" information about ecosystem components in need of attention. This forest scorecard attempts to concisely convey information on each individual metric, and provide summary information only on the number of metrics classified as good, caution and significant concern in each park. We recognize that NPS will need to aggregate this information at higher levels (such as by Vital Sign) for reporting at the national level. For that reason, this scorecard adheres to NPS Vital Signs reporting conventions, and should provide NPS with the necessary information for aggregation.

Metrics and Ratings

Metrics and ratings are summarized in Table S17.1. The text that follows provides an overview, justification, calculation description, scaling rationale, and suggested level of confidence for each metric. Throughout this SOP, we define "tree" as any woody stem greater than 10 cm diameter at breast height (1.37 m); if an individual woody plant forks below 1.37 m and both stems are greater than 10 cm diameter, they are tallied as two separate trees. This definition is similar to the one used by the U.S. Forest Service's Forest Inventory and Analysis (FIA) program, and will facilitate comparisons with FIA data.

Table S17.1. 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 landuse	< 10%	10-40%	>40%
Structure	Structural stage	≥ 70% (MABI, SAGA), 50% (ACAD), and 25% (MIMA, MORR, ROVA, SARA and WEFA) late-successional structure	< 70% (MABI, SAGA), 50% (ACAD), and 25% (MIMA, MORR, ROVA, SARA and WEFA) late-successional structure	< 70% (MABI, SAGA), 50% (ACAD), and 25% (MIMA, MORR, ROVA, SARA and WEFA) combined mature *and* late-successional structure
	Snag abundance	≥ 10% standing trees are snags and ≥10% med-lg trees are snags[1]	< 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[2]
	Tree condition	Foliage problem < 10% *and* no priority 1 or 2 pests[3] *and* BBD ≤ 2	Foliage problem 10-50% *or* priority 2 pest *or* BBD > 2	Foliage problem >50% *or* priority 1 pest
	Biotic homogenization	No change	Increasing homogenization	
	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	Decrease in frequency of most browsed species *and* increase in frequency of browse-avoided species
Function	Tree growth and mortality rates	Growth ≥ 60% mean *and* Mort ≤ 1.6%	Growth < 60% mean *or* Mort > 1.6%	
	Soil chemistry: acid stress	Soil Ca:Al ratio > 4	Soil Ca:Al ratio 1-4	Soil Ca:Al ratio < 1
	Soil chemistry: nitrogen saturation	Soil C:N ratio > 25	Soil C:N ratio 20-25	Soil C:N ratio < 20

[1] Med-lg trees are ≥ 30 cm diameter-at-breast-height.

[2] Tree regeneration stocking index varies by park.

[3] Priority 1 pests are Asian long-horned beetle, hemlock woolly adelgid, emerald ash borer and sudden oak death. Priority 2 pests are balsam woolly adelgid, butternut canker, elongate hemlock scale, and beach bark disease (BBD).

Forest Patch Size

Overview

Forested areas in the northeastern U.S. exist within a matrix of managed, rural, and suburban habitat that limits the ability of species to freely forage, interbreed and disperse, and that creates “edge” habitats which differ from forest interior in environmental conditions, structure, composition and disturbance.

Metric Justification

A large and growing body of scientific literature documents the negative impacts of habitat fragmentation on biodiversity in a wide variety of ecological systems (Fahrig 2003). The impacts of fragmentation have been especially well documented upon avian communities, and population declines of a variety of forest interior avian species are linked to habitat fragmentation (Austen et al. 2001, Boulinier et al. 2001). In general, large forest patches tend to support larger populations of fauna and more native, specialist, and forest interior species (Harris 1984, Forman 1995).

Calculation and Scaling Rationale

Average forested patch size for each park is calculated in hectares using GIS as described in SOP 16 - Landscape Context.

Kennedy et al. (2003) reviewed the literature on minimum patch area for a variety of taxa and found minimum patch areas ranged up to 1 hectare for invertebrates, up to 10 hectares for small mammals, up to 50 hectares for the majority (75%) of birds species, and up to over 200,000 ha for large mammals. The relatively small parks for which this protocol was designed cannot independently support large mammal populations, thus our ratings are based on the needs of birds, small mammals and invertebrates. In other areas, it will be necessary to consider the needs of large mammals which require substantially larger forest patches.

Good: More than 50 hectares.

Caution: 10-50 hectares.

Sig. concern: Less than 10 hectares

Confidence

Medium. While patch size and fragmentation impacts on particular species have been well documented, developing an overall rating for an ecosystem or group of ecosystems is more complex, and may be refined over time.

Anthropogenic Land Use

Overview

This metric assesses the percentage of land in anthropogenic versus natural land use in the local or immediate neighborhood surrounding each forest or woodland plot.

Metric Justification

Habitat loss and fragmentation have synergistic, cumulative impacts upon remaining natural areas. As habitat is lost, the remaining fragments become more important to wildlife populations, and are

more likely to be isolated and impacted by surrounding anthropogenic land use. The Heinz Center (2002) calculated similar neighborhood statistics on immediate (2 ha), local (65 ha) and larger neighborhoods (5,000 ha).

Calculation and Scaling Rationale

We will use GIS to calculate the percentage of anthropogenic versus natural landuse within the local or immediate neighborhood surrounding each plot, as defined below. Northeast Temperate Network parks vary substantially in size, and the "neighborhood" considered will be scaled to park size. For ACAD (>14,000 ha. in size), the neighborhood analyzed will be a 400-m radius circle (equivalent to about 50 ha.). For NHP greater than 100 ha in size (i.e., MABI, MIMA, MORR, ELRO/HOFR, SARA), the neighborhood will be a 200-m radius circle (equivalent to about 12.5 ha). For NHPs less than 100 ha in size (i.e., SAGA, VAMA and WEFA), the neighborhood analyzed will be a 100-m radius circle (equivalent to about 3 ha.). Plantations of native species will be considered natural land use, while plantations of primarily exotic species will be considered anthropogenic land use. Likewise, mowed fields will be considered anthropogenic land use. See SOP 16 - Landscape Context for additional details on calculation.

Theoretical models offer a framework for assessing the combined impacts of habitat loss and fragmentation. Simulations show a marked increase in the likelihood of continuous habitat existing in a landscape that has more than 60% natural cover (McIntyre and Hobbs 1999, O'Neill et al. 1997).

Good: Less than 10% anthropogenic land use.

Caution: 10-40% anthropogenic land use.

Sig. concern: More than 40% anthropogenic land use.

Confidence

Medium.

Structural Stage Distribution

Overview

This metric assesses the structural stage distribution of forest plots in relation to the expected distribution under natural disturbance regimes. It provides an indicator of altered disturbance regimes, and habitat availability for species dependent on specific structural stages. Structural stage is calculated from tree size and canopy position measurements in forested plots, and distribution is assessed at the level of the park.

Metric Justification

At landscape scales, forest structural stage affects the maintenance of biological diversity, particularly of species dependent upon specific structural stages. As multiple stressors including global change and exotic pest and pathogen outbreaks alter disturbance regimes (Dale et al. 2001), structural stage distributions are likely to shift.

Calculation and Scaling Rationale

Structural stage distribution is assessed for each park based on calculations from canopy trees in forested plots (woodlands are excluded). We use a method similar to that of Frelich and Lorimer (1991) but substitute basal area for exposed crown area (Goodell and Faber-Langendoen 2007). Plots are classified as pole, mature, late-successional stage or mosaic based on relative basal area of live canopy trees within pole, mature and large size classes. For the NHPs, size classes are 10-25.9 cm DBH (pole), 26-45.9 cm DBH (mature) and ≥ 46 cm DBH (large). Dominant trees of coastal Maine (balsam fir and red spruce) are typically smaller in size than dominant trees at the NHPs, and ACAD size classes have been adjusted to be 10-19.9 cm DBH (pole), 20-34.9 cm DBH (mature), and ≥ 35 cm DBH (large).

To calculate this metric, first exclude all woodland plots (treed areas with open or patchy tree cover ≤60%). Woodland associations occur at ACAD and may be dominated by jack pine (*Pinus banksiana*), pitch pine (*P. rigida*), northern red oak (*Quercus rubra*), red spruce (*Picea rubens*), white cedar (*Thuja occidentalis*), and/or aspen-birch (*Populus* spp.-*Betula* spp.) (Lubinski et al. 2003). Woodland plots are classified onsite (stand structure = 6). However, woodland plots are not always recognized by field crews. Thus, plots at ACAD with canopy closure ≤ 50 % (code 1, 2 or 3) and dominated by one of the woodland species noted above are likely to be woodland plots. These plots should be verified as forest or woodland during remeasurement; in the meanwhile they are removed from this analysis.

Next, calculate basal area (*BA* in m^2) for each live canopy tree in a forest plot from DBH (diameter-at-breast-height in cm) using the formula below. Canopy trees are identified onsite (i.e., dominant, sub-dominant or intermediate crown class). Open-grown, sub-canopy, and gap-exploiter trees are not used in this calculation. Trees within the open-grown crowns are excluded to avoid mis-interpreting early-successional plots dominated by a few, large open-grown trees as late-successional. However, open-grown trees in early successional or mosaic plots sometimes are mis-classified onsite as "dominant." Thus, it is useful to compare categorization using these calculations with stand structure classifications made onsite.

$$BA = \pi * \left(\frac{dbh}{2*100} \right)^2$$

Next, relative basal area per size class is calculated for the plot by summing the BA of canopy trees within each DBH size class (pole, mature and large as defined above), and then dividing by the total basal area of the plot. Structural stage is assigned to the plot based on the relative basal area distribution as follows:

Pole stage: ≥ 67% BA in pole plus mature sizes, with more basal area in pole than mature size.

Mature stage: ≥ 67% BA in pole plus mature sizes, with more basal area in mature than pole size or ≥ 67% in mature plus large size, with more basal area in mature than large size.

Late-successional stage: ≥ 67% BA in mature plus large sizes, with more basal area in large than mature size.

Mosaic: Any plot not meeting the above criteria.

Frelich and Lorimer (1991) and Lorimer and White (2003) have compiled data and modeled the distribution of old growth stands under natural disturbance regimes for several northeastern forest ecosystems. Northern hardwood and hemlock hardwood forests historically experienced low frequency of natural disturbance (dominated by windstorms) and 70-90% of stands across the landscape are estimated to have historically existed as late-successional. Upland and montane spruce-hardwood forests of northern New England and the Adirondacks may have had similar historical late-successional landscape distribution to northern hardwoods, estimated as 75-80% of stands as late-successional. However, the swamp, flatland and rocky spruce-hardwood forests typical of coastal Maine are more susceptible to coastal storms, windthrow, fire and other disturbances, and only 50% of stands may have existed as late-successional. Less data are available describing oak-hickory forests, but Lorimer and White (2003) suggest that multi-cohort stands may have occupied 25-40% of the landscape. The overall park rating is interpreted from ratings of dominant ecosystems in the park.

Ratings are assigned to each park using assessment points based on the matrix forest ecosystem at each park (Acadian Low-Elevation Spruce-Fir-Hardwood Forest at ACAD; both Appalachian Hemlock-Northern Hardwood Forest and Laurentian-Acadian Northern Hardwood Forest at MABI; Appalachian Hemlock-Northern Hardwood Forest at SAGA; both Appalachian Hemlock-Northern Hardwood Forest and Northeastern Interior Dry-Mesic Oak Forest at ROVA and SARA; and Northeastern Interior Dry-Mesic Oak Forest at MIMA, MORR, and WEFA. At parks with more than one matrix forest ecosystem type, assessment points are based on the type with lower late-successional structure.

Good: At least 70% (MABI, SAGA), 50% (ACAD), and 25% (MIMA, MORR, ROVA, SARA and WEFA) late-successional structure across the park

Caution: Less than 70% (MABI, SAGA), 50% (ACAD), and 25% (MIMA, MORR, ROVA, SARA and WEFA) late-successional structure across the park

Sig. concern: Less than 70% (MABI, SAGA), 50% (ACAD), and 25% (MIMA, MORR, ROVA, SARA and WEFA) combined mature and late-successional structure across the park

Note: Consider adding sapling/seedling or "small" stands to metric calculation to reflect overall distribution of structural stages across the park.

Confidence

Medium. Metric can be fine-tuned over time as more data become available.

Snags and Coarse Woody Debris

Overview

Dead wood, in the form of standing dead trees (snags) and fallen coarse woody debris (CWD), is an important structural feature of forest stands that provides habitat for wildlife and fungi. This metric assesses the density of snags and volume of CWD in relationship to live tree density and volume. Since NETN plots are not designed to pick up rare features such as snags, snag abundance should be evaluated at the scale of the park only.

Metric Justification

Snags and CWD provide important habitat for arthropods, herptiles, birds, small mammals and fungi. Snags are particularly important for cavity-nesting birds, and the density and size of snags is indicative of habitat availability for those species (Zarnowitz and Manuwal 1985, Schreiber and deCalesta 1992). Coarse woody debris is particularly important for herptiles and small mammals (DeGraaf and Rudis 1986, Petranka et al. 1994). Coarse woody debris continues to be used by wildlife as it breaks into smaller pieces over time, thus CWD volume can be a useful indicator of habitat availability. Large diameter snags persist longer than smaller diameter snags (Morrison and Raphael 1993, Garber 2005) and provide habitat for a greater number of vertebrate species (Cline et al. 1980, DeGraaf and Shigo 1985). Silviculture, land management and hazard tree removal can reduce the quantity or quality of these features; however, thoughtful land management can maintain or enhance snags and CWD (Keeton 2006).

Calculation and Scaling Rationale

Density of snags and volume of CWD in mature and late-successional stands varies substantially across ecosystems and with site conditions (Tyrrell et al. 1998). However, positive relationships between live and dead tree density and volume can be used to indicate expected snag and CWD levels (Sippola et al. 1998, Ferugson and Archibald 2002, Stewart et al. 2003).

For snags, Nillson et al. (2003) have calculated a ratio of 1:9 standing dead:live trees for the boreal forest, while Ferguson found about 15% of standing trees were dead in the boreal forest. Goodburn and Lorimer (1998) report that 11% and 16% of standing trees were dead, respectively in Michigan/Wisconsin northern hardwood and hemlock northern hardwood stands. Since larger diameter snags tend to persist longer than smaller diameter snags (Garber 2005) and some studies report snag diameter distributions in late-successional stands which meet or exceed live tree diameter distributions (Goodburn and Lorimer 1998, Spetich et al. 1999, Nilsson et al. 2003), we can expect that these relationships should hold for large snags. Thus we can suggest both overall (>10 cm DBH) and medium-large (≥ 30 cm DBH) snag density should be at least 10% of overall and medium-large live tree density.

To develop a minimum snag density requirement, we reviewed recommendations based on land management and wildlife needs. The USFS recommends 5-10 medium or large (≥ 30 cm DBH) snags per hectare on some Wisconsin and Michigan national forests (USFS 1980). Keddy and Drummond (1996) suggest at least 4 large (> 50 cm) snags per 10 hectares for temperate deciduous forest. Other recommendations range from 0.35 to 2.5 large (> 45 cm) snags per hectare to support

wildlife (Tubbs et al. 1987). These recommendations suggest a minimum of at least five medium or large snags per hectare.

To calculate snag density, the number of snags within a plot is summed, and converted to a per hectare basis as:

$$\frac{Snags}{Plot\_size}$$

where *Snags* is the number of snags in a plot and *Plot_size* is the plot size in hectares (0.0225 or 0.04, respectively, for a 15-m or 20-m square plot). For snags:

Good: At least 10% of all standing trees in a park or group of plots are snags and at least 10% of all medium-large (≥ 30 cm DBH) standing trees in a park or group of plots are snags.

Caution: Less than 10% of standing trees in a park or group of plots are snags or less than 10% of all medium-large (≥ 30 cm DBH) standing trees in a park or group of plots are snags

Sig. concern: Fewer than 5 medium-large snags (≥ 30 cm DBH) per hectare, calculated for the park or a group of plots.

Huber's formula can be used to estimate CWD volume from line intersect transect data using the diameter of each CWD piece measured at the point of intersection with the transect line (Marshall et al. 2000). This formula can be simplified to calculate CWD volume per hectare (m^3/ha) as:

$$\frac{\pi^2}{8 * Horiz\_length} * \sum_i^n Diam_i^2$$

where *Horiz_length* is the horizontal length of the transect in meters and $Diam_i$ is the recorded diameter in centimeters of each piece of coarse woody debris. Please note that conversion factors for length (10,000) and areal units (also 10,000) have canceled out of this simplified equation and thus are not shown.

However, this calculation must be slope-corrected by converting the slope-length of each line intersect transect (15 m) to its equivalent horizontal distance (Van Wagner 1982). Inserting a correction factor into the formula above allows calculation of CWD volume per hectare (m^3/ha) as:

$$CWD = \frac{\pi^2 \sqrt{1 + \left(\frac{\%Slope}{100}\right)^2}}{8 * Slope\_length} * \sum_i^n Diam_i^2$$

where *%Slope* is slope percent of the transect rounded to the nearest 5%, and *Slope_length* is the slope length of the transect in meters (i.e., 15 m). If slope angles are collected rather than slope

percents, slope percent is tan (slope angle)*100. Note that the tan function in Microsoft products uses radians, so a conversion (angle*pi/180) may be needed.

This calculation must be made for each of the three transects in a plot. Then, CWD volume per hectare at each plot is calculated as the average from all three transects in a plot.

For comparison and rating, a simple, conservative estimate of live tree (stem and branches ≥ 10 cm DBH) volume will be made from individual tree measurements and stand height using the geometric formula for a paraboloid. This calculation is conservative because volume from both stem and branches (≥ 10 cm diameter) should exceed paraboloid volume; this will provide additional confidence that ratings of caution or significant concern are warranted. While more nuanced equations exist for calculating stem volume from DBH and height measurements for different species, those equations do not include volume of large branches. Thus, those more complex calculations are unlikely improve accuracy in this case.

Tree volume (v in m^3) is calculated for each *live tree* in the plot as:

$$v = \frac{\left(\pi * DBH^2 * h_c\right)}{80{,}000}$$

where *DBH* is the DBH of the tree (cm), and h_c is an estimate of tree height (m) from stand height adjusted for tree canopy position. For codominant trees, h_c is equivalent to measured stand height. For dominant trees, intermediate and sub-canopy or gap-exploiter trees, respectively, h_c will be estimated as 1.1, 0.8 and 0.5 stand height, respectively. Open-grown trees could potentially be larger or smaller than stand height, so no correction factor will be used.

Volume of all live trees in the stand is then summed and converted to a per hectare basis to yield an estimate of stand volume (V in m^3/ha):

$$V = \frac{\sum_{i=1}^{n} v_i}{plot\_size}$$

where *plot_size* is the plot size in hectares (0.0225 or 0.04, respectively, for a 15-m^2 or 20-m^2 plot).

Volume of dead wood in boreal stands has been reported to range from about 20-40% of total (live and dead) wood volume (Linder et al. 1997, Kuuluvainen et al. 1998, Siitonen et al. 2000, Sippola et al. 1998, Karjalainen and Kuuluvainen 2002), of which about 70% is downed CWD (Siitonen et al. 2000, Sippola et al.1998). Stewart et al. (2003) found dead wood to be 20-28% of live tree volume in late-successional hemlock-spruce-pine and northern hardwood stands, of which about 70% was downed CWD.

Forested systems within NETN parks are relatively young, and may fall short of late-successional CWD and snag benchmarks for some time.

Good: CWD volume > 15% of live tree volume.

Caution: CWD volume is 5-15% of live tree volume.

Sig. concern: CWD volume < 5% of live tree volume.

Confidence
Medium.

Tree Regeneration
Overview
This metric assesses the quantity and composition of advance tree regeneration in the forest understory. Established tree seedlings (>15 cm tall) are quantified by species and size class in three circular 2-m radius microplots (12.57 m^2) per plot. This metric should be used for forest sites only; it has not been adapted for use on woodland sites.

Metric Justification
Shade tolerant forest trees typically regenerate from seedling banks of advance regeneration present in the forest understory prior to disturbance. The quantity and species composition of advance regeneration will impact future canopy structure and composition. Regeneration can be affected by a variety of stressors, including air pollution and climate change. Most notably, sustained, selective browsing by a historically high population of white-tailed deer is currently impacting seedling establishment, growth and composition in parts of the midwest and northeast U.S. (Rooney 2001, Cote et al. 2004). Significant impacts on forest tree regeneration are associated with deer densities ≥ 8.5 per km^2, well above presettlement estimates of 3-4 deer per km^2 in the northeastern U.S. (Russell et al. 2001, Augustine and DeCalesta 2003).

Calculation and Scaling Rationale
In northeast temperate forests, deer selectively browse seedlings of preferred species that are at least 30 cm and less than 75 cm tall (Gill 1992, Kay 1993, Cornett et al. 2000). Sweetapple and Nugent (2004) developed a simple ratio of seedling richness in browsed and unbrowsed size classes to assess ungulate impacts of forest understories. Adapting this approach for NETN forest monitoring, a simple ratio of seedling species richness in heavily browsed size classes (30-100 cm tall) versus shorter size classes (15-30 cm tall) of preferred species will serve as an indicator of impacts on tree regeneration. Browse impacts on tree regeneration vary with species tolerance to browsing, and also with deer browse preference which varies seasonally and regionally. Potential deer browse impacts on northeastern tree species are estimated as High, Medium, Medium/Low and Low in Table S17.2. Most species rated Medium/Low are not preferred, but can be heavily browsed when other choices are not available. Using only species with High to Medium/Low deer impact ratings, the ratio is calculated as:

$$\frac{tall - short}{tall + short}$$

Table S17.2. Potential deer browse impact to northeastern tree species.

Species	Common Name	Potential Deer Impact	Cite[1]	Note
Acer rubrum	red maple	High	2	
Acer saccharum	sugar maple	High	2	
Cornus florida	flowering dogwood	High	1	
Liriodendron tulipifera	tulip poplar	High	2	
Magnolia acuminata	cucumbertree	High	2	
Prunus pensylvanica	pin cherry	High	2	
Sassafras albidum	sassafras	High	1	
Sorbus americana	mountain ash	High	1	
Thuja occidentalis	northern white cedar	High	1	
Tilia americana	basswood	High	1	
Tsuga canadensis	eastern hemlock	High	2	
Betula alleghaniensis	yellow birch	Medium	2	High preference but medium browse tolerance
Betula lenta	black birch	Medium	2	High preference but medium browse tolerance
Carya spp.	Hickories	Medium	2	High preference but medium browse tolerance
Fraxinus spp.	Ashes	Medium	2	High preference but medium browse tolerance
Hamamelis virginiana	witch hazel	Medium	1	
Juglans cinerea	butternut	Medium	1	
Juglans nigra	black walnut	Medium	1	
Nyssa sylvatica	black gum	Medium	3	Sprouts have medium to high palatibility
Quercus spp.	Oaks	Medium	2	High preference but medium browse tolerance
Ulmus spp.	Elm	Medium	1	
Abies balsamea	balsam fir	Medium/Low	1	Low choice but heavily browsed if needed
Acer pensylvanicum	striped maple	Medium/Low	2	Medium preference but high browse tolerance
Fagus grandifolia	American beech	Medium/Low	2	Medium preference but high browse tolerance
Pinus resinosa	red pine	Medium/Low	1	Low choice but heavily browsed if needed
Pinus rigida	pitch pine	Medium/Low	1	Low choice but heavily browsed if needed
Pinus strobus	white pine	Medium/Low	1	Low choice but heavily browsed if needed
Pinus sylvestris	Scotch pine	Medium/Low	1	Low choice but heavily browsed if needed
Alnus spp.	Alder	Low	1	
Betula papyrifera	paper birch	Low	1	
Betula populifolia	gray birch	Low	1	
Carpinus caroliniana	musclewood	Low	1	
Crataegus spp.	Hawthorn	Low	1	
Juniperus virginiana	red cedar	Low	1	

Table S17.2. Potential deer browse impact to northeastern tree species (continued).

Species	Common Name	Potential Deer Impact	Cite*	Note
Larix laricina	tamarack	Low	1	
Ostrya virginiana	hop hornbeam	Low	1	
Picea spp.	Spruces	Low	1	
Populus spp.	Aspens	Low	1	
Prunus serotina	black cherry	Low	2	
Rhamnus cathartica	buckthorn	Low	1	
Robinia pseudoacacia	black locust	Low	1	

[1]1 — New York State Department of Environmental Conservation (NYS DEC). A Preference List of Winter Deer Foods (www.dec.state.ny.us/website/dfwmr/wildlife/deer/foodlist.html); 2 — USFS 2003. Forest Inventory and Analysis. Northeast Field Guide, Version 1.7, App. 12; 3 — USFS Fire Effects Information System tree description. (www.fs.fed.us/database/feis/plants/index.html).

where *tall* and *short* are species richness, respectively, of tall (30-100 cm) and short seedlings (15-30 cm) of browsed species.

While this seedling ratio approach can be useful in detecting moderate impacts due to deer browsing, it will be less effective at detecting severe browsing impacts, which are likely to affect even seedlings < 30 cm tall, as well as impacts on tree regeneration from other stressors, such as air pollution and climate change. An alternative approach by McWilliams et al. (2005) quantifies whether current seedling quantities are sufficient to restock a forest stand with canopy trees. Their index, developed for hardwood stands in Pennsylvania, awards and sums points for seedlings by size class within 2-m radius circular microplots as follows: one point for each seedling 15-30 cm, two points for each seedling 30-100 cm, 20 points for each seedling 100-150 cm, and 50 points for each seedling or sapling > 150 cm tall but less than 10 cm DBH. Only seedlings of native species that typically form the high canopy in northeastern forested sites are counted; this excludes striped maple (*Acer pensylvanicum*), mountain maple (*Acer spicatum*), Allegheny serviceberry (*Amelanchier arborea*), gray birch (*Betula populifolia*), musclewood (*Carpinus caroliniana*), flowering dogwood (*Cornus florida*), hop hornbeam (*Ostrya virginiana*), pin cherry (*Prunus pensylvanica*), chokecherry (*Prunus virginiana*), and black willow (*Salix nigra*), in addition to shrubs such as alders (*Alnus* spp.), hawthorns (*Crataegu*s spp.), witchhazel (*Hamamelis virginiana*), and exotic species such as Norway maple (*Acer platanoides*), glossy buckthorn (*Frangula alnus*), and common buckthorn (*Rhamnus cathartica*).

Good: Seedling ratio ≥ 0.

Caution: Seedling ratio < 0.

Sig. concern: Stocking index < 25 at MORR, ROVA, WEFA; must be refined for other parks.

Confidence

Medium. Metric should be tested and fine-tuned. Many regeneration plots at Acadia NP will have few if any preferred browse species, thus the seedling ratio may not be useful at that park. McWilliams et al. (2005) developed their stocking index for Pennsylvania hardwood stands subject

to harvest, so it must be refined for other NETN systems. NETN will continue to refine this metric so that it effectively monitors deer herbivory in all NETN parks across a broad range of deer herbivory impacts.

Tree Condition

Overview

Qualitative observation of specific tree health problems and canopy foliage condition can provide an early warning indicator of problems or decline in canopy trees of a particular species or region.

Metric Justification

Several exotic pests and pathogens are seriously impacting northeastern forest composition or structure. The hemlock woolly adelgid (Adelges tsugae; HWA) has caused widespread and rapid mortality of hemlock across the eastern U.S. since introduction here in the 1950s, and threatens to rapidly and substantially reduce or eliminate eastern hemlock (Tsuga canadensis) throughout much of its range (Orwig et al. 2002). Hemlock woolly adelgid is currently moving northward into Vermont, New Hampshire and Maine. The elongate hemlock scale (*Fiorinia* externa; EHS) is often found with HWA, and can contribute to increased hemlock mortality rates. The balsam woolly adelgid (*Adelges piceae*; BWA) is another damaging exotic aphid. Introduced in the northeastern U.S. in the early 20th century, this insect has damaged balsam fir in New England and New York, and is decimating Fraser fir (*Abies fraseri*) in the southern Appalachians (Schooley 1976, Smith and Nicholas 2000). An exotic scale insect has caused the widespread occurrence of beech bark disease (BBD) throughout the northeast. Caused by the interaction of this insect and a native fungus, BBD has caused substantial mortality to American beech (*Fagus grandifolia*) throughout the region, though most immature and some mature trees have some resistance to the disease. In areas of high beech mortality, increased sprouting of beech suckers can dramatically alter forest structure (Le Guerrier et al. 2003). Butternut (*Juglans cinerea*) is being killed throughout its range by an exotic fungus that causes butternut canker (BC) (Furnier et al. 1999). Butternut is far less common in NETN forests than hemlock, balsam fir or American beech, but the threat across its native range is still cause for concern. Less destructive but still impacting northeastern forests is the European gypsy moth (*Lymantria dispar*). Repeated outbreaks of this pest can lead to reduced growth rate and some mortality to preferred tree species.

Several other species pose enormous threats if they advance into the region. The Asian longhorned beetle (*Anoplophora glabripennis*;*ALB*) poses an enormous threat to maples (*Acer* spp.) and other species if it spreads from its current documented occurrences in and near New York City (Haack et al. 1997), and more recently, in Worcester, Massachusetts. Likewise, the emerald ash borer (*Agrilus planipennis*; EAB) is of high concern, and has been found in Canada (near the Vermont border), and several mid-Atlantic states. This insect quickly kills all native species of ash (*Fraxinus* spp.), and could have dramatic impacts if it arrives in this region (BenDor et al. 2006). Finally, the fungal pathogen that causes sudden oak death (SOD) could have dramatic impacts on oaks (*Quercus* spp.) and other trees if it spreads across the east coast (Venette and Cohen 2006).

This metric also assesses canopy foliage in canopy trees (e.g., dominant, co-dominant or intermediate crown class). As the season progresses, most trees will develop minor foliage problems (e.g., insect

damage, chlorosis, etc.). However, more extensive damage to canopy foliage is indicative of tree health problems within a species or across a region.

Calculation and Scaling Rationale

Specific tree health problems and the condition of canopy foliage are qualitatively observed. For each tree, the amount of canopy foliage affected by various foliar problems (insect damage, chlorosis, etc.) is visually estimated within broad classes (0-1, 1-10, 10-50, 50-90 and 90-100%). Beech bark disease severity is visually assessed using a four-point scale. To assess EI, specific health problems are tallied per plot, and foliage condition class is averaged across trees in a plot, as well as by species within the plot. Good condition is defined as minor foliage problems averaged across a plot and within individual species (represented by at least two individuals), minor damage from BBD, and no evidence of damage by the other specific invasive exotic pests and pathogens noted. More extensive foliage problems (10-50%), or BBD damage, or evidence of damage by one of several invasive exotic pests and pathogens already widespread in the NETN region (BWA, BC, EHS) indicate cause for concern. Foliage damage above 50% averaged across a stand or within an individual species (represented by at least two individuals) indicates a more serious problem. Likewise, evidence that certain invasive exotic pests and pathogens of high concern for extensive mortality to trees (ALB, EAB, HWA,SOD) have reached NETN forests indicates a significant concern which might still be controlled by management action.

Good: Average foliage problem < 10% <u>and</u> no HWA, BWA, BC, ALB, EAB or SOD <u>and</u> average BBD severity ≤2.

Caution: Average foliage problem 10-50 % for plot or species (represented by at least two trees) <u>or</u> evidence of BWA or BC <u>or</u> average BBD severity > 2.

Sig. concern: Average foliage problem > 50% for plot or species (represented by at least two trees) <u>or</u> evidence of ALB, EAB, HWAor SOD.

Confidence

Medium. New exotic pests and pathogen threats to northeastern forests arise with increasing frequency. This list of key health problems should be regularly reviewed and updated. Seasonal staff will likely recognize some specific health problems (e.g., HWA, BBD) with training, but will be less likely to detect others (e.g., ALB, EAB and SOD). Analysis must consider that foliage damage will typically increase as the field season progresses.

Note: Consider adding sirex woodwasp (*Sirex noctiliobe*) for potential to kill jack pine (*Pinus banksiana*). Currently present in New York, Vermont, and Pennsylvania, this species may be hard to see/identify.

Note: Consider adding Asian gypsy moth (*Lymantria dispar*), a voracious pest of many tree species. This moth is not yet established in the northeastern U.S.

Note: Consider adding winter moth (*Operophtera brumata*), a pest for oaks, maples, American basswood (*Tilia americana*), and ash. This moth is present in Massachusetts and eastern Canada.

Note: Consider using USFS I-PED software for pest detection and identification. Contact is Daniel Twardus, dtwardus@fs.fed.us, 304-285-1545.

Biotic Homogenization

Overview

Biotic homogenization is the process by which regional biodiversity declines over time due to the addition of widespread exotic species as well as the loss of native species (Olden & Rooney 2006). This metric assesses homogenization of forest and woodland biotas by calculating a similarity index.

Metric Justification

Recognition of the extent, magnitude and implications of biotic homogenization due to human activities is growing (Lockwood & McKinney 2001, Olden 2006). Homogenization occurs when regional floras become more similar due to the addition of wide-spread exotic species as well as the extirpation of endemic species. While this process has occurred in the geologic past, most notably when previously separate land masses have become contiguous, activities of modern humans have dramatically increased the rate of biotic homogenization (McKinney & Lockwood 1999). This process is driven both by the spread of invasive exotic species associated with human activity, as well as by physical and environmental habitat modification by humans including landuse and climatic change. Tracking the extent and magnitude of biotic homogenization over time provides a useful metric indicative of the effect anthropogenic change is having upon regional biological diversity.

Calculation and Scaling Rationale

NETN will use a similarity index to compare plant species composition between plots. Among a group of sites, biotic homogenization can be calculated between each site pair as a simple ratio of species present at the two sites over the total species present at either site (Jaccard's Similarity Index; Olden & Poff 2003). Biotic homogenization for the group of sites would then be:

$$BH_1 = \frac{\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \frac{shared_{i,j}}{total_{i,j}}}{n*(n-1)/2}$$

And the change in biotic homogenization between two time periods is:

$$\Delta BH = BH_2 - BH_1$$

Alternatively, species' relative abundance can be included within a more complex similarity metric (Bray-Curtis Distance; Rooney et al. 2004).

We will calculate metrics of similarity both for all species and for native species only, to better understand the causes and implications of change.

NETN will continue to develop this metric, since the approach described here may be too simple, and not sensitive enough to detect increasing biotic homogenization.

Good: No change or decrease in homogeneity.

Caution: Increasing homogeneity.

Confidence

Medium. Metric should be assessed for sensitivity and fine-tuned when trend data are available. NETN may also consider developing additional metrics for understory species dynamics that include plant guilds and species traits.

NOTE: Consider analyzing this metric using G-Test developed by Sarah Johnson and Waller lab at the University of Wisconsin at Madison (Rooney et al. 2004).

Indicator Species—Invasive Exotic Plants

Overview

This metric assesses the presence of key invasive exotic plant species within NETN forested, woodland and successional ecosystems.

Metric Justification

The effects of invasive exotic species on the structure, composition and function of natural systems have become a chief concern of ecologists and land managers over the last 20 years due to the growing number of species successfully exploiting and altering non-native habitats (Drake et al. 1989).

Calculation and Scaling Rationale

Presence of key invasive exotic species (Table S17.3) is inventoried within eight 1-m^2 vegetation quadrats per plot, followed by a 15 minute time-constrained search for additional species within the plot. Additional detections in the microplots and any tree-sized individuals are also included. The average number of key invasive exotic plant species present is summed by plot, then averaged across the park. Indicator species were selected based on the threat they pose as invaders of northeastern forest, woodland and successional habitats, as documented by the Invasive Plant Atlas of New England (IPANE, http://nbii-nin.ciesin.columbia.edu/ipane), the NatureServe Explorer database (http://www.natureserve.org/explorer) or by studies within NETN parks (Ehrenfeld 1999, Greene et al. 2004). Included species are those that may dominate and/or persist under shaded conditions (i.e., in forest or woodland), or that may disrupt succession to forest or woodland. Two species of exotic knapweed (*Centaurea biebersteinii* and *C. jacea*) are not included as indicator species herein because they do not threaten forested or wooded habitats or inhibit succession. However, these and other exotic species of interest may be tracked separately due to their prevalence in early-successional or other habitats at NETN.

Good: Average of less than 0.5 invasive exotic species present per plot.

Caution: Average of 0.5 to < 3.5 invasive exotic species present per plot.

Sig. concern: Average of 3.5 or more key invasive exotic species present per plot.

Table S17.3. Key invasive exotic species of forest, woodland and successional ecosystems in the northeastern U.S.

Latin name	Common name	Habitat
Acer platanoides	Norway maple	Open and forest habitats
Ailanthus altissima	Tree-of-heaven	Edges and successional habitats
Alliaria petiolata	Garlic mustard	Open and forest habitats
Berberis thunbergii	Japanese barberry	Open and forest habitats
Berberis vulgaris	European barberry	Open and wooded habitats
Cardamine impatiens	Narrowleaf bittercress	Open and wooded habitats
Celastrus orbiculata	Oriental bittersweet	Edges and successional habitats
Cynanchum louiseae	Black swallow-wort	Open, successional and wooded habitats
Cynanchum rossicum	European swallow-wort	Open, successional and wooded habitats
Euonymous alatus	Winged burning bush	Open, successional and wooded habitats
Frangula alnus	Glossy buckthorn	Wetland and successional habitats
Ligustrum spp. (obtusifolium, vulgare)	Privet	Successional and forest habitats
Lonicera japonica	Japanese honeysuckle	Edges and successional habitats
Lonicera spp. (morrowii, tatarica, x bella)	Exotic honeysuckles	Open and successional habitats
Luzula luzuloides	Forest woodrush	Open and wooded habitats
Microstegium vimineum	Japanese stiltgrass	Open and forest habitats
Polygonum caespitosum	Oriental ladysthumb	Open and successional habitats
Polygonum cuspidatum	Japanese knotweed	Riparian, open and successional habitats
Rhamnus cathartica	Common buckthorn	Riparian, open and successional habitats
Rhodotypos scandens	Jetbead	Open, successional and wooded habitats
Rosa multiflora	Multiflora rose	Open and successional habitats
Rubus phoenicolasius	Wineberry	Open, successional and wooded habitats

Confidence

Medium. The list of key invasive exotic species should be reviewed and updated periodically by NETN staff and park natural resource managers. NETN may consider using a more comprehensive list of invasive species and may add a metric that looks at relative proportions of native and exotic species and may be adjusted for abundance. It is important to note that the forest vital sign protocol was designed to monitor status and trend of invasive species, and is not appropriate for early detection of new invasions.

Indicator Species—Deer Browse

Overview

This metric assesses the frequency of selected understory species preferred, browsed or avoided by deer to infer severity of deer browse impacts.

Metric Justification

Sustained, selective browsing by a historically high population of white-tailed deer is currently impacting understory species composition in parts of the northeast US (Russell et al. 2001, Cote et al. 2004). Severe impacts on herbaceous species are associated with deer densities $\geq$ 20 per km^2, well above presettlement estimates of 3-4 deer per km^2 (Augustine and DeCalesta 2003). Several studies have attempted to identify indicator plants for deer browse pressure using plant population structure

(Anderson 1994, Webster et al. 2001, Augustine and deCalesta 2003, Rooney and Gross 2003), and relative plant abundance (Balgooyen and Waller 1995, Fletcher et al. 2001).

Following the approach of Balgooyen and Waller (1995), NETN will monitor the frequency of common, highly-visible, herbaceous species preferred or browsed by deer, concentrating on species which have been shown or predicted to be intolerant of deer browsing due to life history traits (Augustine and deCalesta 2003). NETN will also monitor the frequency of species considered unpalatable to deer that have been shown to increase in abundance under heavy deer browse pressure. Frequency will be calculated for each species based on presence or absence in eight herb quads per plot. Selected species are shown in Table S17.4. Canada mayflower (*Maianthemum canadense*) and Jack in the pulpit (*Arisaema triphyllum*) are not included as indicator species because of conflicting results about deer impacts on populations of those species (Balgooyen & Waller 1995, http://www.pitt.edu/~kalisz/Research.html). These species may be included later based on additional evidence that plant population size predictably responds to deer pressure.

Calculation and Scaling Rationale

Frequency of these common species will vary regionally, so ratings will be assigned based on a change in frequency between time periods. Historical park records of species abundance or frequency may be useful in assessing the degree to which deer browse impacts had already occurred prior to the implementation of NETN monitoring. For each park, only species known to occur in that park will be assessed; thus "browse-sensitive species" refers to the species present in that park, not all known browse-sensitive species. For each species recorded within herb quads in the park, successive observations are compared to determine if the species has increased, decreased or remained unchanged in frequency within the park. Frequency will be calculated for each park (or group of plots within a given habitat type) from quad data as:

$$\frac{\#\_quads\_present}{total\_quads}$$

where *#_quads_present* is the number of quadrats in which the species was found and *total_quads* is the total number of quadrats measured in the park or group of plots (i.e., usually 8 times the number of plots).

Good: No decrease in frequency for more than half the browse-sensitive species.

Caution: Decrease in frequency of more than half browse-sensitive species <u>or</u> increase in frequency of browse-avoided species.

Sig. concern: Decrease in frequency of more than half of browsed species <u>and</u> increase in frequency of browse-avoided species.

Table S17.4. Understory indicator species of deer browse pressure in northeastern U.S. forests.

Latin name	Common Name	Deer Preference	Citations
*Ageratina altissima var altissima (*formerly *Eupatorium rugosum)*	White snakeroot	Avoided	Augustine and Jordan 1998
Aralia nudicaulis	Wild sarsaparilla	Preferred	Balgooyen and Waller 1995
Aster divaricatus	White wood aster	Preferred	Williams et al. 2000
Carex spp.	Sedge	Avoided	Williams et al. 2000, Augustine and deCalesta 2003, Horsley et al. 2003
Clintonia borealis	Blue bead lily	Preferred	Balgooyen and Waller 1995
Dennstaedtia punctilobula	Hay-scented fern	Avoided	Horsley et al. 2003
Maianthemum (Smilacina) spp. (racemosum, stellatum)	Canada mayflower and false Solomon's seal	Browsed	Fletcher et al. 2001, Augustine and deCalesta 2003
Polygonatum spp. (biflorum, pubescens)	Smooth Solomon's seal	Browsed	Augustine and deCalesta 2003, Webster et al. 2005, Kraft et al. 2004
Sanguinaria canadensis	Bloodroot	Browsed	Augustine and deCalesta 2003
Thelypteris noveboracensis	New York fern	Avoided	Williams et al. 2000, Horsley et al. 2003
Trillium spp. (cernum, erectum, grandiflorum, undulatum)	Trillium	Preferred	Anderson 1994, Augustine and Frelich 1998, Rooney 2001, Augustine and deCalesta 2003, Webster et al. 2005
Uvularia spp. (grandiflora, perfoliata, sessifolia)	Bellwort	Preferred	Fletcher et al. 2001, Augustine and deCalesta 2003, Webster et al. 2005

Confidence

Medium. While most indicator species have been noted as currently or historically present at most NETN parks, browse-preferred species may be too rare at some parks to detect change over time. Species list may be tested and fine-tuned over time. A more rigorous statistical analysis would be needed to account for the likely lack of independence of quad data within each plot.

Tree Growth and Mortality Rates

Overview

Canopy tree growth and mortality rates provide an integrative, quantitative metric of tree health and vitality. Relative basal area growth rate (% basal area/year) of canopy trees is calculated from repeated bole DBH measurements; annual mortality rate (% stems/year) of canopy trees is calculated from repeated observation. Rates will be calculated only on canopy trees in stands that have succeeded to a mature or late-successional stage as defined by the structural stage metric described earlier in this document. Rates in parks will be compared to regional and species means from the larger FIA dataset.

Metric Justification

Tree growth rates can decline in response to environmental factors or anthropogenic stress, and tree mortality is often preceded by some years of reduced tree growth (Ward and Stephens 1997, Pedersen 1998, Dobbertin 2005). Tree basal area stem growth is affected by stress sooner than more critical growth of foliage or roots (Waring 1987), and is more straightforward to measure. Decreased growth or elevated mortality rate in trees of a particular species can indicate a particular health problem for that species, such as sugar maple decline (Duchesne et al. 2003, Hyink and Zedeker

1987); while altered vital rates for multiple species across a region may indicate a regional environmental stress (Steinman 2004, Dobbertin 2005).

Calculation and Scaling Rationale

Typical growth and mortality rates vary by site, stand structural stage and by tree species, size and crown class (i.e., tree position in the canopy). For this reason, vital rates will be calculated by species and plot using only canopy trees (e.g., dominant, co-dominant or intermediate crown class) in stands that have succeeded to a mature or late-successional stage (see structural stage metric).

Relative basal area growth rate (% basal area/year) has been shown to be a useful predictor of tree mortality risk (Bigler and Bugmann 2003, Bigler et al. 2004). It will be calculated from successive DBH measurements as the percent change in basal area converted to an annual basis. For each live canopy tree, growth rate (*GR*; % basal area / year) is calculated as:

$$GR = \frac{(BA_{t2} - BA_{t1}) * 100}{BA_{t1} * Time}$$

where BA_{t2} and BA_{t1} are, respectively, basal area (m^2) for the present cycle and the previous cycle, and *Time* is the duration (years) between measurements. For each canopy tree, basal area (*BA* in m^2) is calculated from DBH (cm) as:

$$BA = \pi * \left(\frac{dbh}{2 * 100} \right)^2$$

Growth rate is then averaged for canopy trees across the plot, and also by species within the plot.

Choosing an appropriate reference for tree growth rate is complicated by variation in growth rate across regions, stand structural stages, species and tree crown class. Steinman (2004) reported net growth rates for forests in the northeastern U.S. from the FIA data, using 5 categories: > 2, 2.0-1.6, 1.5-1.1, 1.0-0.6, and < 0.6 %, with the first class considered good and the lower classes indicating cause for concern. However, this FIA net growth rate differs from that calculated herein by including ingrowth of new trees, and subtracting out mortality and cull increment (rough or rotten trees) in addition to the stem accretion calculated by NETN. NETN will consider the statistical distribution of growth rate to mean rates by region and/or species from the larger FIA dataset in order to interpret ecological integrity. Studies comparing tree growth in declining or recently dead trees vs. healthy trees report growth rates in the former to be reduced 40-50% (Pederson 1988, Standover and Somogyi 1998).

Annual mortality rate (*MR*; % stems/year) is calculated from successive observations as the percent of stems that died during an interval converted to an annual basis. This rate should be calculated for each plot, and also for individual species within a plot as:

$$MR = \frac{Stems\_died_{t1-t2} * 100}{Stems\_alive_{t1} * Time}$$

where $Stems\_died_{t1\text{-}t2}$ is the number of stems that died during a measurement interval, and $Stems\_alive_{t1}$ is the number of stems that were alive during the measurement prior to the interval.

Typical annual tree mortality rates in old-growth forest range from 0.3% to 1.6% (Busing 2005, Runkle 2000, Woods 2000).

Good: Growth rate ≥ 60% of mean for region (based on FIA data for state or smaller region, like coastal Maine) or species and mortality rate ≤1.6%; for park and all individual species.

Caution: Growth rate < 60% of mean for region (based on FIA data) or species or mortality rate > 1.6%; for park or any individual species.

Confidence

Medium. Variation in the location of DBH measurements can yield inaccurate growth rates, particularly for trees with forked or misshapen boles. NETN will mark location of DBH on bole in these situations. Ratings should be reassessed for suitability when data are available.

Soil Chemistry—Acid Stress

Overview

The molar ratio of calcium to aluminum (Ca:Al) in soil or soil solution has been developed as an indicator of acidification stress to forest vegetation. We will assess soil chemistry from composite samples within the rooting zone only, as an indicator of stress upon vegetation.

Metric Justification

Acidic deposition acidifies soil, leaching important base cations (e.g., Ca^{2+}, Mg^{2+}, K^{+}) from the soil and increasing availability of aluminum; this deprives vegetation of necessary nutrients, and increases availability of a toxin (Al). Broad-scale patterns of wet deposition across the northeast are well characterized and are most substantial at high elevations and in the southern and western parts of the region, diminishing to the northeast (Driscoll et al. 2001). However, substantial additional acidity can result from dry and occult deposition, and these patterns of deposition are not well characterized. Within NETN, coastal fog at Acadia NP may deposit substantial acidity as occult deposition (Weathers et al. 1986).

Calculation and Scaling Rationale

Ca:Al ratio is calculated as the molar ratio of NH_4Cl-extractable ions (Ca^{2+} and inorganic charged Al). Ca and Al data are typically reported as mg/kg of sample or mg/L of extractant; data reported thus will need to be converted to molar concentrations by dividing each concentration by the molar mass of the element in question (40.08 g/mol for CA; 26.98 g/mol for Al). The Ca:Al ratio is then calculated as the simple ratio of the molar concentrations.

Cronan and Grigal (1995) critically reviewed the literature to determine the utility of Ca:Al ratio in soil solution as an ecological indicator of acid stress to vegetation. Based on this review, they estimated a 50% risk of adverse impacts on growth or nutrition across a wide range of tree species when the soil solution Ca:Al ratio is as low as 1.0. However, sensitivity to acid stress varies among

species, and Cronan and Grigal (1995) note impacts have been reported at higher Ca:Al ratios for red oak (4-5), sugar maple (2.5), and several conifers (> 1); Decker and Boerner (1997) reported a Ca:Al ratio of 4.0 depressed growth, production and nutrient uptake in tulip poplar (*Liriodendron tulipifera*). Driscoll et al. (2001) suggest that Ca:Al ratio can recover over time if acid deposition levels are reduced, and Ca:Al ratio can be used to judge ecosystem recovery.

For practicality, NETN will assess exchangeable Ca:Al from soil samples rather than directly sampling soil water. The former is related but not identical to the latter (David and Lawrence 1996) and soil exchangeable Ca:Al ratio been used as a surrogate indicator (Lyon and Sharpe 1999, Wargo et al. 2002). Calcium and aluminum vary substantially through the soil profile (Yanai et al. 2005). Vegetation will be most affected by the Ca:Al ratio of soil in contact with fine roots, the bulk of which are found in the O and A horizons (or in the upper soil depth if not separated by horizon).

Park ratings will correspond to median values for all park samples in O and A horizons or in the upper 10 cm of soil. Median values are used, rather than means, due to the high variation typical in soil chemistry sampling.

Good: Ca:Al ratio > 4.0 in O and A horizons or in upper depth.

Caution: Ca:Al ratio from 1-4 in O or A horizon or in upper depth.

Sig. concern: Ca:Al ratio < 1.0 in O or A horizon or in upper depth.

Confidence

Medium. Spatial and temporal variation in soil properties are typically quite high and may impede detection of significant trends. Yanai et al. (2005) have shown that small differences in separation of soil layers between years are likely to impact Ca:Al ratios. NETN has adopted a protocol that samples by soil layer when layers are evident, and by depth when layers are not evident. Our SOP specifies compositing samples from each plot to reduce spatial variation.

Soil Chemistry—Nitrogen Saturation

Overview

Changes in the carbon to nitrogen (C:N) ratio in soil are a primary indicator of forest nitrogen status and the impacts of atmospheric deposition.

Metric Justification

Nitrogen (N) is a limiting nutrient necessary for plant growth that has historically been retained within northeastern forested ecosystems. As atmospheric deposition has increased N inputs by five- or 10-fold in the northeastern U.S., concern has arisen that excess N may “saturate” forested ecosystems, causing excess nitrification and N leaching which in turn would exacerbate the effects of acidification (Aber et al. 1998).

Calculation and Scaling Rationale

C:N ratio is calculated as the simple ratio of total C to total N (assessed from dry combustion).

Aber et al. (2003) compiled and analyzed data from sites across the northeastern U.S. to find that nitrification increased sharply below a C:N ratio of 20-25. Soil C:N ratios are typically lower beneath deciduous than coniferous stands, and in mineral than organic soil horizons. The Indicators of Forest Ecosystem Functioning (IFEF) database was compiled to evaluate the utility of C:N ratio in the organic horizon as an indicator of nitrate leaching. This effort compiled and analyzed data from 181 forest sites across Europe and found that below a C:N ratio of 25, overall nitrate leaching was significantly higher and more strongly correlated to N deposition (MacDonald et al. 2002). This assessment found no significant differences in these relationships between deciduous and coniferous forest.

As above, park ratings will correspond to median values for all park samples in O and A horizons or in the upper 10 cm of soil. Median values are used, rather than means, due to the high variation typical in soil chemistry sampling.

Good: C:N ratio > 25 in O and A horizon or in upper depth.

Caution: C:N ratio from 20-25 in O and A horizon or in upper depth.

Sig. concern: C:N ratio < 20 in O and A horizon or in upper depth.

Confidence

Medium. These ratings were developed from a robust body of literature. However, as with Ca:Al ratio, soil spatial and temporal variability is high.

NOTE: Dr. Ivan Fernandez recommends that soil rating be based on "…a suite of variables 'related to' acidification concerns that could include % Ca saturation, C/N,...adsorbed SO4..., and of course pH," rather than on single measurements. NETN is working to refine the soil chemistry metrics by incorporating multiple soil variables to address whether acid deposition may be affecting forest ecological integrity.

Literature Cited

Aber, J., W. McDowell, K. Nadelhoffer, and others. 1998. Nitrogen saturation in temperate forest ecosystems. BioScience 48:921–934.

Aber, J. D., C. L. Goodale, S. V. Ollinger et al. 2003. Is nitrogen deposition altering the nitrogen status of northeastern forests? BioScience 53:375-389.

Anderson, R. C. 1994. Height of white-flowered trillium (*Trillium grandiflorum*) as an index of deer browsing intensity. Ecological Applications 4:104–109.

Andreasen, J. K., R. V. O'Neill, R. Noss, and N. C. Slosser. 2001. Considerations for the development of a terrestrial index of ecological integrity. Ecological Indicators 1:21-35.

Augustine, D. J., and D. deCalesta. 2003. Defining deer overabundance and threats to forest communities: From individual plants to landscape structure. Ecoscience 10:472-486.

Augustine D. J., and L. E. Frelich. 1998. Effects of white-tailed deer on populations of an understory forb in fragmented deciduous forests. Conservation Biology 12:995-1004.

Austen, M. J. W., C. M. Francis, D. M. Burke, and M. S. W. Bradstreet. 2001. Landscape context and fragmentation effects on forest birds in southern Ontario. Condor 103:701-714.

Balgooyen, C. P., and D. M. Waller. 1995. The use of *Clintonia borealis* and other indicators to gauge impacts of white-tailed deer on plant communities in northern Wisconsin. Natural Areas Journal 15:308–318.

BenDor, T. K., S. S. Metcalf, L. E. Fontenot, and others. 2006. Modeling the spread of the emerald ash borer. Ecological Modelling 197:221-236.

Bigler, C. and H. Bugmann. 2003. Growth-dependent tree mortality models based on tree rings. Canadian Journal of Forest Research 33:210–221.

Bigler C., J. Gricar, H. Bugmann, and K. Cufar. 2004. Growth patterns as indicators of impending tree death in silver fir. Forest Ecology and Management 199:183-190.

Boulinier, T., J. D. Nichols, J. E. Hines, and others. 2001. Forest fragmentation and bird community dynamics: Inference at regional scales. Ecology 82:1159-1169.

Busing, R. 2005. Tree mortality, canopy turnover, and woody detritus in old cove forests of the southern Appalachians. Ecology 86:73-84.

Cline, S. P., A. B. Berg, and H. M. Wight. 1980. Snag characteristics and dynamics in Douglas-fir forests, western Oregon. Journal of Wildlife Management. 44:773–786.

Cornett, M. W., L. E. Frelich, K. J. Puettmann, and others. 2000. Conservation implications of browsing by *Odocoileus virginianus* in remnant upland *Thuja occidentalis* forests. Biological Conservation 93:359-369.

Cote, S. D., T. P. Rooney, J. P. Tremblay, and others. 2004. Ecological impacts of deer overabundance. Annual Review of Ecology Evolution and Systematics 35:113-147.

Cronan, C. S., and D. F. Grigal. 1995. Use of calcium/aluminum ratios as indicators of stress in forest ecosystems. Journal of Environmental Quality 24:209-226.

Czech, B. 2004. A chronological frame of reference for ecological integrity and natural conditions. Natural Resources Journal 44:113-1136.

Dale, V. H., L. A. Joyce, S. McNulty, and others. 2001. Climate change and forest disturbances. BioScience 51:723-734.

David, M. B., and G. B. Lawrence. 1996. Soil and soil solution chemistry under red spruce stands across the northeastern U.S. Soil Science 161:314–328.

Decker, K. L. M., and R. E. J. Boerner. 1997. Ca:Al ratio effects on growth and competitive interactions of northern red oak (*Quercus rubra*) and yellow-poplar (*Liriodendron tulipifera*). Journal of the Torrey Botanic Society 124:286-296.

DeGraaf, R. M., and A. L. Shigo. 1985. Managing cavity trees for wildlife in the Northeast. U.S. Forest Service General Technical Report NE-101. U.S. Forest Service, Northeastern Forest Experiment Station, Amherst, Massachusetts.

DeGraaf, R. M., and D. D. Rudis. 1986. New England wildlife: habitat, natural history, and distribution. General Technical Report NE-108. U.S. Forest Service, Northeastern Forest Experiment Station, Amherst, Massachusetts.

De Leo, G. A. and S. Levin. 1997. The multifaceted aspects of ecosystem integrity. Conservation Ecology 1:3.

Dobbertin, M. 2005. Tree growth as indicator of tree vitality and of tree reaction to environmental stress: a review. European Journal of Forest Research 124:319-333.

Drake, J. A., H. A. Mooney, F. di Castri, R. H. Groves, F. J. Kruger, M. Rejmanek and M. Williamson (editors). 1989. SCOPE 37: Biological Invasions: A Global Perspective. Scientific Committee on Problems of the Environment, Wiley, United Kingdom.

Driscoll, C. T., G. B. Lawrence, A. J. Bulger and others. 2001. Acidic deposition in the northeastern United States; sources and inputs, ecosystem effects, and management strategies. BioScience 51:180-198.

Duchesne, L., R. Ouimet, and C. Morneau. 2003. Assessment of sugar maple health based on basal area growth pattern. Canadian Journal of Forest Research 33:2074-2080.

Ehrenfeld, J. G. 1999. Distribution and dynamics of two exotic species, *Berberis thunbergii* and *Microstegium vimineum*, in Morristown National Historical Park. MORR-54142.

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology Evolution and Systematics 34:487-515.

Ferguson, S. H., and D. J. Archibald. 2002. The ¾ power law in forest management: how to grow dead trees. Forest Ecology and Management 169:283–292.

Fletcher, J. D., W. J. McShea, L.A. Shipley, and others. 2001. Use of common forest forbs to measure browsing pressure by white-tailed deer (*Odocoileus virginianus Zimmerman*) in Virginia, USA. Natural Areas Journal 21:172-176.

Forman, R. 1995. Land Mosaics: The Ecology of Landscape and Regions. Cambridge University Press, Cambridge.

Frelich, L. E. and C. G. Lorimer. 1991. Natural disturbance regimes in hemlock-hardwood forests of the upper Great Lakes region. Ecological Monographs 61:145-164.

Furnier, G. R., A. M. Stolz, R. M. Mustaphi, and others. 1999. Genetic evidence that butternut canker was recently introduced into North America. Canadian Journal of Forest Research 77:783-785.

Garber, S. M. 2005. Snag longevity under alternative silvicultural regimes in mixed-species forests of central Maine. Canadian Journal of Forest Research 35:787-796.

Gill, R. M. A. 1992. A review of damage by mammals in north temperate forests. 3. Impact on trees and forests. Forestry 65:363-388.

Goodburn, J. M., and C. G. Lorimer. 1998. Cavity trees and coarse woody debris in old-growth and managed northern hardwood forests in Wisconsin and Michigan. Canadian Journal of Forest Research 28:427-438.

Goodell, L., and D. Faber-Langendoen. 2007. Development of stand structural stage indices to characterize forest condition in Upstate New York. Forest Ecology and Management 249:158–170.

Greene, C. W., J. E. Weber, S. C. Rooney, and K. B. Anderson. 2004. Invasive plant species distribution and abundance in Acadia National Park. Technical Report NPS/NER/NRTR-2004/003. National Park Service, Boston, Massachusetts.

Haack, R. A., K. R. Law, V. C. Mastro, and others. 1997. New York's battle with the Asian long-horned beetle. Journal of Forestry 95:11-15.

Harris, L. 1984. The Fragmented Forest: Island Biogeography Theory and the Preservation of Biotic Diversity. University of Chicago Press, Chicago, Illinois.

Harwell, M. A., V. Myers, T. Young, et al. 1999. A framework for an ecosystem integrity report card. Bioscience 49:543-556.

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.

Horsley, S. B., S. L. Stout, and O. S. deCalesta. 2003. White-tailed deer impact on the vegetation dynamics of a northern hardwood forest. Ecological Applications 13:98-118.

Hyink, D. M., and Zedeker, S. M. 1987. Stand dynamics and the evaluation of forest decline. Tree Physiology 3:17–26.

Karjalainen, L., and T. Kuuluvainen. 2002. Amount and diversity of coarse woody debris within a boreal forest landscape dominated by *Pinus sylvestris* in Vienansalo wilderness, eastern Fennoscandia. Silva Fennica 36:147–167.

Karr, J. R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21-27.

Karr, J. R., and E. Chu. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington DC.

Karr, J. R., and D. R. Dudley. 1981. Ecological perspective on water-quality goals. Environmental Management 5:55-68.

Kay, S. 1993. Factors affecting severity of deer browsing damage within coppiced woodlands in the south of England. Biological Conservation 63:217–22.

Keddy, P. A., and C. G. Drummond. 1996. Ecological properties for the evaluation, management, and restoration of temperate deciduous forest ecosystems. Ecological Applications 6:748-762.

Keeton, W. S. 2006. Managing for late-successional/old-growth characteristics in northern hardwood-conifer forests. Forest Ecology and Management 235:129-142.

Kennedy, C., J. Wilkinson, and J. Balch. 2003. Conservation Thresholds for Land Use Planners. Environmental Law Institute, Washington, DC.

Kraft, L. S., T. R. Crow, D. S. Buckley, E. A. Nauertz, and J. C. Zasada. 2004. Effects of harvesting and deer browsing on attributes of understory plants in northern hardwood forests, Upper Michigan, USA. Forest Ecology and Management 199:219-230.

Kuuluvainen, T., K. Syrjanen, and R. Kalliola. 1998. Structure of a pristine *Picea abies* forest in northeastern Europe. Journal of Vegetation Science 9:563–574.

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.

Le Guerrier, C., D.J. Marceau, A. Bouchard, and others. 2003. A modeling approach to assess the long-term impact of beech bark disease in northern hardwood forest. Canadian Journal of Forest Research 33:2416-2425.

Linder, P., B. Elfving, and O. Zackrisson. 1997. Stand structure and successional trends in virgin boreal forest reserves in Sweden. Forest Ecology and Management 98:17–33.

Lockwood, J. L. and M. L. McKinney (editors). 2001. Biotic Homogenization: The Loss of Diversity Through Invasion and Extinction. Kluwer Academic/Plenum Publishers, New York, New York.

Lorimer, C. G., and A. S. White. 2003. Scale and frequency of natural disturbances in the northeastern U.S.: Implications for early successional forest habitats and regional age distributions. Forest Ecology and Management 185: 41-64.

Lubinski, S., K. Hop and S. Gawler. 2003. USGS-NPS vegetation mapping program Acadia National Park, Maine. Project Report, October 2003, revised edition. Appendix I. Vegetation Community Descriptions. Online (http://biology.usgs.gov/npsveg/acad/acadrpt.pdf). Accessed April 3, 2009.

Lyon, J., and W. E. Sharpe. 1999. An assessment of the Ca:Al ratios of selected Pennsylvania forest soils. Water Air and Soil Pollution 109: 53-65.

MacDonald, J. A., N. B. Dise, E. Matzner, M. Armbruster, P. Gundersen, and M. Forsius. 2002. Nitrogen input together with ecosystem nitrogen enrichment predict nitrate leaching from European forests. Global Change Biology 8:1028-1033.

Marshall, P. L., G. Davis, and V. M. LeMay. 2000. Using line intersect sampling for coarse woody debris. Forest Research Technical Report TR-003. British Columbia Ministry of Forests, Vancouver Forest Region, Nanaimo, British Colombia.

McIntyre, S., and R. Hobbs. 1999. A framework for conceptualizing human effects on landscapes and its relevance to management and research models. Conservation Biology 13:1282-1292.

McKinney, M. L., and L. Lockwood. 1999. Biotic homogenization: a few winners replacing many losers in the next mass extinction. Trends in Ecology and Evolution 14: 450-453.

McWilliams, W. H., T. W. Bowersox, P. H. Brose, and others. 2005. Measuring tree seedlings and associated understory vegetation in Pennsylvania's forests. Pages 21-26 *in* R. E.

McRoberts, G. A. Reams, P. C. Van Deusen, and others. Editors. Proceedings of the Fourth Annual Forest Inventory and Analysis Symposium. General Technical Report NC-252. U.S. Forest Service, North Central Research Station, St. Paul, Minnesota.

Mitchell, B. R., W. G. Shriver, F. Dieffenbach, T. Moore, D. Faber-Langendoen, G. Tierney, P. Lombard, and J. Gibbs. 2006. Northeast Temperate Network vital signs monitoring plan. Technical Report NPS/NER/NRTR—2006/059. National Park Service, Woodstock, Vermont.

Morrison, M. L., and M. G. Raphael. 1993. Modeling the dynamics of snags. Ecological Applications 3:322–330.

National Academy of Sciences. 2000. Ecological Indicators for the Nation. National Academy Press, Washington DC.

Nilsson, S. G., M. Niklasson, J. Hedin, and others. 2003. Densities of large living and dead trees in old-growth temperate and boreal forests. Forest Ecology and Management 178:355-370.

Olden, J. D. 2006. Biotic homogenization: a new research agenda for conservation biogeography. Journal of Biogeography 33:2027-2039.

Olden, J. D., and N. L. Poff. 2003. Toward a mechanistic understanding and prediction of biotic homogenization. American Naturalist 162: 442–460.

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

O'Neill, R. V., C. T. Hunsaker, K. B. Jones, and others. 1997. Monitoring environmental quality at the landscape scale. BioScience 47:513-519.

Orwig, D. A., D. R. Foster, and D. L. Mausel. 2002. Landscape patterns of hemlock decline in New England due to the introduced hemlock woolly adelgid. Journal of Biogeography 29:1475-1487.

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.

Pedersen, B. S. 1998. The role of stress in the mortality of midwestern oaks as indicated by growth prior to death. Ecology 79:79-93.

Petranka, J. W., M. P. Brannon, M. E. Hopey, and C. K. Smith. 1994. Effects of timber harvesting on low elevation populations of southern Appalachian salamanders. Forest Ecology and Management. 67:135–147.

Rooney, T. P. 2001. Deer impacts on forest ecosystems: a North American perspective. Forestry 74:201–8

Rooney, T. P., and K. Gross. 2003. A demographic study of deer browsing impacts on Trillium grandiflorum. Plant Ecology 168:267-277.

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

Runkle, J. R. 2000. Canopy tree turnover in old-growth mesic forests of eastern North America. Ecology 81:554-567.

Russell, L. F., D. B. Zippin, and N. L. Fowler. 2001. Effects of whitetailed deer (Odocoileus virginianus) on plants, plant populations, and communities: a review. American Midland Naturalist 146:1–26.

Schooley, H. O. 1976. Recovery of young balsam fir trees damaged by balsam woolly aphid. Forestry Chronicle 52:143-144.

Schreiber, B., and D. S. DeCalesta. 1992. The relationship between cavity-nesting birds and snags on clearcuts in western Oregon. Forest Ecology and Management 50:299–316.

Siitonen, J., P. Martikainen, P. Punttila, and others. 2000. Coarse woody debris and stand characteristics in mature managed and old-growth boreal mesic forests in southern Finland. Forest Ecology and Management 128:211-225.

Sippola, A. L., J. Siitonen, and R. Kallio. 1998. Amount and quality of coarse woody debris in natural and managed coniferous forests near the timberline in Finnish Lapland. Scandinavian Journal of Forest Research 13:204-214.

Smith, G. F., and N. S. Nicholas. 2000. Size- and age-class distributions of Fraser fir following balsam woolly adelgid infestation. Canadian Journal of Forest Research 30:948-957.

Spetich, M. A., S. R. Shifley, and G.R. Parker. 1999. Regional distribution and dynamics of coarse wood debris in midwestern old-growth forests. Forest Science 45:302–313.

Standovar T., and Z. Somogyi. 1998. Corresponding patterns of site quality, decline and tree growth in a sessile oak stand. European Journal of Forest Pathology 28:133–144.

Steinman, J. 2004. Forest health monitoring in the northeastern United States: disturbances and conditions during 1993-2002. U.S. Forest Service, Northeastern Area, State and Private Forestry, NA-TP-01-04. Newtown Square, Pennsylvania.

Stewart, B. J., P. D. Neily, E. J. Quigley, and others. 2003. Selected Nova Scotia old-growth forests: age, ecology, structure, scoring. Forestry Chronicle 79:632-644.

Sweetapple, P. J., and G. Nugent. 2004. Seedling ratios: a simple method for assessing ungulate impacts on forest understories. Wildlife Society Bulletin 32:137-147.

Tubbs, C. H., R. M. DeGraaf, M. Yamasaki, and W. M. Healy. 1987. Guide to wildlife tree management in New England northern hardwoods. General Technical Report NE-118. U.S. Forest Service, Amherst, Massachusetts.

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. U.S. Forest Service Gen. Tech. Rep. NC-197. St. Paul, Minnesota.

U.S. Forest Service (USFS). 1980. Guides for snag and den tree management. Nicolet Supplement 13 *to* Title 2600—wildlife management. Forest Service Manual. USFS, Rhinelander, Wisconsin.

Van Wagner, C. E. 1982. Practical aspects of the line intersect method. Petawawa National Forestry Institute Information Report PI-X-12. Canadian Forestry Service, Chalk River, Ontario. 11 p.

Venette, R. C., and S. D. Cohen. 2006. Potential climatic suitability for establishment of Phytophthora ramorum within the contiguous United States. Forest Ecology and Management 231:18-26.

Ward, J. S., and G. R. Stephens. 1997. Survival and growth of yellow birch (*Betula alleghaniensis*) in southern New England. Canadian Journal of Forest Research. 27:156-165.

Wargo, P. M., R. Minocha, B. L. Wong, R. P. Long, S. B. Horsley, and T. J. Hall. 2002. Measuring changes in stress and vitality indicators in limed sugar maple on the Allegheny Plateau in north-central Pennsylvania. Canadian Journal of Forest Research. 32:629-641.

Waring, R. H. 1987. Characteristics of trees predisposed to die. BioScience 37:569–573.

Weathers, K. C., G. E. Likens, F. H. Bormann, and others. 1986. A regional acidic cloud/fog water event in the eastern United States. Nature 319:657-658.

Webster, C. R., M. A. Jenkins, and G. R. Parker. 2001. A field test of herbaceous plant indicators of deer browsing intensity in mesic hardwood forests of Indiana, USA. Natural Areas Journal 21:149-158.

Webster C. R., M. A. Jenkins, and J. H. Rock. 2005. Long-term response of spring flora to chronic herbivory and deer exclusion in Great Smoky Mountains National Park, USA. Biological Conservation 125:297-307.

Williams C. E., E. V. Mosbacher, and W. J. Moriarity. 2000. Use of turtlehead (*Chelone glabra L.*) and other herbaceous plants to assess intensity of white-tailed deer browsing on Allegheny Plateau riparian forests, USA. Biological Conservation 92:207-215.

Woods, K. 2000. Dynamics in late-successional hemlock-hardwood forests over three decades. Ecology 81:110-126.

Yanai, R. D., R. P. Phillips, M. A. Arthur, and others. 2005. Spatial and temporal variation in calcium and aluminum in northern hardwood forest floors. Water Air and Soil Pollution 160:109-118.

Zarnowitz, J. E., and D. A. Manuwal. 1985. The effects of forest management on cavity-nesting birds in northwestern Washington. Journal of Wildlife Management 49:255–263.

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
2.01	January 2007	-	Calculations included. List of non-high canopy species included in regeneration metric.	-
3.00	June 2007	-	Clarified that "natural" ecological conditions may not be realistic at some cultural parks. Clarified that some metrics are not rated Sig Concern due to lack of information or need for flexibility at NHP Altered regeneration ratio and based on species richness rather than quantity. Clarified only native species count for stocking index. Added separate regeneration stocking for ACAD. Corrected basal area formula in growth rate. Based growth rate rating on statistical distribution, and added additional rationale. Added text describing tree condition foliage calculation. Removed CWD Sig Concern rating pending further review. Added formula to estimate live wood volume per plot. Removed exotic species ratio in favor of exotic indicator species metric. Updated indicator species lists. Adjusted and clarified indicator calculations and ratings. Added biotic homogenization metric. Removed forest patch size rating for Sig Concern—may not be feasible for small cultural parks. Altered Anthropogenic landuse window size Added calculation for stand structure Changed "old-growth" language to "late-successional."	-
3.01	September 2007	-	Changed version number to NETN standard. Formatted document to NPS standards. Minor edits and grammatical corrections. Updated Table S15.1 to include metric type and corrected typo in stand structure metric. Clarified snag rating. Reinserted SC rating for CWD and Forest patch size. Corrected tree volume formula. Adjusted text to clarify intent to rate based on EI, not management goals. Updated Goodell citation. Changed version number to NETN standard.	-
3.02	November 2007	-	Adjusted *Carpinus caroliniana* and *Ostrya virginiana* common names. Added scientific names to Table S15.2.	-

Revision History Log (continued)

Version	Date	Revised By	Changes	Justification
3.03	March 2008	-	Clarified rating breakpoints. Adjusted ACAD tree size classes for stand structural class. Adjusted tree regeneration metric. Clarified that FIA data will be used to establish means for Tree growth rate metric. Adjusted biotic homogenization metric. Adjusted confidence in C:N ratio. Minor editorial changes.	-
3.04	May 2008	-	Adjusted version numbers to meet new NETN standard. Mowed field were classified as anthropogenic land use. Added check for miscategorization of early-successional and mosaic plots. Clarified height correction factors for gap-exploiter and open-grown trees. Defined “tree” in the “Metrics and Ratings” section. Added formulas for biotic homogenization. Clarified cutoffs for invasive exotic species metric. Revised deer browse metric to be a simple proportion of quads with each indicator species, rather than aggregating data per plot (which decreases sensitivity) or calculating on a plot basis (where sample size was small). Minor edits.	-
3.05	October 2008	-	To structural stage distribution, added assessment point for all ecosystem types not specified. Minor edits.	-
3.07	April 2009	Kate Miller	Note for considering adding sapling/seedling or "small" stands to metric calculation to reflect overall distribution of structural stages across the park. Added that NETN is continuing to refine the deer herbivory metric. Added that NETN is working to refine the soil chemistry metric to incorporate a suite of variables to examine impacts of acid deposition. Clarified that the forest vital sign protocol is not appropriate for early detection of new invasions. Added that NETN may consider adding another metric the looks at relative proportion of native and exotic species. Added that NETN may consider additional metrics for understory species dynamics in the biotic homogenization section.	-
3.08	May 2009	Sarah Lupis Kozlowski	Minor editorial changes	Conform to NPS standards
3.09	December 2009	Andrew Vincello, Kate Miller, and Brian Mitchell	Minor editorial changes. Revised Invasive Plant metric to include detections in microplots and as tree-sized individuals.	

Revision History Log (continued)

Version	Date	Revised By	Changes	Justification
3.10	January 2011	Kate Miller	Changed Hemlock Woolly Adelgid to a Priority 1 Pest in Tree Condition Metric.	
3.11	March 2014	Kate Miller	Changed SOP number	

SOP 18 - Deviations, Differences, and Summary of Major Changes

Mid-Atlantic Network/Northeast Temperate Network

Version 2.12

Overview

This SOP documents:

- Differences between methods used by the Mid-Atlantic Network (MIDN) and the Northeast Temperate Network (NETN).
- Known deviations from established methods. Deviations are situations where data were collected in a manner that is substantially different from the methods documented within the SOPs used during a particular field season.
- Major changes in the protocol. Major changes are fundamental shifts in the way data are collected that cannot easily be rectified with earlier data. Major changes are not deviations, provided that the changes are documented in the SOPs. Ideally, any time there is a major change in methods the networks will use both methods long enough to determine whether the results from the different methods are sufficiently correlated to allow old data to be corrected. In some cases (especially early in the use of the protocol), the small amount of data lost by the protocol change will not be worth the cost of overlapping methods.

Differences between MIDN and NETN Methods

Table S18.1 documents any known differences between the established methods used by NETN and MIDN. The purpose of this portion of the SOP is to facilitate the task of the combined NETN/MIDN field teams in adapting to the change in methodology when moving from one network to the next.

Table S18.1. Differences between established methods used by NETN and MIDN, by SOP.

SOP	NETN Methods	MIDN Methods
Preparation and Equipment	#4 rebar center post Stainless steel and aluminum tags and nails used depending on park.	#6 rebar center post Aluminum tags and aluminum nails used throughout.
Using the GPS	No difference	
Using the TruPulse	No difference	
Data management	Front end will adjust to network depending on the park but the backend is the same	

Table S18.1. Differences between established methods used by NETN and MIDN, by SOP (continued).

SOP	NETN Methods	MIDN Methods
Site selection and plot establishment	When a plot is rejected, the next consecutive GRTS priority is used	When a plot is initially rejected, one may relocate the plot 20m away in four possible cardinal directions, starting with North, then East, South and finally West.
	Plot numbers are unique within a park but not within the network	Plot numbers are unique for the entire network
	Plot layout is slightly different due to distance of microplots from center and location of quadrats	Plot layout is slightly different due to distance of microplots from center and location of quadrats
Photopoint	No difference	
Stand and site measurements	Sampling from mid-May to July 31	Sampling from August 1 to September 30
Tree measurements	Aluminum tags at MABI, MIMA, ROVA, SARA, and WEFA; steel at ACAD, MORR, SAGA.	Aluminum used in all MIDN parks
	Tag trees using aluminum (MABI, MIMA, ROVA, SARA, and WEFA) or steel nails (ACAD, MORR, SAGA)	Aluminum nails used in all MIDN parks.
Microplot measurements	4 m (slope distance from plot center)	7 m (horizontal distance from plot center)
	2-m radius	3-m radius
	Saplings not tagged	Saplings tagged with nails if ≥ 4 cm or cable ties if < 4 cm DBH
	Shrubs estimated using cover classes	Shrubs estimated using cover classes except for select few species measured as DBH.
	No reference list used—All shrubs and vine species are recorded	Select species list used to determine which shrub species are measured.
	Seedlings measured in microplots (see below)	Seedlings measured in quadrats (see below)
Seedling regeneration	Falls within Microplot SOP:	Falls within Quadrat SOP:
	Count up to 5 individuals of tree seedlings per size class, estimate number in multiples of 5 if more than 5 per class	All individuals of tree seedlings are counted in each category
		In VAFO only—Seedling heights are also recorded in an additional height class 5-15 cm
Quadrat measurements	8 quadrats along plot edge	12 quadrats; three along each CWD transect and one in each microplot
	1 m x 1 m quadrat	2 m x 0.5 m quadrat
	All herbaceous plants identified and cover estimated.	Select group of native and invasive herbaceous species included only
Coarse woody debris	No difference	
Unknown plant collection	No difference	
Soil	No difference	

Known Deviations and Major Changes

This portion of the SOP documents the major changes over time in the procedures, so that changes that may impact data analyses are all summarized in one place. This portion of the SOP also documents situations where procedures were not followed as specified in the SOPs that were current at the time of data collection.

Overall Protocol Changes and Data Issues

1a) In 2006: The order of parks sampled in NETN was ACAD, MIMA, MABI, SAGA and SARA.

1b) 2007 and later: The NETN park order is from southwest to northeast, and always finishes in ACAD. This schedule allows southwestern parks to be sampled when spring ephemerals may still be present, and allows northeastern parks to be sampled after shrubs and trees have fully expanded their leaves. Tree foliage condition and quadrat data from 2006 parks (i.e., ACAD, MIMA, MABI, SAGA, and SARA) may not be comparable with future data because of this difference in the timing of sampling.

2a) 2010: In ACAD, six plots were added to complete Panel 1, and were be drawn from the next consecutive GRTS priorities following those used in Panel 4.

2b) 2011: In ACAD, two plots will be added to complete Panel 2. One plot will be pulled from Panel 3 (currently has 45 plots), and it will be the plot with the lowest GRTS priority number in Panel 3 (ACAD 098, GRTS 122). The other plot will be the next consecutive GRTS priority after Panel 1 is complete.

3) In 2010, plot 15 in SARA was not sampled because permanent markers were all missing. This plot is in the Hudson River floodplain, and we will need to reinstall the plot in 2012 using larger and more permanent markers.

4) In 2010, plot 29 in ACAD was sampled, but all of the datasheets were lost. The only remaining data associated with this plot are photopoints and soil samples.

Site Establishment

1a) 2006 and 2007: Slope of plot is percent slope, measured across plot.

1b) 2008 and later: Slope of plot is angle (measured from center to top, and center to bottom).

2) 2006: The first 20 (approx.) plots in ACAD were established without a fiberglass stake marking plot mid-points. Following the QA/QC sampling in ACAD, the protocol was changed to install stakes at all mid-points in addition to the plot center, corners and microplot centers.

3) 2006: Only one microplot (UR) was established and sampled in 2006. In 2010, 2 additional microplots were established in UL and B locations.

4) 2009 and later: Plot azimuth was changed to plot orientation.

5a) 2006 – 2011: In NETN, fiberglass stakes were used for all plot markers. After repeat surveys, it became clear that fiberglass stakes are not the best option, as one or more were frequently missing after 4 years.

5b) 2012 and later: In NETN plot corners are marked with bent rebar stakes, and plot center is marked with rebar that has a pre-printed survey cap. Rebar is still needed for UC, MR, BC, ML locations starting in 2016. Installing rebar for UR, B, UL microplots will start in 2020.

6a) 2008 – 2011: In MIDN, fiberglass stakes were used for all plot markers, except plot center.

6b) 2012 and later: In MIDN bent rebar stakes are used for all plot markers, except plot center. Plot center continues to be marked by a rebar stake with a pre-printed survey cap.

6c) 2015: MIDN plot locations all have rebar, need to add fiberglass to following sampling frames - 2016-2018: Need one stake at UC; 2019: VAFO, HOFU, GETT, APCO, BOWA needed at plot corners and microplots.

7) 2016 and later: Tolerance for plot boundary markers increased from 2 degrees and 0.5 m to 4 degrees and 1.0 m.

Coarse Woody Debris (CWD)

1a) 2006: The NETN minimum CWD size was 7.5 cm

1b) 2007 and later: NETN minimum CWD size was increased to 10.0 cm. The MIDN estimated CWD length as < 1m, 1-5m, or > 5m.

2a) 2006 and 2007: Slope measurements are percent slope.

2b) 2008 and later: Slope measurements are angles. The MIDN includes direct measurement of CWD length rather than the length class category used in 2007.

3a) 2006-2008: Pieces of CWD that crossed the same transect multiple times were also recorded as multiple intersections. Pieces that crossed two or more different transects were not recorded as being the same piece.

3b) 2009: Pieces of CWD that crossed the same transect more than once were recorded as a multiple intersection. Pieces that crossed two or more different transects were noted as being the same piece in the notes section of the datasheet.

3c) 2010 and later: Pieces of CWD that either cross the same transect or different transects more than once will be given the same letter in the datasheet/database to denote that this was the same piece of CWD.

4a) 2006-2009 (DEVIATION FROM SOP): Length of minor CWD forks may have been measured to the end of the major fork instead of to the junction of the major fork. This was a rare occurrence, but it's possible that CWD volume may have been over estimated on some plots.

5a) 2006-2012: Suspended pieces of CWD were tallied.

5b) 2013 and later: pieces of CWD are only tallied if the piece is touching the ground at some point along its length.

6) 2017 and later: pieces of CWD were paint marked at the point of measurement (where it crosses the transect) to improve repeatability.

Microplot

1a) 2006: In NETN, only one regeneration microplot. In addition, shrub % cover was never estimated; number of stems estimated instead. One microplot did not provide sufficient data to estimate tree regeneration metrics in the EI scorecard, and 2006 data may not be comparable to later data.

1b) 2007 and later: In NETN, increased to three microplots. In dense early successional shrub thickets, shrub percent cover estimated instead of stem counts.

2a) 2007: In MIDN all individuals of each shrub species in a microplot are measured and tagged.

2b) 2008 and later: In MIDN, the first five individuals of each shrub species in a microplot are measured and tagged, and a count is provided for additional individuals of the same species.

3a) 2006-2008: In NETN, all saplings in each microplot are measured for diameter at breast height (DBH).

3b) 2009 and later: In NETN, the first 10 saplings of a particular species per microplot are measured for DBH. The remaining saplings of that species will be tallied in the microplot.

4a) 2006-2007: In NETN, shrub species were measured by stem counts.

4b) 2008-2009: shrub species were measured by stem counts, except shrub species in early successional were estimated using percent cover.

4c) 2009 and later: in MIDN, shrub species indicated as cover have cover estimates measured in microplots and quadrats.

4d) 2010 and later: shrub species are estimated by percent cover.

5) 2009 (DEVIATION FROM SOP): Shrubs in MORR 19, 20, 21 and 22 were considerably underestimated, particularly for *Berberis thunbergii*. Shrub patches were tallied as an individual instead of each shrub stem within the patch. Each patch contained around 10 stems. Vines species (i.e., *Lonicera japonica*) were also not tallied in the microplot in these four plots.

6) 2010 (DEVIATION FROM SOP): all microplot data are missing for SAGA 008. The 2010 report analyses omitted this plot from regeneration analyses.

7) 2015 and later: NETN saplings are painted at DBH with green paint.

Photopoint

1a) 2006 and 2007: In NETN parks, photopoints were taken from outside the plot, looking in, plus a photo of the UR regeneration microplot; all photos had an ID card. In MIDN parks, photopoints were a series of five scenes (UC, UR, BR, BL, UL), all taken horizontally, plus photo of plot marker.

1b) 2008 and later: The MIDN/NETN photopoint protocols were combined. The new protocol has six scenes: UC UR, BR, BL, UL and UR regeneration microplot, plus a photo of the plot marker. The UC photo is oriented vertically, and the rest are oriented horizontally.

2) 2013 and later: Photopoints must be oriented so that the stake of interest is in the center of the frame. If the stake is not visible in the camera view, a crew member should stand directly behind the stake and point out the location in the photo.

Quadrat

1a) 2006: NETN only measured quadrat vegetation up to 1.0 m in height.

1b) 2007 and later: NETN increased quadrat sampling height to 1.5 m.

2a) 2006 and 2007: Stem and CWD diameters had to be 10 cm to be recorded in quadrats. Woody germinants were not recorded separately.

2b) 2008 and later: Stem recorded when > 1.0 cm, and CWD recorded when > 5.0 cm diameter. Woody germinants recorded separately from established seedlings.

3a) 2007: In MIDN, herbaceous plant species were documented in the quadrats only.

3b) 2008 and later: In MIDN, a time constrained search was included to record the presence of the indicator species that were not found in the quadrats.

4) 2007: In NETN, crew sampled herb quadrats on their own in WEFA, and did not have the botanical expertise to really do this well. Starting in 2009, a contract botanist or NETN plant ecologist was present to sample herb quadrats in WEFA.

4) 2008 and 2009: The MIDN included additional species to the list of native and exotic herbaceous plants and vines measured in the quadrats.

5) 2009: The MIDN begins including lichen cover in quadrat cover.

6) 2009: Location of microplot quadrats incorrectly placed from 7 to 7.5 m from plot center rather than from 6.5 to 7 m from plot center.

7) 2006-2009 (DEVIATION FROM SOP): In NETN the plot search for additional species only included species rooted in the plot. The protocol states that overhanging vegetation should also be included. The number of species that were not recorded because they were not rooted in but were overhanging is likely very few.

8) 2009 and 2010 (DEVIATION FROM SOP): On several occasions, crews confused % cover classes between quadrats and stand data, and recorded <1% as the lowest category for quadrat characteristics. Where noticed, the <1% was changed to 0, but it is possible that some were truly <1%. To help dispel confusion, we changed the lowest % cover category for stand data from <1% to 0%.

9) 2010 and later: % wood only includes wood that is on the ground.

10) 2009-2016: MIDN quadrats: The presence or absence of deer browse was assessed at the species level for each tree species. All species recorded in the quadrat were considered, regardless of whether they were represented by an individual rooted in or overhanging the quadrat. The presence of deer browse was only recorded if the browse was determined to have occurred within the last year (low confidence). Careful attention was paid to differentiate between deer and rabbit browse.

11) 2015-2016: MIDN quadrats: Individual seedlings taller than 15cm (5cm in VAFO) with recent deer browse were tallied. To be tallied, a seedling had to be rooted in the quadrat. Deer browse was only recorded if it was thought to have occurred within the last year.

12) 2017 and later: Deer browse in MIDN quadrats is assessed for each tree seedling that is >15cm (>5cm VAFO) tall and rooted in the quadrat. Browse is recorded as a tally of browsed seedlings by species per quadrat. The presence of deer browse is only recorded if the browse is determined to have occurred within the last four years.

Soil Collection

1a) 2006: The NETN soil sampling protocol used a soil corer in all parks to collect O_a, A, E and B soil horizons. Horizon thickness was measured with a ruler along the core. Soil cores were collected to a maximum depth of 20 cm, including soils with no detectable horizons.

1b) 2007: The NETN soil sampling protocol was modified to use a 100 cm^2 frame to collect O_a and A soil horizons in all parks. Thickness of horizons was measured at the edge of the excavation. Where soils were undifferentiated, 10 cm was the maximum depth collected.

1c) 2008 and later: The NETN soil sampling protocol was modified for National Historic Parks to use a soil corer, rather than 100 cm^2 soil frame. The 100 cm^2 sampling frame will continue to be used in Acadia NP. Layers collected are forest floor (consolidated litter + humus) and A in all parks. The maximum collection depth in all parks is 20 cm. Peat and soils without horizons are collected to depths up to 10 cm.

1d) Data comparisons between 2006 and 2007 are not possible, because soil collection methods in 2007 differed considerably from 2006 methods. Data from 2006 and 2008 (and later) samples in National Historic Parks may be comparable (note that forest floor was called O_a or humus in 2006). Soil samples in 2007 and later may be comparable (in some cases, maximum depth of collection may have exceeded 20 cm in 2007).

2) 2009 (DEVIATION FROM SOP): Depth of leaf litter in MORR plots 19, 20, 21, 22, 23, 24, 25 and 26 was over estimated, because crew members incorrectly included consolidated leaf litter into the measurement. Leaf litter depths for plots in MORR that were sampled correctly range between 0.5 and 2 cm. Leaf litter depths on plots 19-26 range from 2.5-6 cm.

3) In NETN, S3 soil sample location started in 2014
4) In MIDN, sample frame of S1 taken during period 2010-2013. No more samples taken until further notice.

Stand and Site Measurements

1a) 2006 and 2007 (DEVIATION FROM SOP): The % Cover by Layer measurement included all plant foliage (vascular + non-vascular), rather than vascular only. This only affected the data for the Ground layer.

1b) 2008 and later: A measure of non-vascular ground cover was added. The MIDN standardized metrics measured with those of NETN.

2a) 2006: Stand height was measured on all plots. Stand types included “Two-storied”.

2b) 2007 and later: No stand height measurement on early successional plots without closed canopy. “Two-storied” stand type removed.

3a) 2006 and 2007: Terrain position used to describe plot location in relation to topography and land form.

3b) 2008 and later: Physiographic class used to describe plot location in relation to topography, land form and soil moisture.

4) 2008 (DEVIATION FROM SOP): Microtopography was incorrectly recorded by S. Demaio and J. Burka as absent when pit and mound microtopography were absent due to thin soils or bedrock. There was no evidence of plowing at these plots, and therefore microtopography should have been recorded as present.

5a) 2006-2008: Stand height was measured for 1 co-dominant tree in the plot.

5b) 2009 and later: Stand height will be measured by averaging the height of 3 co-dominant trees.

6a) 2006-2008: Presence/absence of a deer browse line was recorded for each NETN and MIDN plot.

6b) 2009 and later: NETN and MIDN adopted Eastern Rivers and Mountains Network’s deer browse index that ranges from 1 (no browse and in a deer exclosure) to 5 (extreme browse pressure and presence of browseline). Previous plots where a browseline was recorded as present are compatible with class 5 of the deer browse index.

7) 2009 (DEVIATION FROM SOP): On plots with N. Lightle or K. Wilkin as recorders disturbances were recorded where there was minor herbivory/foliage damage to enough trees to meet the

disturbance threshold. During the data entry process, most of these records were removed, but it's possible that some were still entered.

8) 2010 and later: Changed the lowest % cover class for strata and substrate estimates from <1% to 0. Cover classes are now: 0, 1-5, 5-25, 25-50, 50-75, 75-95, >95%.

9) 2013 and later: Three intermediate trees are sampled for stand height, in addition to the three co-dominant trees.

Tree Measurements

1a) 2006 and 2007 (DEVIATION FROM SOP): Only the most severe Tree Condition was recorded, rather than all tree conditions. Database was not set up for multiple entries.

1b) 2007 and later: Some changes to tree condition categories from 2006.

2a) 2006 and 2007: At NETN parks, forking was in the notes field; however, it may not always be clear which stems belong to which individual tree. In 2007, in MIDN plots, multiple stems of the same individual were measured and marked, but not tagged.

2b) 2008 and later: NETN added a “Fork” field to clarify which stems belong to which individual tree. Some additional changes to tree condition categories. For MIDN plots, the stems are still treated as being from the same individual but each is given a tag number to allow us to track them from one census to the next.

3a) 2006 to 2008: NETN considered crown class in terms of both relative height in canopy and light availability.

3b) 2009 and later: NETN revised the definition of crown class to only consider relative height in canopy to match MIDN crown class definitions.

4) 2009 and later: MIDN started treating stems of the same individual tree in the same manner as NETN. Each stem ≥ 10 cm DBH individually tagged and condition measurements taken.

5a) 2006-2009: Tree quadrants were recorded in NETN.

5b) 2010 (and ACAD 2009) and later: tree horizontal distance and angles are recorded.

6a) 2006-2008: In NETN the species of vines on trees was not recorded.

6b) 2009 and later: NETN records species of vines in canopy to have the same procedures as MIDN.

7a) 2009 and later: Tree condition codes (Table S18.1) were changed to facilitate data entry. Definitions of the conditions haven’t changed, except advanced fungal decay. In NETN advanced fungal decay was included in the advanced decay condition. Beech bark disease is no longer tracked in the tree condition section. Instead a 4-point index of severity is used to assess beech bark disease on all beech trees in NETN.

7b) 2012 and later: Added small cavity and large cavity as a tree condition for live and dead trees. Dogwood anthracnose was also added to the list of tree conditions, but was not incorporated into the database tree condition lookup table until 2014.

8a) 2006-2009: NETN used the following FIA tree status codes.

0 No status—Previously tallied tree is no longer in sample because tree was incorrectly tallied last time, or a change in procedure now excludes this tree. Record reason in Tree Notes.

Table S18.1. History of tree condition codes.

2012	2009	2006-2008	Description
AD	AD	AD	advanced decay/advanced fungal decay
ALB	ALB	ALB	Asian longhorned beetle
BBD	BBD	BBD	beech bark disease
BC	BC	BC	butternut canker
BWA	BWA	BWA	balsam wooly adelgid
CAVL			cavity- large
CAVS			cavity- small
CW	CW	OW	canker/ open wound
DBT	DBT	LDB	large dead branches in canopy or broken/dead top
DOG			dogwood anthracnose
EAB	EAB	EAB	emerald ash borer
EB	EB	EB	epicormic branching
EHS	EHS	EHS	elongated hemlock scale
G	G	BG	burl/gall
GM	GM	GM	gypsy moth
H	H	H	healthy
HWA	HWA	HWA	hemlock wooly adelgid
ID	ID	ID	insect damage
OTH	OTH	OD	other visible damage
SB	SB	SB	spruce budworm
SOD	SOD	SOD	sudden oak death
SW	SW	SW	sirex wood wasp
VIN	VIN	VC	vines in the crown

1 Live tree—New live trees in re-measured plots are assumed to be ingrowth. If a new tree is tallied that was missed during a previous inventory, note this in Tree Notes.

2 Standing dead tree.

3 Removed—Previously tallied tree has been cut and removed by humans during harvest, silviculture or land clearing.

4 Fallen dead tree—Previously tallied tree has fallen and will no longer be tracked as a tree.

8b) 2010 and later: NETN adopted MIDN's tree status codes.

9a) 2010 (DEVIATION FROM SOP): Three witness trees were selected and permanently marked instead of two.

10) 2010 (DEVIATION FROM SOP): super canopy white pines were mistakenly classified as the co-dominant layer instead of the dominant layer, and measured stand height off these super canopy pines. This resulted in an overestimation of live tree volume, and underestimation of the CWD ratio. This mistake occurred in SAGA plots 001, 005, 006, and 008. Analyses in the 2010 report used QA/QC crown classes and stand heights on plots 005 and 006, and used crown classes and stand heights from 2006 on plots 001 and 008.

11) 2012 and later: In NETN, tree DBH painted with green paint.12) 2013 and later: Fork tally rules follow FIA, which may exclude some forks that were measured during previous surveys, especially sapling forks that occur above larger forks that have already been tallied.

13) In cycle 1 (2006-2009), trees with vines along the stem were often incorrectly measured for diameter at breast height (DBH) by placing the diameter tape over the vines on the stem. Starting in 2010, trees with vines along the stem were measured for DBH using tree calipers. This often resulted in artificially negative growth rates, because the initial DBH was larger because of the vines. This occurred frequently in WEFA, and occasionally in MIMA and ROVA.

14a) 2010-2014: Trees that were excluded from a plot were given the status "EX", and the reason for exclusion was recorded in the notes for that tree.

14b) 2015 and later: The EX status was split into three categories. Trees that are excluded because they shrank below 10 cm DBH are given a status of XS. Trees that are excluded because they are determined to be outside of the plot are given a status of XP. Trees that are excluded for any other reason are given a status of XO (Excluded-Other), and the reason for the exclusion is recorded in the notes.

15) 2016 and later: For trees that are very close to the plot boundary, we will continue to measure it, if the previous visit included it. If the previous visit excluded it, we will continue to exclude it.

16) 2016 and later: Percent of leaf area affected will be assessed in addition to total foliage affected.

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	October 2007	Brian Mitchell	New SOP Deviation: % cover by layer, 2006 and 2007	
2.00	May 2008	Brian Mitchell Jim Comiskey Kate Miller	Deviation: Tree condition, 2006 and 2007 Added definitions for “Differences” and “Major Changes” Added placeholder for “Differences” Added numerous major changes Added table of differences between NETN and MIDN procedures	
2.01	November 2008	Kate Miller	Changed fiberglass and rebar deviation to only occur at plot center Changed NETN mark at DBH to only occur on tree with an unusual DBH.	
2.02	December 2008	Kate Miller Jim Comiskey	Changed Regeneration section to Microplot Added Microtopography deviation from SOP in 2008. Added change in NETN crown class definitions to only consider relative canopy height. Added NETN sapling threshold requiring only the first 10 saplings per species in a microplot be measured for DBH. The remaining saplings of the species will be tallied. Added change from terrain position to physiographic class in stand and site measurements. Minor editorial changes	
2.03	May 2009	Sarah Lupis Kozlowski Kate Miller	Minor editorial changes, formatting. Added change from 1 to 3 stand height measurements Added change from deer browseline (presence/absence) to deer browse index Added difference in park order between 2006 and 2007 and beyond.	Conform to NPS standards.
2.04	December 2009	Kate Miller Andrew Vincello Brian Mitchell Jim Comiskey	Added changes to tree condition codes, shrub measurements, multiple intersections of coarse woody debris, tree mapping in NETN, species of vines in crown and 2009 deviations from SOPs. Revised Table S16.1 MIDN/NETN protocol differences.	
2.05	October 2010	Kate Miller Jesse Wheeler	Changed overall protocol changes heading to overall protocol changes and data issues. Changed soils to no differences in Table S16.1. Clarified difference between NETN and MIDN when a plot location is initially rejected. Added that in 2010 SARA plot 15 was not sampled and datasheets for ACAD plot 29 were lost. Added the minor forking deviation with CWD Added wood defined as only touching ground to protocol change section.	

Version	Date	Revised By	Changes	Justification
			Added occasional <1% versus 0 deviation from SOP issue in quadrats for 2009 and 2010 data. Added change in cover classes for stand data. Added that in 2010, 3 witness trees were selected instead of 2. Removed cable ties as method for tree tagging in Table S16.1 Added the misclassification of super canopy pines in SAGA as the co-dominant layer. Added that microplot data was missing for SAGA plot 008.	
2.06	March 2012	Kate Miller	Added that in 2007, WEFA herb quadrats were not sampled by a quadrat botanist, and the data are not very good. Added change in plot markers from fiberglass to rebar. Added that in 2012 tree cavities will be recorded.	
2.07	January 2013	Kate Miller	Added that suspended CWD pieces are no longer tallied. Added that FIA fork tally rule may exclude some forks that have been measured previously.	
2.08	March 2014	Kate Miller	Added that tree with large vines along the stem were not sampled for DBH consistently between cycle 1 and 2. Changed SOP number. Updated tree condition table to include CAVS, CAVL, and DOG. Corrected other visible damage (OTH), combined DEC and AD, and added Asian longhorned beetle (ALB)	
2.09	December 2014	Kate Miller	Added the change in tree status codes from EX to XO, XP and XS.	
2.10	November 2015	Jesse Wheeler and Kate Miller	Added change in tolerance and specifics of material (fiberglass or rebar) for plot boundary markers. Added soil locations for 2010-2014. Added that NETN tree painted at DBH starting in 2012. Trees determined inside/outside the plot last visit will be treated as such during current visit. Added that percent leaf area affected is a new measurement starting in 2016. Added that NETN saplings painted at DBH starting in 2015.	
2.11	February 2016	Aaron Weed	Added change in monitoring of deer browse to tree seedlings in MIDN quadrats in 2015 and 2016 and on.	
2.12	January 2017	Camilla Seirup	Clarified MIDN quadrat deer browse assessment protocol from 2009-2016. Added that starting in 2017 CWD was paint marked at the point of measurement.	

SOP 179 - Protocol and Database Revision

Mid-Atlantic Network/Northeast Temperate Network

Version 1.01

Overview

This SOP outlines the procedures and deadlines for making changes to the forest protocol and the forest database.

Revision Process

There are several approaches to revising the forest protocol and database, and the ideal approach is to discuss changes at the annual protocol review. However, all protocol changes require approval by the lead authors of this protocol, and all changes to the database must be approved by the MIDN and NETN data managers.

Review Panel

A review panel consisting of NETN and MIDN staff and cooperators will meet annually within a few months after the completion of the forest field season. Several weeks prior to the review panel, the NETN plant ecologist will distribute a draft outline of discussion topics to each panel member to revise. The plant ecologist will incorporate the panel members' comments and distribute a final version of the outline no later than the day before the review. This outline will serve as the framework for the discussion during the meeting. Discussion topics should cover lessons learned during the field season, forest crew feedback, and potential protocol and database changes that came up during the field season. After the review the NETN plant ecologist will revise the protocol based on the review discussions, and send the revised protocol to panel members for approval. NETN and MIDN data managers will revise the forest database, which will also be sent to panel members for approval.

Revision Timeframe

While not ideal, it is possible to make changes to the forest protocol and/or database after they have gone through the annual revision process. However, protocol changes must be made and approved by the review panel no later than 3 weeks before the crew is scheduled to begin training. If the protocol change also requires the database to be changed, then changes must be proposed no later than 6 weeks prior to the start of training to allow time for the data managers to modify the database and NETN and MIDN staff to prepare the database materials covered during training. Proposed changes to the protocol or database that arise after this timeline will be added to the list of discussion topics at the following year-end panel review.

Database Tracker

Network program managers or plant ecologists should send a list of proposed database changes to their corresponding data manager using the Database Tracker spreadsheet. Network staff should provide at a minimum a description of the change request and why it is needed. NETN and MIDN

data managers will meet to compare change requests and develop a strategy for handling write access to the master database.

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	October 2009	Kate Miller	New SOP	
1.01	March 2014	Kate Miller	Changed SOP Number	