



Early Detection of Invasive Species— Surveillance, Monitoring, and Rapid Response

Version 2.0

Natural Resource Report NPS/ERMN/NRR–2014/837



ON THE COVER

Jetbead (*Rhodotypos scandens*).
Photograph by: Douglas Manning.

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Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be increased incrementally 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	December 2013	Douglas Manning and Jesse Wheeler	Added MIDN and NCBN to protocol Added four SOP's: Data Collection: What's Invasive, LEST, Appalachian NST Invasive Species Prioritization, and Appalachian NST Sampling Design and Field Procedures. Updated species, added digital data collection through What's Invasive, and minor editorial changes	Update to reflect current operational procedures.

Executive Summary

Early detection monitoring of incipient invasive plants, animals, and diseases was ranked among the top priorities in the Eastern Rivers and Mountains Network (ERMN), Mid-Atlantic Network (MIDN), Northeast Coastal and Barrier Network (NCBN), and the Northeast Temperate Network (NETN) in the vital signs selection process due to the clear identification of, and concern about, the effects these organisms can have on park ecosystems. Known ecological impacts of invasive species include loss of threatened and endangered species, altered structure and composition of terrestrial and aquatic communities, and reduction in overall species diversity.

While long-term changes associated with invasive species are being monitored through other protocols, it is also critical to catch new populations of invasive species early in their invasion of new and sensitive habitats. Only when invasions are caught early will the chance of eradication remain high.

Early detection monitoring in the ERMN, MIDN, NCBN and NETN will include three main components:

- creation of individual park early detection species lists;
- opportunistic surveillance monitoring of invasive plant and forest pest species that will focus on educating monitoring field crews, cooperators, volunteers, and resource managers on invasive species identification; and
- development and maintenance of a coherent framework for reporting and disseminating information on potential infestations. These components will allow park resource managers to assess each invasive species early detection on an individual basis and target limited management resources and coordination toward the highest priority risks.

Acknowledgments

This protocol uses some text and ideas without citations from the “Invasive Exotic Plant Monitoring Protocol for the Heartland Network Inventory and Monitoring Program” (Young et al. 2007) and the “Early Detection Monitoring of Invasive Plant Species in the San Francisco Bay Area Network, A Volunteer Approach” (Williams et al. 2007). We want to acknowledge both of these Networks for helping to lay the foundation for invasive species early detection work within the NPS Inventory & Monitoring Program. In addition, we would like to thank Kathryn Miller, NETN Plant Ecologist, Wayne Millington, Northeast Regional Integrated Pest Management Coordinator, Les Mehrhoff, Director, Invasive Plant Atlas of New England (IPANE), and all ERMN, MIDN, NCBN, and NETN park resource managers and staff; all contributed their time and assistance in developing early detection species lists, synthesizing protocol logistics, and/or providing general feedback.

Introduction

Background and History

An “invasive species is an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health” (USPEO 1999). Presidential Executive Order 13112 further defines an “alien species, with respect to a particular ecosystem, as any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem” (USPEO 1999). In broad terms, an invasive species is an organism that has been introduced deliberately or unintentionally into an environment in which it did not evolve, is capable of establishing self-sustaining populations in “untransformed ecosystems” (MacDonald et al. 1989), has no natural enemies to limit its reproduction and spread, and is likely to cause harm to human health or the environment.

Invasive species tend to have broad ecological requirements and tolerances, effective reproductive and dispersal mechanisms (Rejmanek and Richardson 1996), competitive ability superior to that of natives in the original or modified system, and the capability of altering the site by significantly changing resource ability and/or disturbance regimes (Baker 1965). Invasive species negatively impact park resources and visitor enjoyment by altering landscapes and fire regimes, reducing native plant and animal habitat, blocking and altering viewsheds, and increasing the need for and cost of additional trail maintenance. Examples from national parks include alteration of geochemical cycling by feral pigs (*Sus scrofa*) in Great Smoky Mountains National Park, acceleration of soil erosion rates by feral mammals in Channel Islands National Park, alteration of hydrological cycles by salt cedar (*Tamarix* sp.) in Death Valley National Monument and Big Bend National Park (MacDonald et al. 1989), and obstruction of cultural viewsheds by common mullein (*Verbascum thapsus*) on Skyline Drive in Shenandoah National Park (James Åkerson, pers. Comm., March 2, 2010). Inventory and Monitoring Networks in the northeastern U.S. are witnessing the destruction of the eastern hemlock (*Tsuga canadensis*) in multiple parks by the hemlock woolly adelgid (*Adelges tsugae*) and the imminent demise of ash species (*Fraxinus* spp.) caused by the advancing front of the emerald ash borer (*Agrilus planipennis*) (Figure 1), now in several northeast parks, including New River Gorge National River.

National parks are clearly susceptible to invasions. Each park within the ERMN, MIDN, NCBN, and NETN is in close proximity to a major waterway, dissected by roads and trails, and/or bordered by developing communities and private lands. These waterways, roads/trails, and borders are all major “vector pathways” or means of introducing and moving invasive species from one point to another (Mack 2003). Each park is also impacted by visitor and animal use on a daily basis. MacDonald et al. (1989) linked increased visitor use to an increase in the number of invasive species in 41 southern Africa nature reserves, and Hodkinson and Thompson (1997) demonstrated that motor vehicles act as seed dispersal mechanisms. Animals, such as horses (Wells and Laurenroth 2007), deer (Myers et al. 2004), and birds (Simberloff and Von Holle 1999) are also potentially important seed dispersal vectors. In addition, parks like Marsh-Billings-Rockefeller National Historical Park are dealing with invasive plants that were deliberately planted as part of the historic estate design (Christina Marts, pers. comm., February 13, 2009).



Figure 1. Emerald ash borer (*Agrilus planipennis*). Photo taken by Jennifer Stingelin Keefer.

Why Perform Invasive Species Early Detection (ISED)?

Early detection followed by rapid response can detect and eradicate incipient populations of invasive species before they have a chance to become widely established; thus, eliminating the need for costly and resource-intensive control programs (Ashton and Mitchell 1989, OTA 1993, Atkinson 1997, Myers et al. 2000, Harris et al. 2001, Timmins and Braithwaite 2001, Rejmanek and Pitcairn 2002, FICMNEW 2003). Only when invasions are caught early will the chance of eradication remain high (Rozenfelds et al. 1999, NISC 2008). In addition to saving money, early detection and rapid response efforts minimize ecological damage by preventing habitat fragmentation and ecosystem degradation associated with large or widespread invasive species populations and related management activities (Smith et al. 1999, Timmins and Braithwaite 2001).

One of the most vital steps in confronting new invasive species problems is to know they exist (FICMNEW 2003). “Early Detection and Rapid Response” is one of five long-term strategic goals of the National Invasive Species Council’s (NISC) Management Plan (NISC 2008). It is also a main element of the Federal Interagency Committee for the Management of Noxious and Exotic Weed’s (FICMNEW) “National Early Detection and Rapid Response System for Invasive Plants” (FICMNEW 2003). Next to prevention, “early detection, rapid assessment, and rapid response (EDRR) is a critical second defense against the establishment of invasive populations” (NISC 2008).

To understand the benefits of early detection, it is easier to calculate the costs of an invasion where early detection was not performed. Damages associated with alien invasive species effects and their control amount to approximately \$120 billion/year (Pimentel et al. 2005). For example, the total cost of destruction by introduced rats on U.S. farms is more than \$19 billion per year, while invasive weeds, pest insects, and plant pathogens cause several billion dollars’ worth of losses to crops, pastures, and forests annually in the United States (Pimentel et al. 2005). The chestnut blight fungus

(*Cryphonectria parasitica*) and the virtual elimination of the American chestnut (*Castanea dentata*) in the early 1900's (von Broembsen 1989) demonstrate the potentially devastating economic and ecological consequences of invading species.

Eradication of established invasive species is difficult, if not impossible in many cases, but early detection and associated management responses have proven effective in reducing, if not eliminating, the associated costs and consequences (MacDonald et al. 1989, Braithwaite 2000). Early detection and rapid response success stories include retharrow (*Ononis alopecuroides*) in San Luis Obispo County, California (Tu 2002a), Egeria (*Egeria densa*) in the Connecticut River (Tu 2002b), and water hyacinth (*Eichhornia crassipes*) and parrot-feather watermilfoil (*Myriophyllum aquaticum*) in the Shawnee National Forest, Mississippi (Corey 2008).

Measurable Objectives

The goal of this protocol is to assist park managers in identifying high priority invasive species, quickly disseminating new occurrence information to all interested parties (NPS, public, private, etc.), and assessing the risk presented by incipient populations. In some situations, networks may assist with management of newly detected species.

The focus of early detection monitoring in the ERMN, MIDN, NCBN, and NETN will begin with surveillance monitoring of invasive plant and forest pest species and will focus on educating all field crews and interested cooperators, resource managers, and volunteers on invasive species identification. The protocol will also provide a coherent framework for reporting and disseminating information on potential infestations.

The primary monitoring objective is to detect incipient populations (i.e., small or localized) and new introductions of target invasive species on each park's early detection list through opportunistic observations before the species become established.

To achieve the monitoring objective, this protocol describes the following components:

- Develop and maintain a list of target species that occur in localized areas of parks, are extremely rare, or are not currently present within a park, but have the potential to cause major ecological, cultural, or economic problems if they were to become established;
- Develop, maintain, and distribute appropriate target species identification information to all ERMN, MIDN, NCBN, and NETN field crews and other interested cooperators, resource managers, and volunteers; and
- Develop and maintain an early detection reporting and tracking system that disseminates information on potential infestations in a timely and efficient manner.

These components will allow ERMN, MIDN, NCBN, and NETN member park resource managers to assess each invasive species' early detection on an individual basis and target limited management resources and coordination toward the highest priority risks.

Parks Involved

The following parks are included in Early Detection of Invasive Species; Surveillance, Monitoring, and Rapid Response:

Eastern Rivers and Mountains Network (ERMN)

All ERMN parks (Figure 2): Allegheny Portage Railroad National Historic Site (ALPO), Bluestone National Scenic River (BLUE), Delaware Water Gap National Recreation Area (DEWA), Fort Necessity National Battlefield (FONE), Friendship Hill National Historic Site (FRHI), Gauley River National Recreation Area (GARI), Johnstown Flood National Memorial (JOFL), New River Gorge National River (NERI), and Upper Delaware Scenic and Recreational River (UPDE).

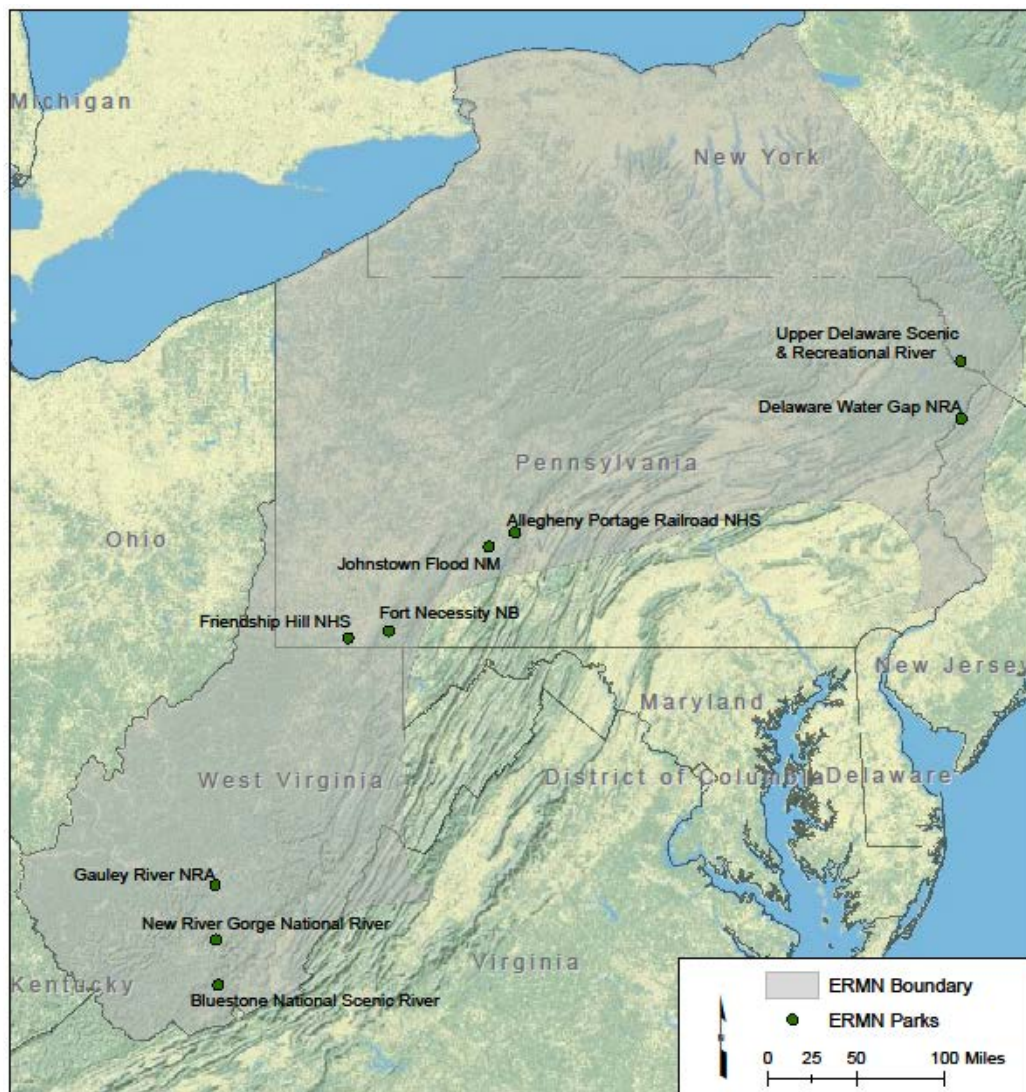


Figure 2. Location of parks in the Eastern Rivers and Mountains Network (ERMN) participating in the ISED program.

Mid-Atlantic Network (MIDN)

All MIDN parks, except Shenandoah National Park (SHEN) (Figure 3): Appomattox Court House National Historical Park (APCO), Booker T. Washington National Monument (BOWA), Fredericksburg and Spotsylvania National Military Park (FRSP), Gettysburg National Military Park (GETT), Hopewell Furnace National Historic Site (HOFU), Petersburg National Battlefield (PETE), Richmond National Battlefield Park (RICH), and Valley Forge National Historical Park (VAFO).

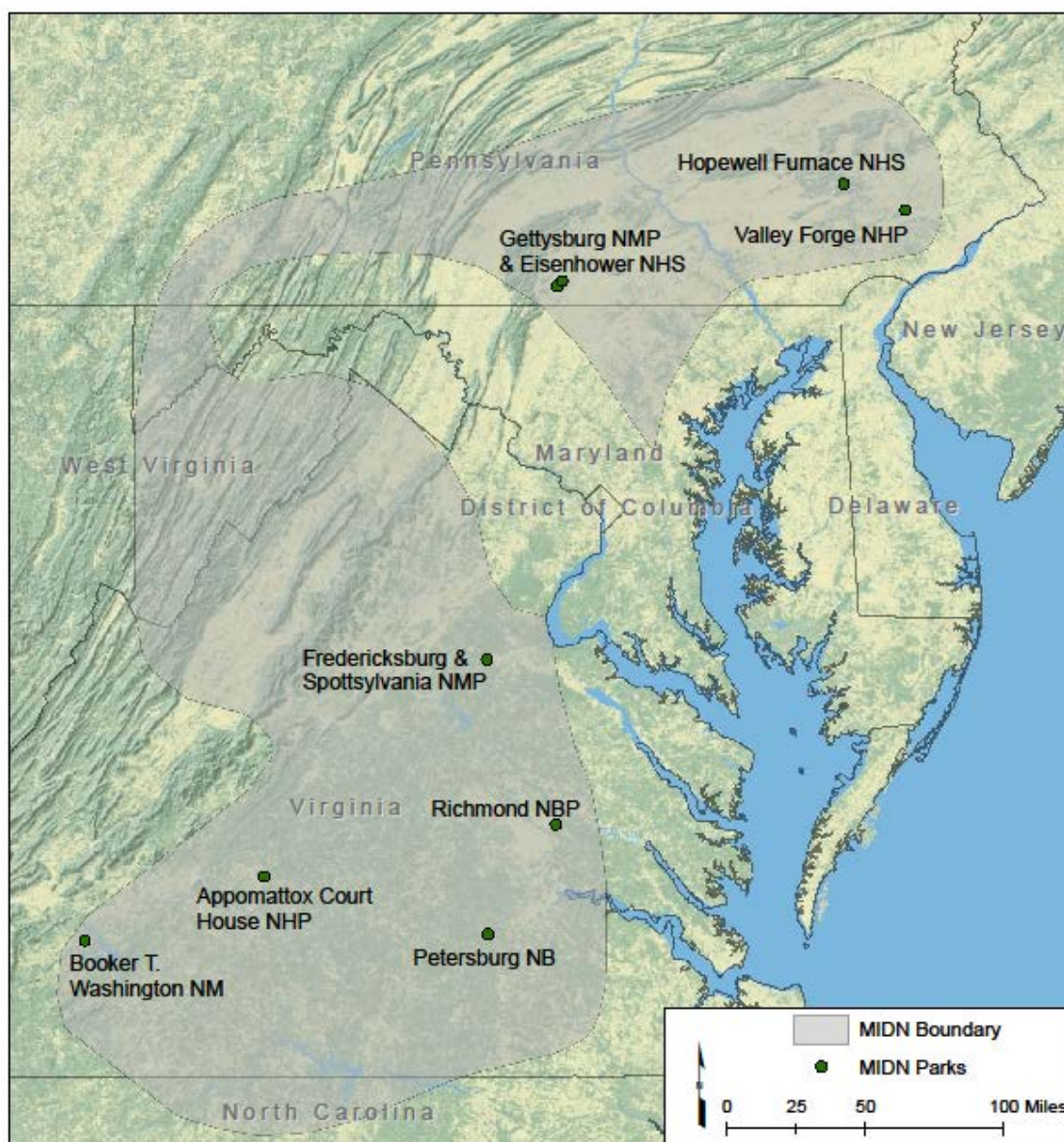


Figure 3. Location of parks in the Mid-Atlantic Network (MIDN) participating in the ISED program.

Northeast Coastal & Barrier Network (NCBN)

Parks with Forest Health Monitoring being conducted: Colonial National Historical Park (COLO), George Washington Birthplace National Monument (GEWA), Sagamore Hill National Historic Site (SAHI), and Thomas Stone National Historic Site (THST).

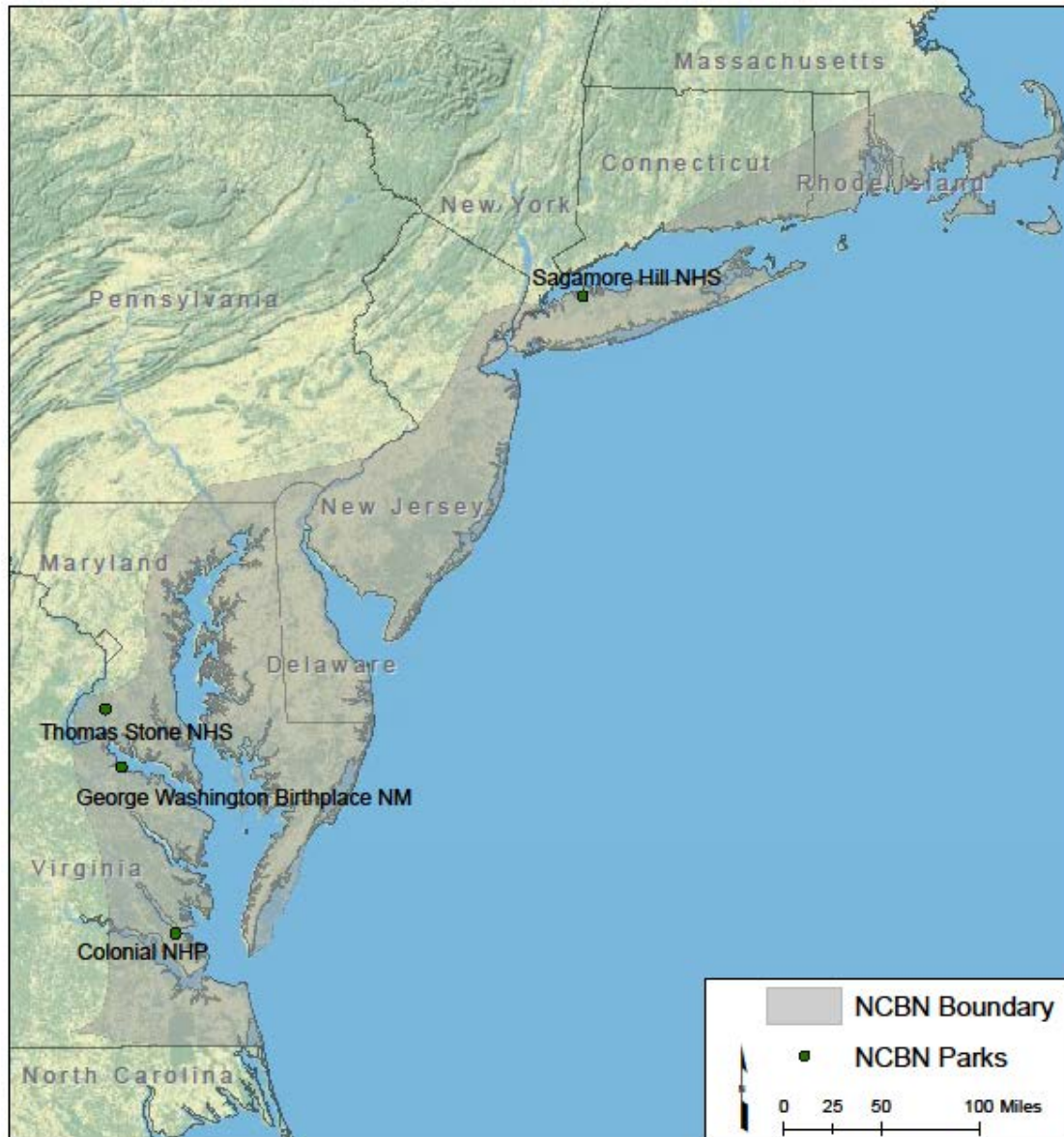


Figure 4. Location of parks in the Northeast Coastal & Barrier Network (NCBN) participating in the ISED program.

Northeast Temperate Network (NETN)

All NETN parks (Figure 3): Acadia National Park (ACAD), Appalachian National Scenic Trail (APPA), Boston Harbor Islands National Recreation Area (BOHA), Marsh-Billings-Rockefeller National Historical Park (MABI), Minute Man National Historical Park (MIMA), Morristown National Historical Park (MORR), Roosevelt-Vanderbilt National Historic Sites (ROVA), Saint-Gaudens National Historic Site (SAGA), Saugus Iron Works National Historic Site (SAIR), Saratoga National Historical Park (SARA), and Weir Farm National Historic Site (WEFA). ROVA includes Eleanor Roosevelt National Historic Site (ELRO), Home of Franklin D. Roosevelt National Historic Site (HOFR), and Vanderbilt Mansion National Historic Site (VAMA).

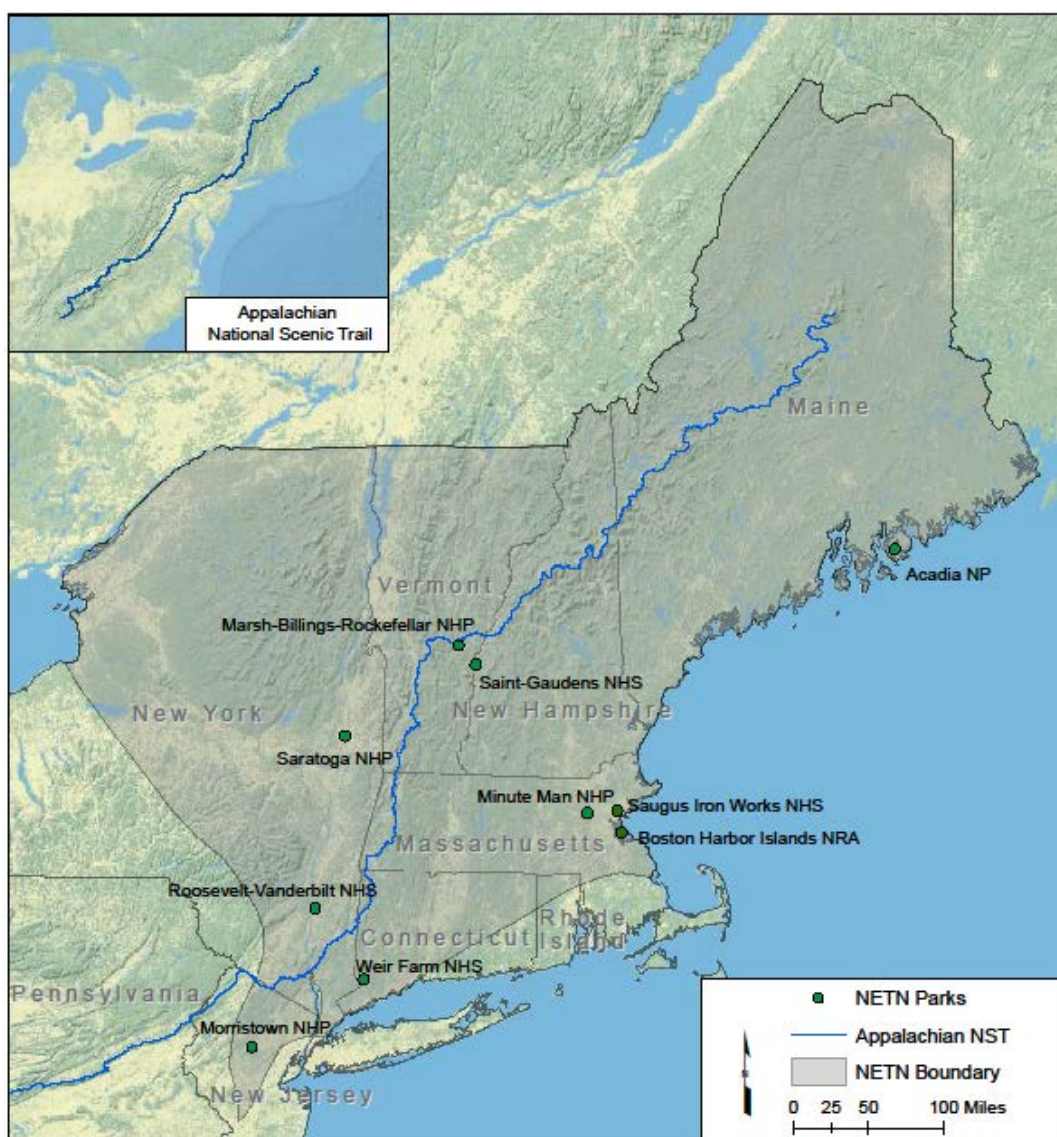


Figure 5. Location of parks in the Northeast Temperate Network (NETN) participating in the ISED program.

Sampling Design

Selecting Early Detection Species

The process for selecting a short list of target invasive species for each park in the ERMN, MIDN, NCBN, and NETN consists of four main components:

- Review existing park datasets and literature and compile a list of all invasive species known or thought to occur in the parks;
- Remove all common and well-established species from this list;
- Consult relevant existing invasive species data sources from nearby parks, towns, counties, and states for incipient invasive species not yet present in the parks and add them to the candidate invasive species early detection (ISED) list; and
- Conduct more extensive species research and consult with park natural resource managers to narrow down and create the final species lists for each park.

Initially, the protocol focused on terrestrial plants and insect pests. Version 2.0 (2014) incorporated aquatic plants and algae. Aquatic and terrestrial animals, as well as diseases, will be added if time and resources permit.

See SOP 1 – Updating Invasive Species Early Detection Lists to view the details of the invasive species early detection prioritization process for each network. An alternative prioritization approach is described in SOP 6 – Appalachian National Scenic Trail Invasive Species Prioritization. The Appalachian Trail Non-indigenous Plant Assessment System described in this SOP is a Microsoft Access-based tool that streamlines some of the species assessment process by automating the linking of tables contained in the NPSpecies database and species ranking systems that then generate numerical scores, enabling the user to prioritize ED species candidate lists.

The final ISED park lists are managed by the ISED program leads and generally consist of between 10 and 20 species, although 10–15 is a more realistic number of species individuals can be expected to recall and identify in the field while conducting other duties (Leslie Mehrhoff, pers. comm., January 15, 2008). Parks that employ volunteers for the ISED protocol may also have a subset of species suitable for individuals with varying levels of botanical experience.

ISED lists for each park will be reviewed periodically by network staff, park natural resource managers, and other pertinent contacts to ensure that the list is current and contains the top priority species. New invasive species threats should be evaluated for possible inclusion in a park's ISED list, while the prior year's list of species should be evaluated to determine if any should be removed from the list. For example, if an early detection (ED) species is detected and eradicated, the species will likely remain on the park ISED list. However, if an ED species is detected at high levels and not eradicated due to lack of resources or type of infestation, the natural resource manager, Exotic Plant Management Team (EPMT), and field crew leaders will be consulted to determine whether the species should be removed from the park ISED list. In situations where ED species are present in

localized areas of the park and are predicted to spread but absent from the rest of the park, the park natural resource manager will be consulted regarding species list inclusion or removal and included in all decision-making processes. See SOP 1 – Updating Invasive Species Early Detection Lists to see the process for creating new invasive species short lists of candidate species and questions to ask when prioritizing new species.

Invasive Species Early Detection Field Guide

To assist with the identification of target early detection species, ISED cards will be provided to monitoring crews and interested parties. Target species identification information is distributed via park-specific field guides that contain the relevant species from two separate field guides. The first is a hand-held, weather-proof pocket guide provided cost-free by the USDA Forest Service (USFS), “Invasive Plants Field and Reference Guide: An Ecological Perspective of Plant Invaders of Forests and Woodlands,” (USFS field guide) (Huebner et al. 2005). The second is a supplemental identification field guide developed by the ERMN and NETN. Production of the “Early Detection of Invasive Species Surveillance Monitoring Field Guide” (NPS field guide) and 11 species cards were completed in 2009 by the ERMN and 11 terrestrial and 9 aquatic species were added through 2013 by NETN. Additional cards will be added in the future on an as-needed basis. Each completed species card, as well as the entire field guide, will be posted on-line and made available for download at http://science.nature.nps.gov/im/units/ermn/monitor/earlydetection_targets.cfm (ERMN) and http://science.nature.nps.gov/im/units/netn/monitor/programs/invasiveSpecies/earlydetection_guides.cfm (NETN).

The USFS’s Adobe® InDesign® template for the USFS field guide was utilized to create the NPS’s field guide with the same look and feel of the USFS publication. Each species card in the NPS field guide contains a concise species description, photos, and commonly misidentified/look-alike species. Title, index, and reference pages are also included. Each card is color-coded to easily identify the general taxonomic category or life form, in the case of plants. For the purpose of this protocol, the word “Pest” represents non-plants. The NPS field guide title page and an early detection card example are presented in Figure 6.

Park-specific cards containing a list of target species for each park and designated park contact information were designed to be integrated into each park’s customized field guide. Figure 7 shows a specific park example. When arriving at a new park, each monitoring crew (or participating staff and volunteers) will insert the new park species list card and then add the designated early detection species list cards to the field guide.

Reporting invasive species detections via a smartphone app is highly encouraged to simplify data management (see SOP 3 – Data Collection: What’s Invasive). However, as an alternative, each taxonomic group (i.e. pests and plants) will have a different data reporting form in the park-specific field guide. Forms are produced on “Rite in the Rain”® all weather paper, are compatible with the NPS and USFS field guides, and contain early detection reporting directions (See SOP 2 – Data Collection: ISED Reporting Forms). Directions include information on how to properly mark the observation location, how to take a descriptive photo, and where to send the observation information.

Form fields can be viewed in SOP 2 – Data Collection: ISED Reporting Forms at the end of this document.

Initial coordination and production of new species identification cards for 32 parks was implemented from 2011 to 2013 to complement (not duplicate) species information already present in the USFS field guide. As new park species threats arise, new species cards will be produced.

Opportunistic Sampling

“Every person working or recreating in a national park has the potential to serve as an early detector” (Williams et al. 2007). Given available funding in the ERMN, MIDN, NCBN, and NETN, the networks’ existing monitoring crews initially will be used for opportunistic sampling. Because these crews are already performing monitoring field work in the parks, there are no additional travel and personnel costs. Knowledgeable crew members provide an additional “set of eyes and ears” to detect incipient species occurrences while they are collecting data at monitoring sites, walking to and from monitoring sites, and driving along park roads. Park natural resource managers, EPMTs, volunteers, and other NPS individuals with scientific backgrounds will be used for their daily park presence also. If time and resources permit, other individuals, like park maintenance crews and local organizations, will be trained to aid in the effort.

When resources and personnel time permits, a more targeted approach to locating incipient populations of invasive species may be worthwhile. For example, a stratified random sampling approach has been developed for APPA as an optional method for invasive species detection (SOP 7 – Appalachian NST Sampling Design and Field Procedures). This method targets surveys on the Appalachian Trail footpath as well as locations within a 2-mile buffer of the trail by creating random data points using the Generalized Random Tessellation Stratified (GRTS) algorithm. An adaptive sampling design may be employed if time and resources do not allow for a full stratified random approach. An adaptive sampling approach uses a stratified random or other statistical sampling design, but incorporates lower plot density with the potential for additional plots when an invasive species is detected within the originally defined search zone. Adaptive methods are generally more effective in locating detections than standard transect approaches (Maxwell et al. 2012), and can be especially valuable for mapping the extent of a dispersed local population of an invasive species. The adaptive cluster sampling method described by Maxwell et al. (2012) provides a very time-efficient and effective approach when implemented along roads or other conduits of invasive species introductions. However, managers should be aware that adaptive sampling methods often overestimate infested areas and that detection remains relatively low ($\leq 33\%$) among invasive species populations.

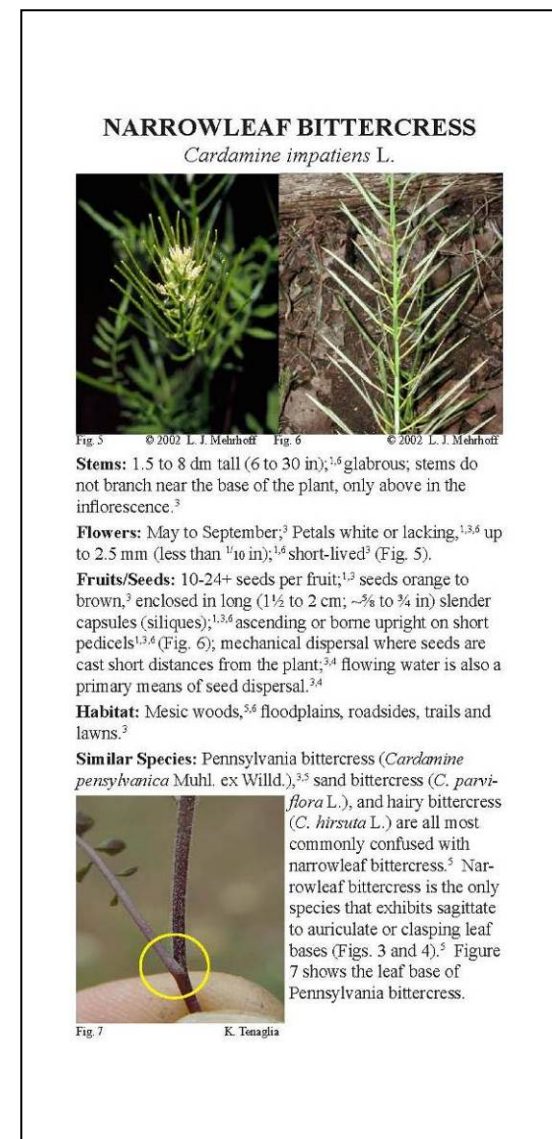
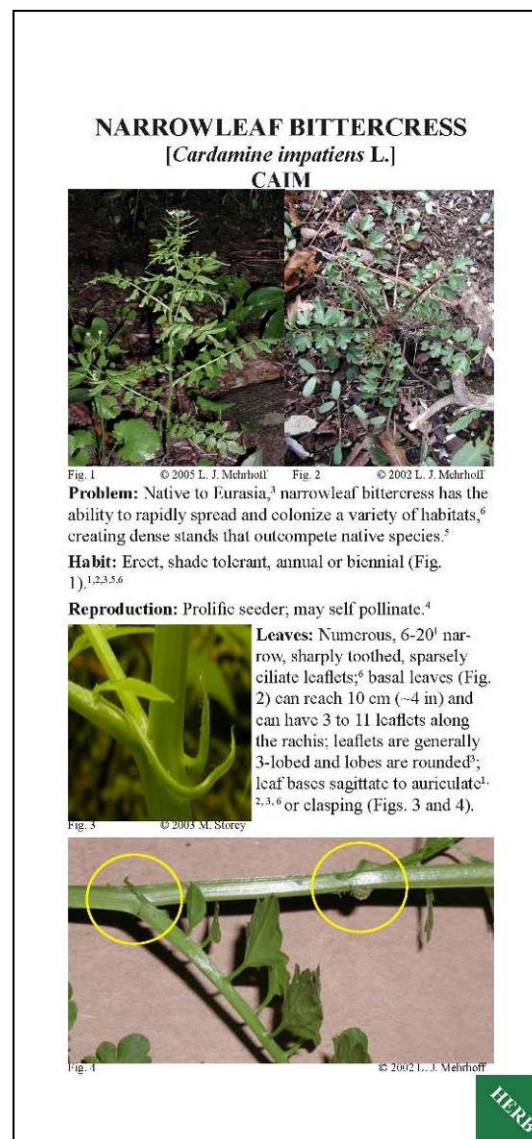
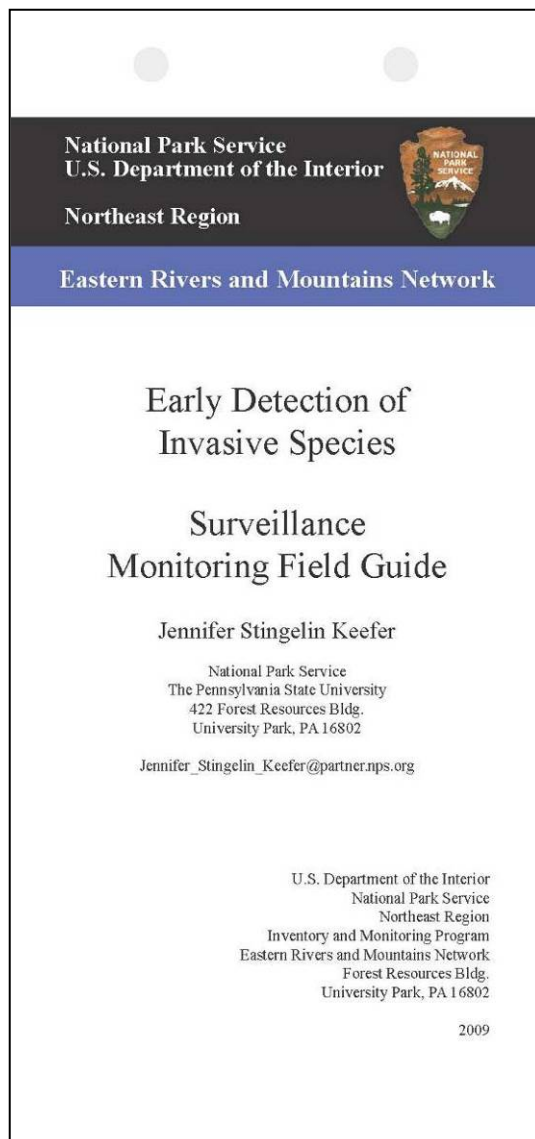


Figure 6. Early Detection of Invasive Species Surveillance Monitoring Field Guide title page and species card example.

<div data-bbox="305 338 691 443"> <p>WEST VIRGINIA Bluestone National Scenic River BLUE</p> </div> <div data-bbox="246 476 747 531"> <p>Designated park contact for noxious and high priority species ONLY:</p> </div> <div data-bbox="391 533 604 678"> <p>John Perez 104 Main St. Glen Jean, WV 25846 304-465-6537 John_Perez@nps.gov</p> </div> <div data-bbox="243 707 748 825"> <p>Noxious weeds and high priority species are designated with an asterisk. Please see "Species Reporting Forms" for contact information when reporting ALL OTHER early detection species for the WV parks.</p> </div> <div data-bbox="475 833 524 858"> <p>Pest</p> </div> <div data-bbox="243 877 660 905"> <p><i>Agilus planipennis</i> emerald ash borer*</p> </div> <div data-bbox="469 917 531 940"> <p>Herb</p> </div> <div data-bbox="243 959 719 1188"> <p><i>Dioscorea oppositifolia</i> Chinese yam <i>Heracleum mantegazzium</i> giant hogweed* <i>Oplismenus hirtellus</i> ssp. <i>undulatifolius</i> wavyleaf basketgrass <i>Phragmites australis</i> phragmites <i>Polygonum cuspidatum/</i> Japanese/giant knotweed* <i>P. sachalinense</i> <i>Ranunculus ficaria</i> lesser celandine</p> </div> <div data-bbox="472 1203 524 1228"> <p>Vine</p> </div> <div data-bbox="243 1245 669 1413"> <p><i>Akebia quinata</i> chocolate vine <i>Ampelopsis brevipedunculata</i> Amur pepervine <i>Celastrus orbiculata</i> Oriental bittersweet <i>Polygonum perfoliatum</i> mile-a-minute <i>Pueraria montana</i> var. <i>lobata</i> kudzu</p> </div> <div data-bbox="729 1507 810 1589"> <p>SPECIES</p> </div>	<div data-bbox="945 327 1292 390"> <p>WEST VIRGINIA: BLUE CONTINUED</p> </div> <div data-bbox="1079 399 1156 424"> <p>Shrub</p> </div> <div data-bbox="863 445 1286 529"> <p><i>Berberis thunbergii</i> Japanese barberry <i>Frangula alnus</i> glossy buckthorn <i>Rhamnus cathartica</i> common buckthorn</p> </div> <div data-bbox="1091 543 1148 567"> <p>Tree</p> </div> <div data-bbox="863 583 1255 611"> <p><i>Acer platanoides</i> Norway maple</p> </div> <div data-bbox="1073 625 1164 651"> <p>Aquatic</p> </div> <div data-bbox="863 674 1185 701"> <p><i>Didymosphenia geminata</i> didymo</p> </div>
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Figure 7. Park-specific target early detection species list card example.

The benefit of utilizing volunteers for ISED has been successfully demonstrated nationwide (Williams et al. 2007, Leslie Mehrhoff, pers. comm., 2008, Webb n.d.). Although volunteer training and coordination is not feasible at most parks, given available funding, an example of volunteer training and use for ISED occurred in 2009 at Boston Harbor Islands National Recreation Area (BOHA). The one-day training was coordinated by the ERMN Invasive Species Early Detection Coordinator (ISEDCC), park natural resource manager, and NETN personnel, and was conducted by Les Mehrhoff, Director of the Invasive Plant Atlas of New England (IPANE). The training included protocol background information, a PowerPoint presentation, specimen identification, field walk, and an identification quiz. All volunteer surveillance activities are being coordinated by the BOHA Natural Resource Manager. To obtain a copy of the BOHA volunteer training agenda and PowerPoint presentation, contact Marc Albert, BOHA Natural Resource Manager.

Alert System

Data acquired from ISED are time-sensitive, and all new detections should be immediately reported through the appropriate chain of command as described in SOP 2 – Data Collection: ISED Reporting Forms. In all networks it is the responsibility of each observer or monitoring crew leader to promptly report all new species detections and deliver completed field reporting forms (originals or copies), photographs, and/or specimens to the designated park contact prior to completing field work in that park.

Alternatively, ISED detections can be reported with smartphones using the application (app) “What’s Invasive!” or on-line at www.whatsinvasive.com. See SOP 3 – Data Collection: What’s Invasive! for details. This app and website were developed by the Early Detection & Distribution Mapping System (EDDMapS), which is the University of Georgia’s Web-based mapping system for documenting invasive species distributions. Smartphone apps can be downloaded for the iPhone at <https://itunes.apple.com/us/app/whats-invasive/id410103132?mt=8> and for the Android at <https://play.google.com/store/apps/details?id=edu.ucla.cens.whatsinvasive>.

In the NETN, it is then the responsibility of the designated park contact to forward all ISED information to the ISEDCC, additional park and regional personnel, EPMTs, and outside agencies, as appropriate. In the ERMN, each observer or monitoring crew leader will also be responsible for alerting the ISEDCC to all new species detections and delivering completed field reporting forms (originals or copies), photographs (originals or copies), and/or specimens upon return to the network office. Alerting the ISEDCC, in addition to the designated park contact, ensures the species will be reported in a timely manner and removes the added burden of relaying information to the network from the designated park contact. In cases where noxious weeds or high priority pests are detected, the ISEDCC will follow-up with each designated park contact and may assist with alerting relevant outside agencies. See SOP 4 – Rapid Response for more information on the ISED alert system.

Rapid Response

Rapid responses to invasions are effective and can prevent the spread and establishment of invasive species. Coordinating and/or executing a rapid response is/are primarily the responsibility of the respective park resource manager(s) where the infestation was detected. Rapid response should include positive species identification and management/eradication activities, and may involve

coordination with the EPMT, agencies such as the Bureau of Plant Industry and the Animal and Plant Health Inspection Service (APHIS) within the U.S. Department of Agriculture, local weed management organizations, and network and park personnel, as well as park interns. Each response will be based on the individual needs of the park and the resources available (SOP 4 – Rapid Response).

At the conclusion of the field season, park resource managers should evaluate their responses to invasive species early detections and ask the question, “Could we do better next time?” Rapid response assessments will provide critical information that will improve the quality and timeliness of future rapid responses.

Mapping

To accomplish additional invasive species tracking and reporting, ERMN, MIDN, NCBN, and NETN will be using the smartphone app What’s Invasive! in conjunction with EDDMapS (www.eddmaps.org). At the time of writing, the Principal Investigators for EDDMapS are Chuck Barger and David Moorhead of the University of Georgia's Center for Ecosystem Health and Invasive Species. The Internet application combines Google Maps with interactive county-level species introduction data and documents distribution across the country. EDDMapS provides a convenient solution for the storage, display, and sharing of occurrence and distribution data on known and newly introduced invasive species. The system will continue to expand and be increasingly valuable as more data are obtained and entered. National parks and other organizations and individuals around the country can input county-level and point location information on invasive species. These data are then immediately accessible to all system users and, more specifically, users who request occurrence alerts for user-defined alert areas. Once well populated with species occurrence reports, it will vastly expand the ability of land managers to review and prioritize invasive species management and prevention needs and identify potential information gaps that need to be addressed. As time and resources permit, direct collaboration with other mapping programs like IPANE, iMapInvasives, and IPAlert would be beneficial to all networks. All new ISEDs that were not reported using What’s Invasive! will be entered annually into EDDMapS by the ISEDC by late fall (This is done automatically when reporting with What’s Invasive!).

Use of the What’s Invasive! / EDDMapS mapping system, in conjunction with the network websites, will provide a data entry port, alert system, and a one-stop resource for invasive species information, including links to other invasive species websites, photos, important contacts, and other information for potential use by the entire Northeast Region. To view the current ERMN website, visit <http://science.nature.nps.gov/im/units/ermn/monitor/earlydetection.cfm>.

Field Methods

Field Season Preparations and Equipment Set-up

Prior to the commencement of a field season (see Annual Workload and Field Schedule below), the ISEDC is responsible for coordinating and making any changes or additions to each park species list, creating new species cards, and printing park species lists, reporting forms, and field guides. Materials will be distributed on an as-needed basis.

Because this protocol is initially being carried out by existing network monitoring crews, additional equipment preparation and set-up will be minimal. Each ERMN, MIDN, NCBN and NETN monitoring crew will utilize their own respective monitoring equipment (i.e., GPS unit, digital camera, smartphone with invasive mapping and reporting application, and first aid kit) with the exception of the following items that will be provided by the ISEDC:

- Early Detection of Invasive Species Surveillance Monitoring Field Guide
- USFS Invasive Plants Field and Reference Guide
- Individual park species lists
- Pest and Plant Reporting forms
- Additional species identification materials (as necessary)

Volunteers and park personnel not involved with network monitoring should have the following list of supplies before performing invasive species surveillance monitoring:

- Smartphone with invasive mapping and reporting application (recommended)
- GPS unit and spare AA batteries
- GPS antennae and spare battery (if applicable)
- Biodegradable flagging (red or pink)
- Pencils (sharpened or with extra lead)
- Permanent markers
- 10x hand lens
- Digital camera, extra batteries
- Sealable gallon-sized plastic bags for plant or pest samples
- Early Detection of Invasive Species Surveillance Monitoring Field Guide
- USFS Invasive Plants Field and Reference Guide
- Individual park species lists
- Pest and plant reporting forms
- Additional species identification materials (as necessary)

Gathering Field Data

The primary directions and details regarding field data gathering can be found in SOP 2 – Data Collection: ISED Reporting Forms and SOP 3 – Data Collection: What’s Invasive! All field crews should operate in a safe manner and should review their respective safety protocols, such as the MIDN/NETN Forest Health Monitoring SOP 1 – Safety (Tierney et al. 2013). Generally, when an

ED species is encountered by a monitoring crew member, he/she will physically mark the location of a detected species with biodegradable flagging (at the request/permission of the park's resource manager, and label it with permanent marker), record species occurrence, location information, and confidence of identification, and take photograph(s) of distinguishable features and/or signs and symptoms, in the case of pests. If a plant is observed, the infested area, stem count, habitat, vigor, and site accessibility will be recorded. If a pest is observed, host species, host species evidence, such as crown dieback, foliar injury symptoms, and general injury, and additional factors, such as habitat and site accessibility, will be recorded.

Crew members will follow SOP 5 – Limiting Exotic Seed Transport in order to reduce the potential spread of invasive species to other areas or parks.

Sample Collection and Post-collection Processing

Photographic or specimen vouchers may be taken and/or collected to confirm identification of ED species, especially those that are likely to be identified incorrectly. Photographic specimens are preferred to avoid potential spread of invasive plant and pest material. In some cases, if collecting is permitted by the specific park, small or partial specimens may be collected and stored in a plastic bag or vial. Specimens are only used for confirmation of ED species identity and will not be stored in a collection.

Photographs received from field observations will be named in accordance with network file naming standards. For example, park, protocol, name of specimen or brief description, location or site code, sequence number, date (yyyymmdd), observer:

DEWA_ISED_*Viburnum dilatatum*_Hialeah_03_20091020_JShreiner.jpg

ERMN, MIDN, NCBN, and NETN's species identification photographs will be stored on the respective network's server for future reference.

Data Management and Reporting

Database

Currently, the ERMN, MIDN, NCBN, and NETN are using Microsoft Excel spreadsheets and ArcGIS maps to keep track of all new invasive species occurrences. The EDDMapS database is the formal repository for all ISED observations; storing species record information that can be viewed by the public on the EDDMapS website.

Data Entry, Verification, and Validation

Data processing typically involves the following steps: initial raw data verification, data entry, electronic data verification, data processing, and storage/backups. The initial raw data verification includes reviewing photos and confirming species identification. Data entry consists of transferring raw data from field data forms and/or ISED e-mail alerts into the EDDMapS database or inputting data into a smartphone application. Data verification immediately follows data entry and involves checking the database records, GPS coordinates, and the original data entry forms for accuracy. Validation procedures seek to identify generic errors (i.e. missing, mismatched, or duplicate records), as well as logical errors specific to the protocol. The ISEDC will initially be responsible for data entry and 100% verification and validation, and will be in charge of contacting field observers to rectify any discovered GPS coordinate or observation form inaccuracies.

Data Archival Procedures

Raw and back-up copies of field data forms will be stored at the appropriate network office. Data forms and exported records from EDDMapS will be archived and backed up according to each network's data management plan. ISED species lists are stored in a Microsoft Excel spreadsheet. This spreadsheet acts as a repository for the most up to date ISED species list, archived lists from previous years, and records of detections and responses to those detections.

Annual park species lists will be housed in Excel spreadsheets that are managed by the ISED protocol lead. This spreadsheet will also contain the year(s) that species are added or removed from the list, observed in the field, the rapid response action taken, if any, and if the detection was reported to EDDMapS.

Data Analysis and Reporting

The ISEDC will communicate with all park contacts on an annual basis in late fall or winter to review associated park ED species lists, receive feedback, and make any necessary adjustments to the protocol. Summary year-end reporting will be conducted by the ISEDC annually in the fall and will consist of two major formats: an annual summary report and a resource brief. ERMN and NETN will produce annual summary reports and resource briefs, whereas MIDN and NCBN will provide less formal updates to participating Parks as needed. A Natural Resource Data Series report targeted towards natural resource managers, summarizing species detections, rapid responses, and success stories, will be distributed every year. An informational resource brief targeting park interpreters and superintendents will also be distributed. In addition, e-mails to network and regional staff, as well as other federal, state, and private organizations, and website updates will be conducted on an as-needed basis.

Protocol Revision

This protocol is a living document. Changes and revisions will be incorporated into the protocol as we learn more about invasive species early detection and rapid response. Changes will be documented in the Change History logs at the beginning of this narrative and in each SOP. Changes to this narrative will also be tracked using the ERMN, MIDN, NCBN and NETN file naming conventions and archived at the network level.

Personnel Requirements and Training

Roles and Responsibilities

The ISEDC for each network serves as the project manager and works closely with existing monitoring crews, especially each network's vegetation monitoring crew members (or leader, if this is not the same person as the ISEDC). ISEDCs are responsible for protocol development, refinement, overall quality assurance, database development, website development, and coordinating with their counterpart in the other networks, as well as outside agencies, private organizations, and regional mapping programs (e.g. EDDMapS). Data management is the responsibility of the ISEDC, and occasional assistance will be needed from network data managers and science communication specialists to assist with database and website development. The ISEDC is also responsible for training field crews in how to identify invasive ED plant and pest species and, on occasion, making site visits to confirm ED species occurrences. This position requires moderate to high skill with plant and pest identification, writing, and ability to effectively communicate with park personnel and citizen scientists. Basic database management and development, GIS, and website design skills are also helpful, but may also be supplied by other network staff. The ISEDC is designated and/or contracted by the respective network program managers.

Training Procedures

Training is essential for the proper identification of invasive pests and plants. The ISEDC must ensure that all monitoring crew members and other observers have a clear understanding of the major identifying characteristics of each early detection species as well as characteristics of common look-alike species. Training materials will include NPS and USFS field guides, photographs, and supplemental texts or presentations.

Because this protocol is primarily being carried-out by existing network monitoring crew members, additional training will be minimal. Prior to field season, all monitoring crew members and observers must review the network safety plan and the entire ISED protocol. All will engage in training exercises (e.g., test plot or site) designed to meet their individual monitoring protocol needs. Each network monitoring crew will utilize their own respective monitoring protocol SOPs for training specifics. For example, for field season preparation and Global Positioning System utilization, the ERMN vegetation monitoring crew will utilize Using the Global Positioning System (GPS) and Field Season Preparation SOPs (Perles et al. 2009).

Training will occur prior to each monitoring crew's respective field season (Table 1); for other observers it will occur prior to the peak of the growing season. If a single training does not work for all monitoring crews, some crews will receive separate pest and plant identification training provided by the ISEDC, or, in NETN's case, a "Road show" presentation by the Science Communication Specialist. The vegetation monitoring crew will receive separate pest and plant identification training provided by the ISEDC. Crews deficient in plant and pest identification skills will receive additional training on a case-by-case basis. In the future, as additional non-natural resource park personnel (e.g., interpretation and/or maintenance staff), and possibly volunteers, become involved, this protocol will be modified to include specific training instructions geared towards these focus groups.

Table 1. General field season sampling months for each monitoring crew in the Eastern Rivers and Mountains Network (ERMN), Mid-Atlantic Network (MIDN), Northeast Coastal & Barrier Network (NCBN) and Northeast Temperate Network (NETN).

Monitoring Protocol Crews	ERMN Parks	NETN Parks	MIDN & NCBN Parks	Field Season
Forest Vegetation	All parks except UPDE			May–August
Forest Vegetation			All MIDN parks except SHEN NCBN parks include: COLO, GEWA, SAHI, THST	July–Sep
Forest Vegetation		All parks except APPA, BOHA, SAIR		May–July
Benthic Macroinvertebrate	ALPO, BLUE, DEWA, FONE, FRHI, NERI			March–May
Streamside Birds	ALPO, BLUE, DEWA, FONE, FRHI, NERI			May–June
Coastal Breeding Birds		BOHA		May–July
Breeding Landbird		All parks except APPA, BOHA		May–July
Water Quality and Quantity		All parks except APPA, BOHA	All MIDN parks	May–October
Salt Marsh Vegetation		ACAD, BOHA, SAIR		August
Freshwater Wetlands		ACAD		August

Operational Requirements

Annual Workload and Field Schedule

While ISED can occur year-round, the majority of surveillance will commence with each monitoring field season. Table 1 lists general field season sampling months for each monitoring crew. The ISEDC will be responsible for year-round data management, annual reporting, website updates, and communications with individual parks.

Budget and Staffing Scenarios

This protocol is flexible and can operate on varying budget levels. Currently, field staffing consists of existing monitoring crew members and park personnel. Now that the ISED protocol is in the implementation phase, ISED responsibilities are assigned to network staff. Table 2 details the estimated in-kind cost for implementing the protocol with a network ISEDC. The ISEDCs for ERMN, MIDN, NCBN, and NETN are permanent network employees; additional travel and salary costs are minimal. Material costs up to \$1,000 per year may be required for ISED card production and field data forms printed on “Rite in the Rain”® all-weather paper. Since all equipment is on-hand and being used by existing monitoring crews, additional equipment and supply costs are minimal.

Table 2. Estimated yearly costs for one permanent network Invasive Species Early Detection Coordinator (ISEDC) to coordinate all invasive species early detection activities for the Eastern Rivers and Mountains Network (ERMN) and Northeast Temperate Network (NETN).

Line Items	Estimated Yearly Costs
Salary 6 weeks (GS-7 equivalent)	\$4,500
Materials	\$1,000
Total	\$5,500

Rapid response will be assessed on an as-needed basis. Depending on the size of the infestation and whether the species is a pest, pathogen, or plant, EPMTs, network staff, park staff, and/or outside agencies will be contacted to curb rapid response costs. Currently, qualified monitoring crews may remove small infestations of plants if the population size is small and the complete removal of the plant is feasible, except when the detection occurs in a monitoring site. If monitoring crews do remove an ISED population to increase the efficiency of the rapid response, care will be taken to inform and coordinate the action with the Designated Park Contact (DPC). Generally, it is up to the park to conduct rapid response measures and the network will assist on an as-needed and as-available basis.

Facility and Equipment Needs

Minimally, the ISED coordinator will need a regular phone line with long-distance calling for Internet and Intranetwork communications, an e-mail account, and a computer with several software programs installed. Table 3 shows computer software required to perform ISED. Occasionally, transportation will be required for park visits.

Table 3. Computer software required to perform invasive species early detection duties in the Eastern Rivers and Mountains Network (ERMN), Mid-Atlantic Network (MIDN), Northeast Coastal & Barrier Network (NCBN), and Northeast Temperate Network (NETN).

Software Programs	Reason
Microsoft Office	
Access/Excel	ISED database; General database management
Word	Publications development and reporting
Adobe Products	
InDesign	ISED card development and production
Dreamweaver	ISED web site development
Acrobat	ISED card production
Photoshop	ISED card production
ESRI ArcMap or ArcView	ISED Mapping

Interagency Cooperation and Education

Invasive species do not conform to political boundaries, and interagency cooperation and information sharing is vital to the battle waged against them. Partnerships and networking is one of the main goals listed in the “National Early Detection and Rapid Response System for Invasive Plants in the United States” (FICMNEW 2003). ERMN, MIDN, NCBN, and NETN staff are already working closely with network parks, EPMTs, and the Northeast Region Integrated Pest Management Coordinator. In addition, several of the network parks are currently cooperating with the United States Forest Service (USFS), Animal and Plant Health Inspection Service (APHIS), state agencies, Cooperative Weed Management Areas (CWMA), and private organizations for guidance and technical rapid response assistance. Similar cooperation and information sharing should be encouraged whenever appropriate. See Appendix A and B for a list of interagency contacts by state and taxa.

If time and resources permit, network staff will work closely with parks to educate the public on the importance of invasive species early detection. Visitor centers, campgrounds, and boat launch areas are examples of areas where informative posters or displays could be placed to make an impact regarding public awareness of invasive species.

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SOP 1 - Updating Invasive Species Early Detection Lists

Version 1.01

Every year, each park's invasive species early detection (ISED) list will be reviewed by ERMN staff, park natural resource managers, and other pertinent contacts to ensure that the list is current and contains the top priority species. Most NETN park ISED lists will be reviewed biennially (except BOHA and SAIR every three years), following the sampling schedule of the Forest Health Monitoring crew (Table S1.1). MIDN and NCBN ISED lists will be reviewed at least every five years, starting with their ISED program adoption year of 2012. The prioritization process for creating the initial ISED list for each network is described in Appendix C. New invasive species threats should be evaluated for possible inclusion in a park's ISED list, while the prior year's list of species should be evaluated to determine if any should be removed from the list. For example, if a species on a park's ISED list is detected and eradicated, the species will likely remain on the list. However, if an Early Detection (ED) species is detected at high levels and not eradicated due to lack of resources or type of infestation, the natural resource manager, Exotic Plant Management Team (EPMT), and field crew leaders will be consulted to determine whether the species should be removed from the park ISED list. The following steps should be taken to produce a new short list of invasive candidate species to add to a park list:

1. Review the previous year's candidate species and invasive species early detection lists. Species marked as low priority or species waiting to receive confirmation regarding presence/absence are good candidates. Pay attention to species presence status at nearby parks. A species could be absent at one park, but present at an adjacent park or park that is located several counties away.
2. Speak with the park natural resource manager or relevant park contact to determine if he or she has any new information or concerns (e.g. recent early detections and their population extent, nomination of new species to add to the ISED list).
3. Speak with the EPMTs to determine if they have any new information or concerns.
4. Check the Early Detection and Distribution Mapping System (EDDmapS; <http://www.eddmaps.org/>), the Non-indigenous Aquatic Species (NAS) database (<http://nas.er.usgs.gov/Default.aspx>), and other pertinent databases and invasive species information storehouses for updates on species distributions and new species occurrences.
5. Where appropriate, network and call local and regional invasive species contacts. Each federal, state, and private agency, non-profit group, and invasive species expert may have new information regarding the spread of a new invasive species.

Once a short list of possible candidates is generated, the species prioritization process must take place. The following questions should be asked when prioritizing each new invasive species:

1. Does the species have an invasive history? “A species is likely to become invasive in a new habitat if it has a prior history of invasion elsewhere” (Rejmanek 2000, National Research Council 2002).
2. What is the species’ current distribution and have there been any recent outbreaks? What is the species proximity to the park? If aquatic, does it occur up or downstream of the park?
3. Does the species have the potential to become naturalized in the park?
4. Does species have the potential to establish in minimally managed habitats?
5. What is the species’ habitat suitability (e.g., wetland or upland forest)? A wetland species is not as high a threat to a park that does not contain wetland habitat.
6. Are there host species present (pests and diseases only)?
7. Is the species a significant threat to park resources and communities of ecological significance (e.g., bogs, river scour communities, cliff communities)?
8. Does the species negatively affect forest crop production, commercial agriculture, or human health?
9. Does the species possess reproductive strategies and dispersal mechanisms that enable it to disperse rapidly and widely? A species that reproduces by seed and is dispersed by animals is more likely to be a threat than a species that reproduces only by vegetative means.
10. Does the species have a competitive ability? For example, if the species is a plant, does it have an advantage over native plants when acquiring resources like water, light, and nutrients?
11. If the species already exists in the park, have there been any disturbances or changes in the park landscape that would alter or enhance the species’ invasibility?
12. What are the individual parks’ desires? *Didymo* might be impossible to currently control, but species tracking and spread prevention via public education might be important to the park.
13. What is the NatureServe Explorer Invasive Species Impact Rank (I-Rank) if available?
I-Rank should only be used for guidance in the prioritization process. “Species for which I-Rank information is currently available do not represent a random sample of species exotic in the United States; available assessments may be biased toward those species with higher-than-average impact.” (NatureServe 2009).
14. Using the Invasive Plant Atlas of the United States (www.invasiveplantatlas.org), search by park to see what is listed as top invasive plants within that park. Consider candidates that have high invasive potential but are not already on the list.

In some cases it might be helpful to discuss each species with other natural resources professionals to help narrow down each park’s invasive early detection species. It is important to remember that this process is not perfect and outcomes can vary depending on who is involved in the prioritization process and how much weight is placed on the answer to each prioritization question listed above.

After completing species prioritization, each park species list must be updated in each network's respective yearly invasive early detection candidate species and final invasive early detection species tables. The updated and final park species lists will be available on ERMN and NETN websites, What's Invasive! website (especially for MIDN and NCBN), annual ISED summary reports, and from the ISED program leads.

Table S1.1. Northeast Temperate Network Early Detection Species Review panel design.

Park	Year								
	1	2	3	4	5	6	7	8	9
ACAD	X		X		X		X		X
MABI	X		X		X		X		X
MIMA	X		X		X		X		X
SARA	X		X		X		X		X
BOHA		X			X			X	
MORR		X		X		X		X	
ROVA		X		X		X		X	
SAIR		X			X			X	
WEFA		X		X		X		X	

BOHA and SAIR will be reviewed the same year as salt marsh vegetation monitoring, sampled every three years.

SOP 1 References

National Research Council. 2002. Predicting Invasions of Non-indigenous Plants and Plant Pests. National Academy of Sciences. Washington, DC. 198 pp.

NatureServe. 2009. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Accessed: November 24, 2009.
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Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be increased incrementally 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	December 2013	Douglas Manning and Jesse Wheeler	Added MIDN and NCBN to protocol Add links to online databases Update to prioritization steps (added step 14) Added NETN sampling frame table	Operational update and incorporation of NCBN and MIDN into protocol

SOP 2 – Data Collection: ISED Reporting Forms

Version 1.01

Once a new early detection species is observed, it is imperative that accurate information regarding the species description and location be recorded. When smartphones or cellular service is not available for reporting (see SOP 3 – Data Collection: What’s Invasive!), the optional Early Detection Plant or Pest Reporting forms should be used instead. Completed reporting forms, as well as accompanying photos and/or specimens should be submitted to the designated park contact and/or ISEDC. Each form provides specific detailed instruction regarding data collection procedures. Observers are to follow these steps when reporting a new species observation:

- 1) Fill out the appropriate Early Detection Species Reporting Form
 - a) Name
 - b) Email
 - c) Phone
 - d) Date
 - e) Time
 - f) Park
 - g) Species name (scientific or common)
 - h) GPS coordinates [Universal Transverse Mercator (UTM) coordinates, UTM zone or Decimal Degrees (DD)], Datum, and Coordinate error (meters)
 - i) Body of water name if the species is aquatic
 - j) Specific location of the species including road names, trails, signs etc.
 - k) Circle stem count (plants only): 1–5, 6–25, 26–50, 51–150, 151–500, 500+
 - l) Circle infested area (plants only):
 - i) 0.001 ac = 3.7-ft radius
 - ii) 0.01 ac = 12-ft radius
 - iii) 0.1 ac = 37-ft radius
 - iv) ½ ac = 83-ft radius
 - v) 1 ac = 118-ft radius
 - m) Host species involved (pests only)
 - n) Type of evidence present (pests only):
 - i) Crown dieback
 - ii) Foliar injury (chlorosis, necrosis, other discoloration)
 - iii) Sawdust
 - iv) Exit holes
 - v) Other
 - o) Certainty of identity:
 - i) Extremely Confident
 - ii) Moderately confident
 - iii) Not very confident
 - p) Additional comments (habitat, vigor, number of individuals present, site accessibility etc.).

- 2) Depending on park approval, flag the species location with biodegradable forestry tape. The tape must be labeled with “EDRR” or Early Detection and Rapid Response, the name of the observer, and the date of the observation. In some cases permits or study numbers are required.
- 3) Photos should be taken of distinguishable features or identifying characteristics. In some cases photos of the surrounding area may assist in relocation.
- 4) If collection of a plant specimen is warranted by a trained botanist, the following procedures apply to plants:
 - a) Collect as many identifying characteristics of the plant as you can (e.g., flowers, fruits, leaves, roots)
 - b) Before pressing, clean dirt from plant roots and try not to press wet specimens. When pressing try to orient leaves so that you can see both upper and lower surfaces. Press flowers so the interior reproductive structures are visible (open faced).
 - c) Place each plant in a single fold of newspaper or between a couple blank field sheets in a field notebook. If needed, bend plants into a 'V' or 'N' shape before pressing. Parts that stick out won't dry properly and may get broken off.
- 5) Identify the plant or pest as soon as possible. Contact the ISEDC to obtain a list of qualified botanists who can assist with plant identification.
- 6) Pest specimens should be placed in a sealed plastic bag or vial. See Appendixes D and E for State and Federal contact information for reporting new plant pest discovery information.
- 7) Send or deliver card and photographic evidence to the designated park contact or the ISEDC. Original forms should always be sent back to the appropriate network office for data entry and archival purposes.

Figures S2.1 and S2.2 show examples of pest and plant reporting forms for the Eastern Rivers and Mountains (ERMN) and Northeast Temperate (NETN) Networks.

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 increased incrementally 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	December 2013	Jesse Wheeler	Changed title. Removed table of botanist contact info Minor editorial changes.	Reduce personal information

<div style="text-align: center;"> <h2>EARLY DETECTION PEST SPECIES REPORTING FORM</h2> <hr/> <h3>DIRECTIONS</h3> </div> <p>1) Fill out this form. 2) Flag location with pink flagging and label flagging with "EDRR," name of person making ID and date. 3) Take a photo(s) and make sure species and any distinguishable features are visible in the photo(s). Include additional photos of signs and symptoms. 4) ASAP, send card and/or information on card and photos to designated park contact (see species list pages) and Jennifer Stingelin Keefer at the ERMN office: 309 Forest Resources Laboratory University Park, PA 16802 Phone: 814-865-8497 Fax: 814-863-4710 Jennifer_Stingelin_Keefer@partner.nps.gov</p> <hr/> <div style="text-align: center;"> <h3>GENERAL INFORMATION</h3> </div> <p>Name(s): _____ Email: _____ Phone: _____ Date: _____ Time: _____</p> <hr/> <div style="text-align: center;"> <h3>SPECIES INFORMATION</h3> </div> <p>Park: _____ Species name: _____</p> <p>GPS Coordinates (UTMs or DD's--circle): Y (Northing): _____ X (Easting): _____ UTM Zone: _____ Datum: _____</p> <p>Coordinate error (meters): _____ (Over)</p> <div style="background-color: #800080; color: white; padding: 5px; text-align: center; width: fit-content; margin: 0 auto;">PEST</div>	<div style="text-align: center;"> <h2>EARLY DETECTION PEST SPECIES REPORTING FORM</h2> <hr/> <h3>SPECIES INFORMATION (cont.)</h3> </div> <p>Location Description (be as specific as possible): _____</p> <p>Host Species Involved: _____</p> <p>Type of evidence present (circle): 1. Crown dieback 2. Foliar injury (chlorosis, necrosis, other discoloration) 3. Sawdust 4. Exit holes 5. Other _____</p> <p>Certainty of identity (circle one): Extremely confident Moderately confident Not very confident</p> <p>Other comments (habitat, # individuals, site accessibility etc): _____</p>
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Figure S2.1. Early Detection of Invasive Species Surveillance Monitoring and Rapid Response pest species reporting form.


<div style="text-align: center; border-bottom: 1px solid black; margin-bottom: 10px;"> <h2 style="margin: 0;">EARLY DETECTION PLANT SPECIES REPORTING FORM</h2> </div> <div style="text-align: center; margin-bottom: 10px;"> <p>DIRECTIONS</p> </div> <ol style="list-style-type: none"> 1) Fill out this form. 2) Flag location with pink flagging and label flagging with "EDRR," name of person making ID and date. 3) Take a photo(s) and make sure any flowers, fruits, and any other distinguishable features are visible in the photo(s). 4) ASAP, send card and/or information on card and photos to designated park contact (see Species List pages) and Jennifer Stingelin Keefer at the ERMN office: <div style="text-align: center; margin-bottom: 10px;"> <p>309 Forest Resources Laboratory University Park, PA 16802 Phone: 814-865-8497 Fax: 814-863-4710 Jennifer_Stingelin_Keefer@partner.nps.gov</p> </div> <div style="text-align: center; border-bottom: 1px solid black; margin-bottom: 10px;"> <p>GENERAL INFORMATION</p> </div> <p>Name(s): _____</p> <p>Email: _____</p> <p>Phone: _____</p> <p>Date: _____</p> <p>Time: _____</p> <div style="text-align: center; border-bottom: 1px solid black; margin-bottom: 10px;"> <p>SPECIES INFORMATION</p> </div> <p>Park: _____</p> <p>Species name: _____</p> <p>GPS Coordinates (UTMs or DD's--circle):</p> <p>Y (Northing): _____</p> <p>X (Easting): _____</p> <p>UTM Zone: _____</p> <p>Datum: _____</p> <p>Coordinate error (meters): _____ (Over)</p> <div style="text-align: right; margin-top: 20px;">  </div>	<div style="text-align: center; border-bottom: 1px solid black; margin-bottom: 10px;"> <h2 style="margin: 0;">EARLY DETECTION PLANT SPECIES REPORTING FORM</h2> </div> <div style="text-align: center; margin-bottom: 10px;"> <p>SPECIES INFORMATION (cont.)</p> </div> <p>Body of Water Name (aquatic species only): _____</p> <p>Location Description (be as specific as possible): _____</p> <p>Stem Count (circle one):</p> <p>1-5 6-25 25-50 51-150 151 - 500</p> <p>500+</p> <p>Infested Area (circle one):</p> <p>0.001 ac = 3.7 ft. radius</p> <p>0.01 ac = 12 ft. radius</p> <p>0.1 ac = 37 ft. radius</p> <p>1/2 ac = 83 ft. radius</p> <p>1 ac = 118 ft. radius</p> <p>Certainty of identity (circle one):</p> <p>Extremely confident</p> <p>Moderately confident</p> <p>Not very confident</p> <p>Other comments (habitat, vigor, site accessibility etc): _____</p>
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Figure S2.2. Early Detection of Invasive Species Surveillance Monitoring and Rapid Response plant species reporting form.

SOP 3 – Data Collection: What’s Invasive!

Version 1.00

This SOP focuses on reporting detections of invasive terrestrial plants, invasive aquatic plants and algae, disease complexes, and insect pests by utilizing the digital format provided by the “What’s Invasive!” mobile application (app) and website reporting form. The Invasive Species Early Detection Coordinators (ISED) will be responsible for setting up and maintaining lists for each of their network parks in the What’s Invasive! app. Field crews and observers will be responsible for reporting ISED sightings through the What’s Invasive! app or online reporting form. ISED data, reports and maps stored in What’s Invasive! will be accessible to the ISED and the designated park contact (DPC) for each park.

Where cell reception permits, ERMN, MIDN, NCBN and NETN field crews will record ISED sightings into the smartphone application “What’s Invasive!” and parks are encouraged to do the same. If the mobile app is not functioning properly, ISED sightings will be recorded using the online “What’s Invasive!” reporting form. This app and website are managed by the Early Detection & Distribution Mapping System (EDDMapS), which is the University of Georgia’s web-based mapping system for documenting invasive species distributions. The app and website will include updated target lists for each ERMN, MIDN, NCBN and NETN park and separate island units for BOHA. The app will automatically store important data associated with the detection including GPS location, photographs, and extent of population. This information can later be downloaded as an excel spreadsheet from the website. Smartphone apps can be downloaded from: <https://itunes.apple.com/us/app/whats-invasive/id529665562?mt=8> for the iPhone and at <https://play.google.com/store/apps/details?id=edu.ucla.cens.whatsinvasive> for the Android.

Steps for setting up and using What’s Invasive!:

Register an account;

- Go to <http://www.whatsinvasive.org/register.cfm> and fill out the appropriate information (Figure S3.1).
- Get the iPhone app (version 2.1) <https://itunes.apple.com/us/app/whats-invasive/id529665562?mt=8> or Android (version 3.0) app <https://play.google.com/store/apps/details?id=edu.ucla.cens.whatsinvasive> and follow installation instructions.

What's Invasive! Community Data Collection

Home Top Invasives Summary Data Maps Login Register

Use your Smartphone to Help Us Locate Invasive Species!

Registration

Please complete the form below (* required field):

Email*: jesse_wheeler@nps.gov

Password*:

Repeat Password*:

First Name*:


Last Name*:

Organization:

User Knowledge Level: ☐ Beginner ☐ Some ID Training ☐ Expert

Your e-mail address will be used as your username. This account will also work for EDDMapS. If you already have an EDDMapS

Help us document invasive species!



Using your smartphone, help us locate invasive species in participating areas.

The species you identify will be placed on public map and alert site managers of the spread of these habitat-destroying invasives.

You can also participate using our web forms, all valid observations are sent to [EDDMapS](#), the national invasive species database!.

Figure S3.1. Registration of a personal account, enabling access to What's Invasive! reporting on-line and through the smartphone app.

Managing "What's Invasive!":

- Log into account at <http://www.whatsinvasive.org/log.cfm>.
- Select a participating park from the drop down list or set up a new park: <http://www.whatsinvasive.org/ManagePark.cfm> (Return to this page by selecting 'Home' on the green bar).
- You will be taken to the park's home site and will see species listed on the left of the screen and a photo with description of the park (Figure S3.2). When logged in as a manager, you will see a green bar to select these options; Manage Data, Edit Managers, Edit Species, Edit Park Information and Deactivate Park.



Figure S3.2. Park home page with species lists for each taxa category (e.g., plants, animals) and park information.

Observers are to follow these steps when reporting a new species observation:

To report an observation on-line:

- 1) Go to 'Summary' on the green bar at top of page, then click 'Create an Observation, Enter web form data' on the left of the screen.
 - a) Select species
 - b) Select species quantity (One, Few or Many)
 - c) Enter Latitude and Longitude (e.g., 40.74586, -74.55982)
 - d) Add an image, choose from file
 - e) Provide any notes
 - f) Upload to EDDMapS

- 2) Once observations have been reported, the Summary page will display species data for that park. Click 'Download the Data; get all data from park' on the left under Links to download sightings.
- 3) Click on 'Data' on the green bar to list all observations for the park with a record #, image, Date, Species, Park, Lat/Long and User.
 - a) Select the Record to view more information on Location (with map), comments and number of species observed.

Reporting ISED observations via Smartphone app.

- 1) Once the smartphone app is installed, open the What's Invasive! App on the screen.
- 2) The park and its ISED list closest to the mobile device's location will come up as the default to pull from*.
- 3) When on a park's page under "Map a Weed", select the species you want to record an observation for.
- 4) Press the image of a camera to take a photograph of the species. The phone will also record the location.
- 5) Select one, few or many to indicate size of population or cover.
- 6) Click the 'Save' button when finished.

If you are using an iPhone, you can update the list of plants by going to the Settings tab, and then click the park name to get to the list of parks. Select the site again and the phone should download the newest list of plants. Update the list on Android version by going to Settings via the MENU, then the "Refresh Lists" option. This will download the latest list items.

*The iPhone app has a feature allowing use of a map to manually determine your location (just click on the lat/long during an observation), because sometimes the iPhone GPS location can be a bit off, especially under a canopy or near buildings. Manually determining the location does require connectivity, though. "What's Invasive!" will be adding this feature to the Android version soon.

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 increased incrementally 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 version	

SOP 4 – Rapid Response Procedures

Version 1.01

When a new species or occurrence is detected an assessment must be made before a response can be initiated. The following questions and actions must be asked and carried out:

- Is it a State or Federal noxious weed? A weed such as *Heracleum mantegazzianum* (giant hogweed) should only be handled by experts due to its phototoxicity.
- Is it a new county record and is it considered a significant threat? A pest species such as *Agrilus planipennis* (emerald ash borer) would be a good candidate for this category.
- Has the species been positively identified? If not, the site must be re-visited or photographs must be examined by an expert.
- If the observer is confident in his/her identification and is highly skilled in plant identification, can the population be eradicated on-site (plants only)? For example, a crew leader would be considered skilled, but probably not a volunteer unless the volunteer's skills are vetted. In some cases, if the number of plants is small and the plant is easy to pull, a rapid response can occur on site at the initial identification; however plants should not be removed if they occur in a monitoring site.
- If a rapid response is required, who does the observer contact? Each park has a designated park contact (DPC). The name of this contact is listed on each park's Early Detection Species List. This is either the park natural resource manager or the Invasive Species Early Detection Coordinator (ISED). It is the DPC's responsibility to alert the ISED or park natural resource manager (if different) of the new species detection. From this point on, it is up to the ISED and park natural resource manager to alert the appropriate agencies such as the Bureau of Plant Industry or the Animal and Plant Health Inspection Service (APHIS) within the U.S. Department of Agriculture, local weed management organizations, and network and park personnel, and coordinate with the EPMTs.

Figure S4.1 depicts the Early Detection of Invasive Species Rapid Response system for the Eastern Rivers and Mountains Network (ERMN), Mid-Atlantic Network (MIDN), Northeast Coastal and Barrier Network (NCBN), and Northeast Temperate Network (NETN).

Each response will be based on the individual needs of the park and the resources available and the nature of the infestation. Because most of the parks lack funding and resources to perform invasive species rapid response on their own, cooperation with EPMTs, networks, and outside agencies will usually be necessary. In addition, in some cases, "no response" may be the appropriate action. Eradication or control of certain pest infestations may not be feasible due to pest abundance, lack of chemical or biological control measures, or the cost to implement control measures.

Unique circumstances as well as sufficient funding and resources exist at some parks within the ERMN, MIDN, NCBN, and NETN and enable them to respond more quickly to new invasive species occurrences. For example, Fort Necessity National Battlefield (FONE) and Friendship Hill National Historic Site (FRHI) are part of the Southern Laurel Highlands Plant Management Partnership (SLHPMP), a Cooperative Weed Management Area (CWMA). Potentially, this group that brings together state, federal, and private and non-profit organizations will be able to respond to any new species occurrences. Saratoga National Historical Park (SARA) is fortunate to have trained maintenance personnel that enjoy and prioritize invasive species management and New River Gorge National River (NERI) uses a Biological Science Technician to rapidly respond to new species detections.

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 increased incrementally 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	December 2013	Jesse Wheeler and Kate Miller	Added MIDN and NCBN to protocol, Clarified response to detections in monitoring sites. Replaced Figure 1 with a simpler figure.	

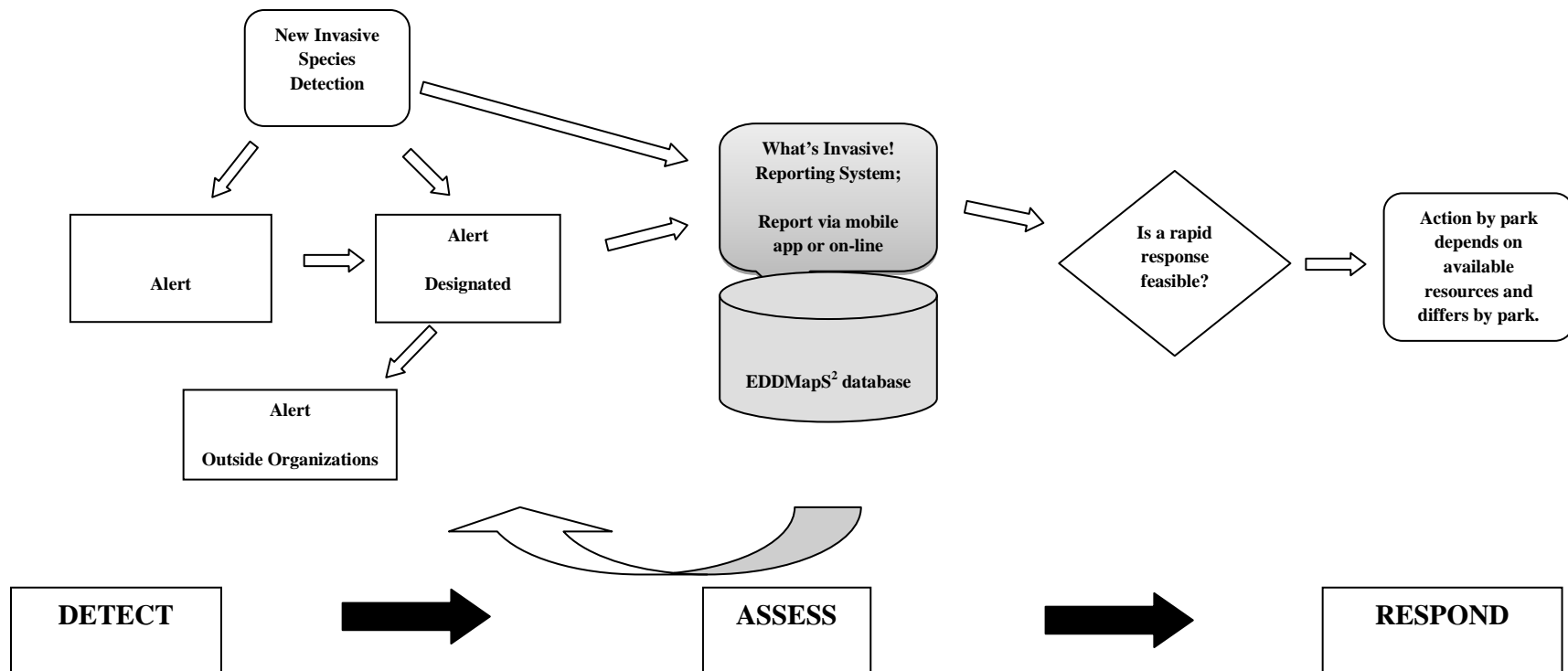


Figure S4.1. Early Detection of Invasive Species Rapid Response system for the Eastern Rivers and Mountains Network (ERMN), Mid-Atlantic Network (MIDN), Northeast Coastal and Barrier Network (NCBN), and Northeast Temperate Network (NETN).¹Invasive Species Early Detection Coordinator (ISEDCC), ²Early Detection & Distribution Mapping System (EDDMapS).

SOP 5 – Limiting Exotic Species Transport (LEST)

Version 1.01

Overview

This SOP provides instructions for cleaning clothing and field equipment in order to limit the spread of exotic species by 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 procedures in this SOP. 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, for crew members who have been hiking in other places over the weekend.

Materials Needed

- 5 gallon 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

Before leaving a site that requires following these procedures, the crew shall visually inspect gear, clothing, and boot treads and remove any obvious attached seeds, plant fragments, or excess soil. When the crew returns to the vehicle, they should remove the 5-gallon bucket and do a more thorough investigation for exotic species. 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, Findley pole, 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 increased incrementally 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	Douglas Manning	Initial version	
1.01	April 2014	Douglas Manning	Added an initial clothing and gear inspection at the site of the infestation.	Improve the chances of limiting exotic seed transport.

SOP 6 – Appalachian National Scenic Trail Invasive Species Prioritization

Version 1.02

Introduction

There are various tools available, primarily for plants, to assist with invasive species prioritization, categorization, and risk assessment. Invasive plant prioritization tools focus on criteria such as specific geographic regions (Mehrhoff 2000, Warner et al. 2003), current level of species impact, and feasibility of control (Hiebert and Stubbendieck 1993), while invasive pest prioritization can involve cost criteria (Moffitt and Osteen 2006), life history measures (Causton et al. 2006), or in the case of gastropods, criteria such as survivability in shipments and difficulty of pest detection through visual inspection (Floyd 2008). For example, U.S. Invasive Species Impact Ranks (I-Ranks) and the associated Invasive Species Assessment Protocol, which guides individuals through a series of questions to determine I-Rank, use extensive biogeographical information as criteria to rank plant invasiveness at local, regional, national, and global scales (Morse et al. 2004). The Invasive Plant Atlas of New England (IPANE) uses six specific biological criteria to prioritize or “track” specific invasive plants in New England (IPANE 2009). Each of these systems provides a well-conceived model for ranking invasive plants. Other less formal lists draw on experience across a range of resource management disciplines. As an example, state and federal noxious weed lists have historically targeted agricultural pest plants.

Invasive Plant Assessment System

The Invasive Plant Assessment System (IPAS) is a Microsoft Access based utility that incorporates two existing and accepted invasive plant assessment systems. The IPAS was developed to improve use of the two systems by automating some of the tasks, and by linking to tables contained in the National Park Service NPSpecies database thereby eliminating the need to generate a new plant list. The IPAS does not alter either of the two systems. The sole purpose of the IPAS is to provide a user interface that streamlines the assessment process for the user. The first system incorporated into the IPAS is the Alien Plant Ranking System, or APRS, developed by Hiebert and Stubbendieck (1993), and the second system is the Invasive Species Assessment Protocol, or ISAP, developed by NatureServe (2004). Both systems are response driven, and each generates a series of scores that enable the user to prioritize management of invasive plant species.

Installation

For the IPAS to operate, it must be installed on a computer that uses MS-Access 2000 or higher. After the system has been installed, simply ‘double-click’ the file name and MS-Access will start. The IPAS will open with a menu screen (Figure S6.1) from which the desired assessment system can be selected, background on each system can be reviewed, park combinations can be built, and plant lists can be reviewed.

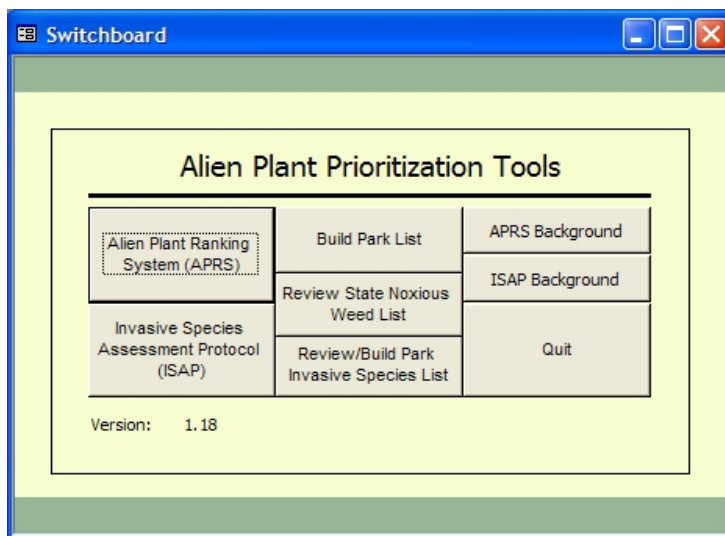


Figure S6.1. Main switchboard

Build a Park List

Selecting this button gives the user the ability to add or remove parks as well as administrative units from the list of parks for which an invasive plant prioritization may be performed. Once a park (and administrative unit) has been selected, the appropriate state and/or agency must be added to the sub-form by clicking on the ‘+’ on the left side of the window (Figure S6.2). The list assembled by the user establishes the pick lists found in the two systems.

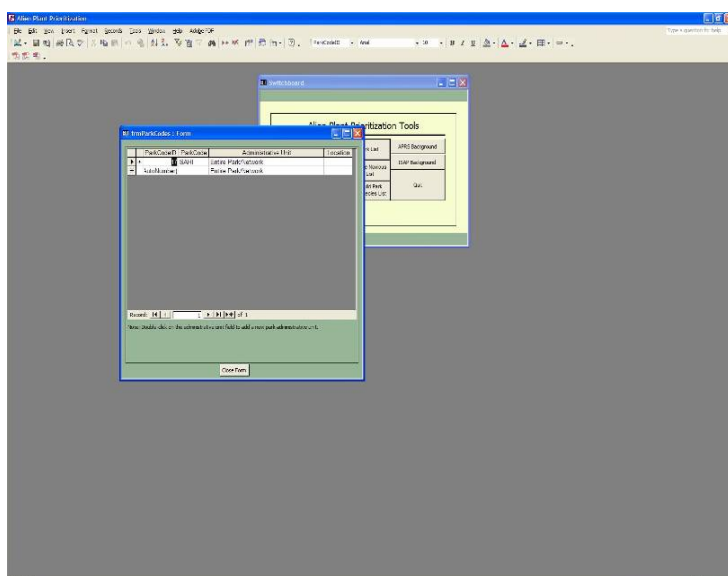


Figure S6.2. Park List Builder.

Review State Noxious Weed List

Selecting this button and then a state/agency will generate a list of species identified by that state/agency as being noxious. The combination of the state species list, the name of the park, and the list of species present in the park will yield a list of species that can be prioritized for a given park (Figure S6.3).

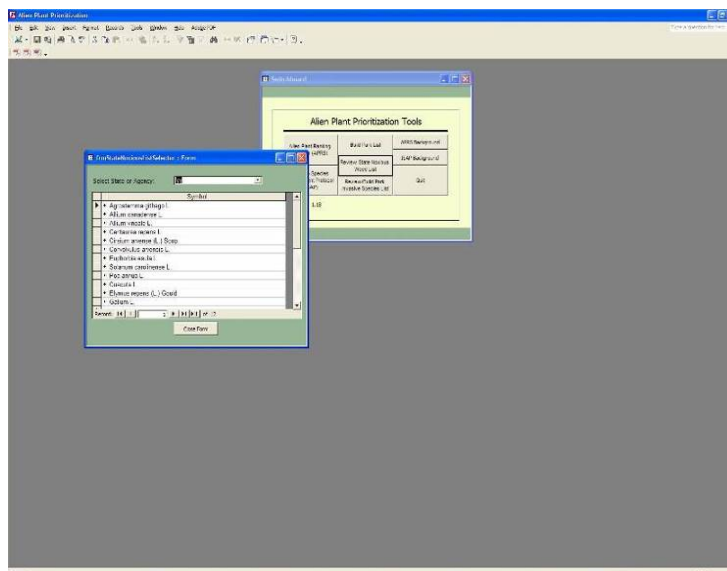


Figure S6.3. State/Agency noxious species list.

Review/Build Park NIS List

In the current version of the application, the user can either manually populate the list of species by selecting this button and selecting plant names from the drop-down list, or can replace the existing tblNpspecies table with a version that resides in the current version of NPSpecies from that park (Figure S6.4).

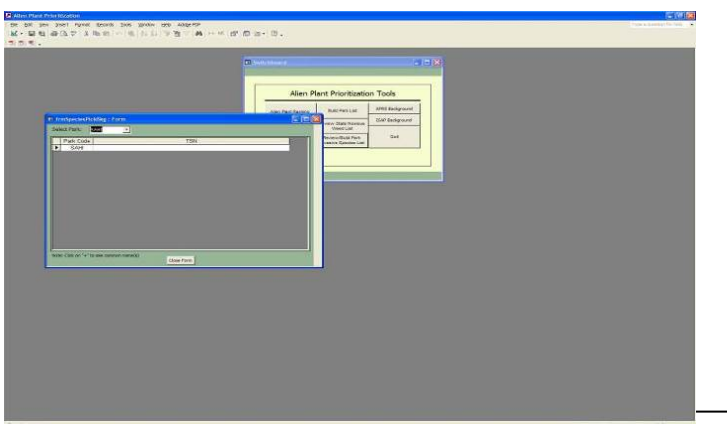


Figure S6.4. Blank Species list for Sagamore Hill (SAHI).

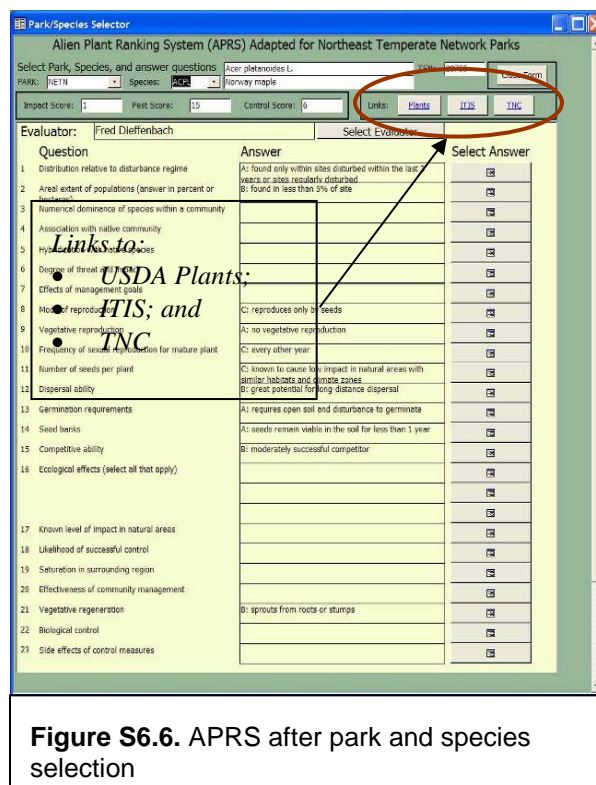
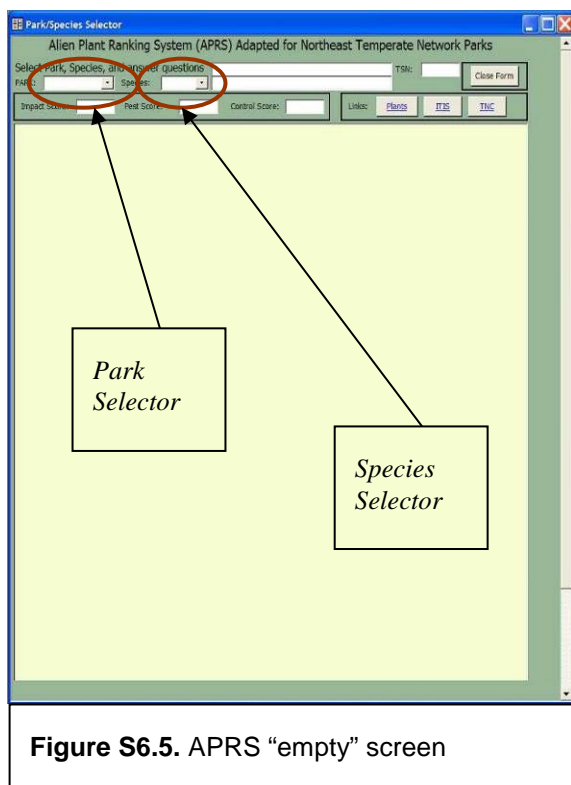
After a plant list is produced, the species on the list are compared to another list that contains species identified by one or more state(s), the federal government, or the National Park Service as being noxious or non-indigenous. This effectively limits the entire species list contained in the database to only those species that are deemed problematic. By clicking on the '+' sign in the left-hand column, you can access the common name(s) for the selected species.

Alien Plant Ranking System

The current version of the IPAS incorporates version 5.1 of the Alien Plant Ranking System. Later versions of the Alien Plant Ranking System do exist and incorporate one additional question. The more recent version of the system will be incorporated into the IPAS in the near future.

Assessment

An evaluation is begun by selecting a park/landowner from the pick list, followed by the selection of the species you intend to evaluate (Figure S6.5). After these two steps are complete, questions relating to the species can be answered and links to resources can be followed (Figure S6.6). If the chosen species was assessed at an earlier time, the results from the earlier assessment should be visible and may be edited. As answers are selected, numerical assessment scores corresponding to the assessment category with which the question is associated will begin to appear. Though it is not a requirement of this SOP, the user should enter their name as the evaluator. If the user's name does not appear on the pick list, simply double-click in the ContactID field contained in the evaluator selection form and a new form will appear into which the evaluator's name and contact information may be added.



Links

Three links will appear after a species is selected. Internet connectivity is required for the links to work. The first link establishes a connection between the chosen species and resources located on the U.S. Department of Agriculture “Plants” database Web site. A wide variety of resources are located at this site. The second button links the selected species to the Integrated Taxonomic Information

System web site. The information available at this location may overlap the information available from the Plants site, but one additional feature available from the ITIS site is a link to literature in which the species in question has been mentioned. The final button links the species to management information available from The Nature Conservancy (TNC). The TNC site lists fewer species than either of the other two, so many of the invasive species found on individual parks lists will not be present, but TNC does have management oriented documents detailing recommendations and their experience controlling these species (if the link button is pressed for a species that TNC does not have on its site, an error message will appear).

Invasive Species Assessment Protocol

The current version of the IPAS utilizes version 1 of the Invasive Species Assessment Protocol.

Assessment

An evaluation is begun by selecting the network/landowner from the pick list, a management unit if appropriate, and the species to be evaluated (Figure S6.7). Once the species has been selected, the three link buttons will activate, giving the user the ability to find additional species specific resources (Figure S6.8). The next step in the process is to identify the evaluator. If an evaluator is not selected for each species being assessed, the species prioritization report that the user will generate after multiple species have been assessed will be incomplete (i.e., an evaluator is a required element for every assessment, and only complete assessments are included in reports). As questions are answered, scores along the right side of the screen and at the top of the form will build. Scores aren't complete and shouldn't be used for comparison purposes until all questions have been answered (i.e., unanswered questions indicate incomplete scores). After the user answers all questions, the user must either accept the calculated score or revise the score based on additional insight. If the user elects to revise a score, a reason should be added into the comment box that will appear after the 'modify' button has been selected. In addition, the revised

Figure S6.7. ISAP "Blank" screen

Figure S6.8. ISAP screen after park, unit, species were selected

score is automatically flagged with a checkmark indicating that the score may differ from the calculated value. In the event that the revised score has the same rank as an un-revised score, the un-revised score will automatically receive higher priority than revised species.

Links

Three links will appear after a species is selected. Internet connectivity is required for the links to work. The first link establishes a connection between the chosen species and resources located on the U.S. Department of Agriculture “Plants” database web site. A wide variety of resources may be found at this site. The second button links the selected species to the Integrated Taxonomic Information System web site. The information available at this location may overlap the information available from the Plants site, but one additional feature available from the ITIS site is a link to literature in which the species in question has been mentioned (Figure S6.9). The final button links the species to management information available from The Nature Conservancy (TNC). The TNC site lists fewer species than either of the other two, and many of the invasive species found on individual parks lists will not be present, but TNC does have management oriented documents detailing recommendations and their experience controlling these species.

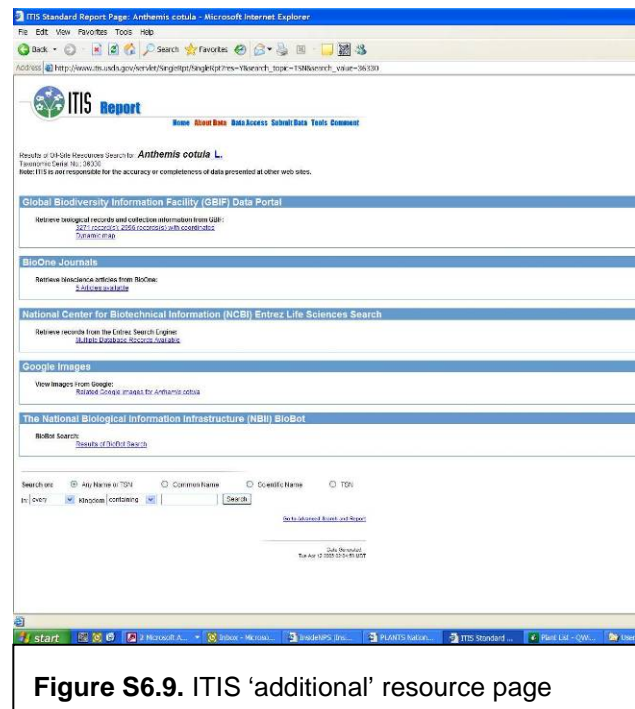


Figure S6.9. ITIS ‘additional’ resource page

Prioritization Report

After you have assessed a collection of species, you can generate a report to view a prioritized list (Figure S6.10). The highest priority species will appear first on the list and the lowest priority species will appear at the bottom. Those species whose calculated scores have been modified by the user will follow ‘un-edited’ species of the same priority value and will be identified by a checkmark visible on the report.

Invasive Species Prioritization Results										
ParkCode	NETN	Scientific name	Common name	SubRank I	SubRank II	SubRank III	SubRank IV	SubRank V	SubRank VI	Evaluator Name
High	<input type="checkbox"/>	Ceanothus americanus L.	leavesy blueberry	High	High	High/Medium	Low/Medium	High	Low	Paul Diefenbach
High/Medium	<input type="checkbox"/>	Acer pseudoplatanus L.	sycamore maple	High/Medium	Medium	Medium	High/Low	High	Low	Paul Diefenbach
High/Medium	<input type="checkbox"/>	Lonicera tatarica L.	Tatarian honeysuckle	High	Medium/Low	High/Medium	High/Low	High	Low	Thomas Moore
High/Medium	<input type="checkbox"/>	Ceanothus americanus Gray	Ceanothus	High/Medium	Low/Medium	High/Low	Low/Medium	High	Low	Thomas Moore
Medium	<input type="checkbox"/>	Acer palmatum L.	Norway maple	Medium	Medium/Low	Low	High	High	Low	Thomas Moore
Medium	<input type="checkbox"/>	Berberis thunbergii DC.	Japanese barberry	Medium/Low	High/Medium	Medium	Medium	High	Low	Thomas Moore
Medium/Low	<input checked="" type="checkbox"/>	Albizia julibrissin (P. Walp.) tree of heaven	tree of heaven	Low/Medium	High	Medium/Low	Medium/Low	High	Low	Paul Diefenbach
Low	<input type="checkbox"/>	Celtis occidentalis L.	hackberry	Medium	High/Medium	High/Low	Low	High	Low	Paul Diefenbach
Low	<input type="checkbox"/>	Cedrus deodora (L.) Mill.	Deodar cedar	Low	Low	High/Medium	Low	High	Low	Thomas Moore

Figure S6.10. Prioritization report.

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Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be increased incrementally 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	November 2010	Fred Dieffenbach	Original draft	
1.01	March 2014	Brian Mitchell	Replaced "Non-indigenous species" or NIS with "invasive species" Deleted prioritization questions Other minor edits and formatting changes	Ensure compatibility with protocol Duplicated from SOP 1 and not actually used in this SOP Clarity and consistency

SOP 7 – Appalachian National Scenic Trail Sampling Design and Field Procedures

Version 1.04

Introduction

While most of this protocol focuses on opportunistic sampling to detect newly invading species, some management questions require more rigorous data collection. For example, parks that are interested in documenting status and trends in populations of established invasive species, or parks that want to document the effectiveness of management efforts will need more intensive and consistent data collection that preferably follows a statistical sampling design. The National Park Service (NPS; Northeast Temperate Network [NETN] and Appalachian National Scenic Trail [APPA]), and Appalachian Trail Conservancy (ATC) have jointly developed these procedures to identify, monitor, and control invasive species along the Appalachian National Scenic Trail.

The APPA invasive species detection program is dependent on a combination of staff and volunteers to perform this work on such a large scale. Accordingly, this SOP is built around several existing detection methodologies, making it flexible and able to accommodate a variety of projects, interests, and management objectives. ATC holds periodic workshops to train volunteers on identification of invasive species and how to monitor a section of the Appalachian Trail. Monitoring may be highly organized, but may also occur independently by volunteers on their own schedule.

We have selected the EDDMapS (Early Detection and Distribution Mapping System) system for data input and storage (see SOP 2 – Data Collection: ISED Reporting Forms and SOP 3 – Data Collection: What’s Invasive). For projects that want more detail than is currently available through the What’s Invasive app and the reporting forms used by most parks, a set of data forms has been developed that contains additional data fields that should be considered (see below).

The following guidelines are designed to describe several alternatives for detecting invasive species because each project is independent and may have differing requirements and objectives. Some may be NPS driven; in which case, a particular methodology described herein may be specified by the National Park Service. Conversely, other projects may be externally funded and may opt for a less rigorous sampling methodology, also described herein, that focuses on specific trail features. For these reasons, the following guidelines are not rigid or prescriptive, but instead describe a variety of options that a given project should consider before collecting data. Regardless of the project objectives, funding, or motivation, one of the sampling approaches, whether opportunistic, random stratified, or adaptive must be selected prior to project commencement.

Data Collection Fundamentals

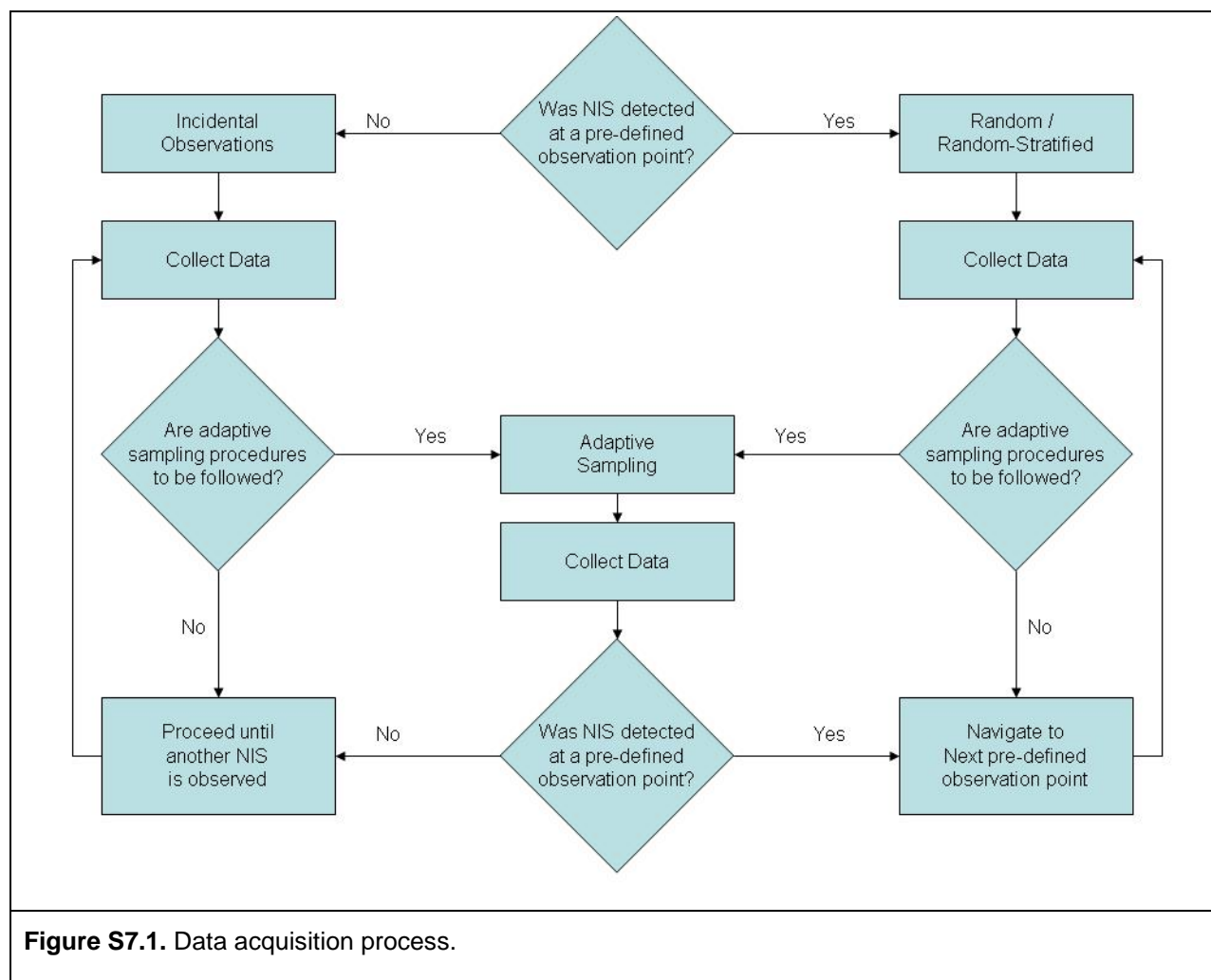
Regardless of whether the observation is of a new detection or an old infestation, it is important that the reporting form be fully completed and promptly entered into the on-line system and submitted to the designated resource manager. In addition to the basic information requested on the form, the following additional information will help resource managers determine whether a rapid response is required or not:

- 1) Descriptive comments (habitat, vigor, number of individuals present, site accessibility, etc.).
- 2) Photo-documentation; we strongly encourage use of the Appalachian Trail panoramic photo protocol (Paquette and Dieffenbach in development) for this purpose. Additional photos can be taken of distinguishable features or identifying characteristics.
- 3) If material is needed for ID confirmation AND photographs cannot adequately capture the requisite information, the following guidelines apply:
 - a) Material collected for identification purposes are NOT intended to be entered as a specimen into the park collection and should be destroyed after the purpose for collecting the material has been fulfilled.
 - b) Collecting invasive species material should be an uncommon situation to minimize the risk of transporting viable material to uninfested locations.
 - c) Collect as many identifying characteristics as necessary (e.g., flowers, fruits, leaves, roots), but not in excess [e.g., collect only what you need to confirm identification]).
 - d) Before pressing plants, clean dirt from roots and try not to press wet material. Orient leaves so that you can see both upper and lower surfaces. Press flowers so the interior reproductive structures are visible (open faced). Place each plant in a single fold of newspaper or between blank field sheets in a field notebook. If needed, bend plants into a 'V' or 'N' shape before pressing. Parts that stick out won't dry properly and may get broken off.
 - e) Identify the plant or pest as soon as possible following collection. Contact the APPA Resource Manager for qualified botanists.
 - f) Pest material should be placed in a sealed plastic bag or vial.
 - g) Be familiar with State and Federal contact information for reporting new plant and / or pest discovery information prior to collecting any material.

Observations

The APPA invasive species detection program incorporates two “general” techniques for deciding where to make an observation (Figure S7.1). The first technique relies on incidental observations while the second requires the observer to navigate to pre-designated random sampling locations.

Understanding the differences between the techniques and where each is most appropriate is necessary before collecting data. For example, collecting data opportunistically (recording invasive species as they are encountered) has been the method of choice for most prior efforts along the APPA. This is the least complicated of the methods described herein, which is the reason that it has been so frequently used. However, opportunistic sampling may be the least appropriate approach if the purpose of the effort is to comprehensively understand the magnitude of the invasive species problem throughout a defined area. This is because data collected opportunistically cannot be extrapolated beyond where the data were obtained. Conversely, if the purpose is to inventory the presence of invasive species in advance of a management action, opportunistic sampling may be the best alternative.



Incidental Observations

Under this approach an individual walks sections of the APPA and documents the presence of any observed invasive species as they are encountered. The observations may be for the explicit purpose of identifying invasive species, or the observations may literally be “accidental.” Regardless, at each point a species is encountered its location is marked using a GPS receiver and information about the infestation is recorded on a datasheet. The field data are submitted to ATC and subsequently entered into EDDMapS where they can be viewed by resource managers, agency partners, Trail Club members, and the general public.

If this technique is being used to inventory invasive species along a section of the APPA, a side trail, or a road, observers should reference a regionally targeted invasive species watch list that identifies particularly troublesome species, invaders that are new to the region, or that have been targeted by managers for some other reason. Some species are obscure and difficult to spot while others are easier to locate. Using a watch list gives the observer the ability to adjust their search pattern. If other invasive species are encountered they may be documented, but the emphasis of the inventory should be on watch list species. Optimally, the observer will document all watch list invasive species within 50 feet of the footpath. Take extra time to walk around shelters, road-crossings, stream crossings, power line crossings, or other high-traffic areas with a greater likelihood of infestation. Whenever an invasive species is encountered the observer will record all elements specified below.

Observers using the incidental observation process typically rely on professional insight or experience to guide the detection of invasive species. Data collected in this manner are not amenable to building inferences about the extent of invasive species across the landscape but may be suitable for directing management actions to control invasive species in specific areas.

Random Sampling

This approach to sampling requires an individual to make invasive species observations at pre-determined “random” locations. In some instances the observer may find invasive species, but there is no guarantee that they will be present. Positive as well as negative detections must be documented. For the APPA, there are two random sampling options. The first option relies on a set of 800,000 randomly distributed *Generalized Random Tessellation Stratified* (GRTS) points in an area that includes the APPA corridor plus a 2-mile buffer (a higher density GRTS layer is also available). The second option uses a series of random points oriented along the trail centerline. In either case, subsets of points are selected from the complete set in advance of field work.

Figure S7.2a shows a portion of a segment (the referenced segment was selected for a forest health monitoring project) in Maine with all possible GRTS points displayed. Figure S7.2b shows GRTS points that were selected for sampling.

Figure S7.3 shows random points oriented along a short segment of trail, while Figure S7.4 shows a sampling transect that could be installed along the centerline at random point locations.

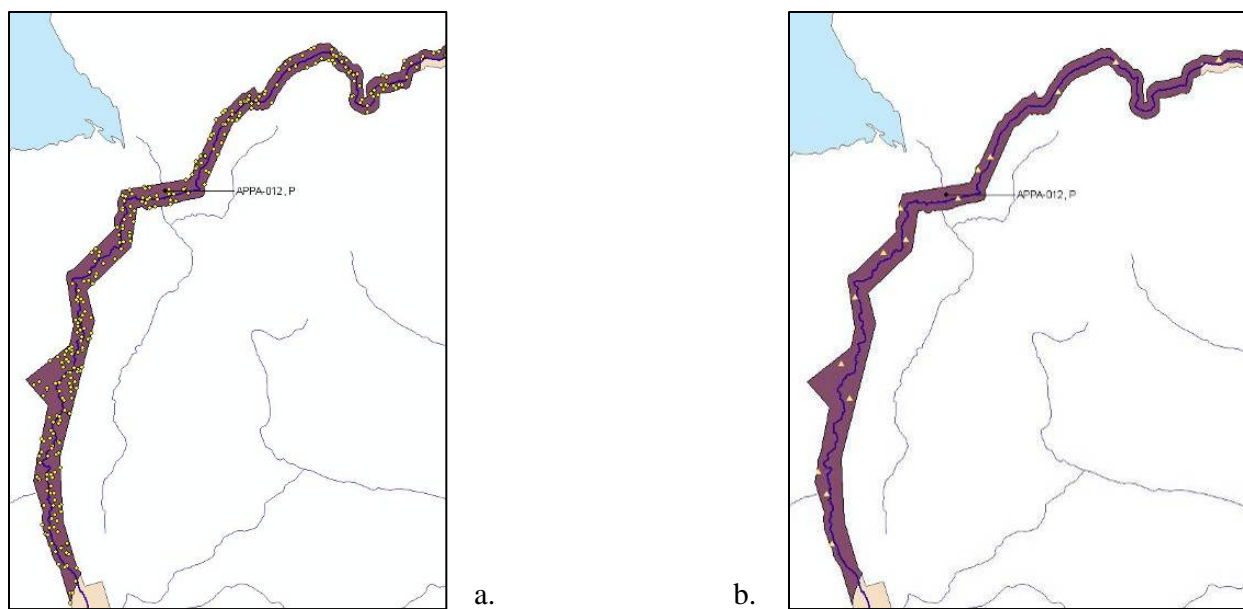


Figure S7.2. a. Potential points in selected segment; and, b. selected sampling points.

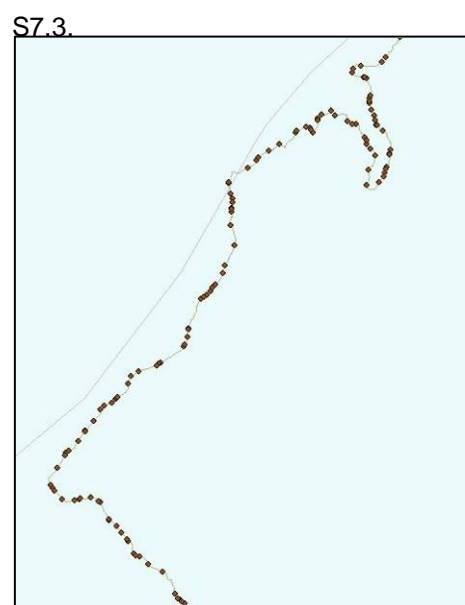


Figure S7.3. Random points along the APPA footpath.

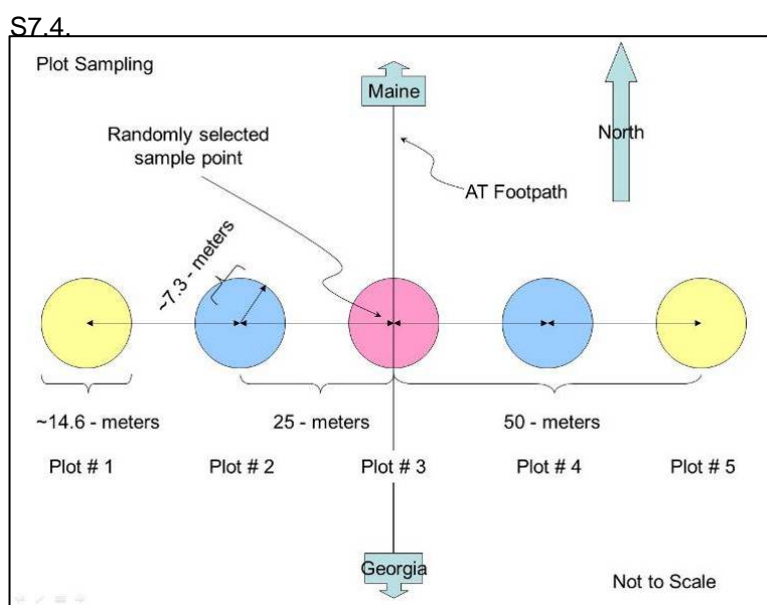


Figure S7.4. Possible sampling plot layout.

When sampling at randomly established sampling points, field personnel may encounter invasive species as they navigate from one observation point to the next. This inevitability can be resolved by documenting the incidental observation just as any other invasive species occurrence except that the incidental observation and the random observations must be kept separate to maintain the integrity of the random sampling process.

Prior to beginning a random sampling effort, coordinate with APPA managers to select an appropriate number of observation points for the desired region.

Stratification

Site attributes can be associated with random points to guide the sampling process. For example, if invasive species are thought to occur near roads and parking lots, points can be “stratified” according to the distance they are from this type of disturbance. Points can be stratified by elevation, ecoregion, distance from trail center, slope, etc. If points are stratified in advance of sampling, a proportional number of points may be selected for each strata, thereby ensuring a sufficient number of points occur in all areas of interest. Stratification may be performed following sampling as well (“post” stratification). When post stratification is performed, some unifying element is brought into the analysis that may not have been known when sampling was conducted. The same things that may be used to stratify a sample in advance can be used to post-stratify a dataset. The primary disadvantage to post-stratification is that it is not possible to ensure that each stratum has a sufficient sample size.

Adaptive Sampling

Strictly employing a stratified random approach can be resource intensive, while sampling only opportunistically may seriously limit the value of the collected data. In an attempt to bridge this divide, nonnative plant species can be mapped, measured, and located by installing a series of stratified random plots, as described above, but at a lower density. When using a purely stratified random approach a density between 1 plot per 5 acres and 1 plot per 30 acres may be appropriate. For adaptive sampling, however, densities between 1 plot per 50 acres and 1 plot per 100 acres may suffice. A key consideration in determining the plot density is ensuring sufficient coverage of all strata. Every time an invasive species is encountered, the surrounding area should be searched (and mapped) for occurrence of other infestations. Additional plots are installed systematically, and if additional invasive species are detected, additional observation plots are established and the process continues until no additional invasive species are detected (Figure S7.5). Adaptive sampling is founded on the principal that invasive species occurrences are not entirely random and that many species do not disperse great distances. Thus, where there is one individual there are probably more.

Several adaptive sampling approaches exist, not all of which are appropriate for all circumstances.

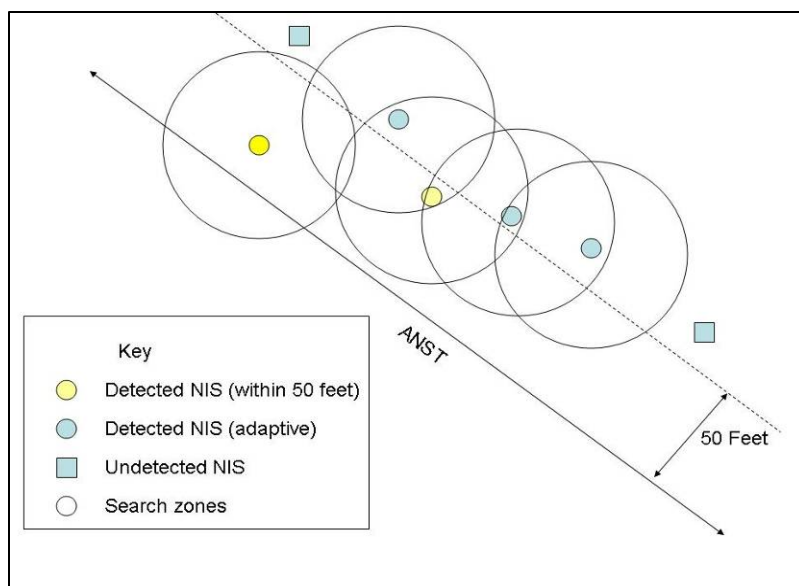


Figure S7.5. Adaptive sampling.

Data Collection

A set of data collection forms have been developed for projects that want more intensive data than is possible with the What's Invasive! app (SOP 3 – Data Collection: What's Invasive) and the reporting forms used by most parks (SOP 2 – Data Collection: ISED Reporting Forms). These forms (Figures S7.6 and S7.7), developed by the ATC, are designed to support a variety of invasive species projects along the trail.

Data Elements:

1. Track Name (optional): If you record a track on the GPS, give it a unique name and enter that name in this field.
2. Waypoint (optional): If you are marking/saving waypoints on a GPS unit, record the name or number of each point in this field.
3. Species Name: Common or scientific name of invasive plant observed.
4. Latitude/Longitude: Use datum WGS84 and record decimal degrees (e.g., 35.86079, -81.34517 or N 35.86079, W 81.34517).
5. Gross Area (ft²): The total area in which the infestation occurs (may include areas not covered by invasive exotic plants).
6. % Cover: Percentage of Gross Area covered by the foliage of the invasive exotic plant of interest (0, 1–5, 6–25, 26–50, 51–100).
7. Infested Area (ft²): Estimation of the area that contains only the species of interest (Infested Area = Gross Area × Percent Cover).

8. Estimated # of Stems: Estimate the number of stems for tree, shrub, or woody vine species.
9. Abundance: **P** = Single Plant; **SP** = Scattered Plants; **SDP** = Scattered Dense Patches; **DM** = Dense Monoculture.
10. Habitat Code: General habitat description that most closely matches that of the infestation being reported.

01 - Forest: Conifer	06 - Edge: upland/wetland	11 - Open Field	16 - Yard/Garden
02 - Forest: Hardwood	07 - Edge: lake	12 - Old Field	17 - Abandoned Lot
03 - Forest: Mixed	08 - Edge: field/forest	13 - Agricultural Field	18 - Other (describe)
04 - Wetland	09 - Edge: roadside	14 - Park	
05 - Stream Bank	10 - Rocky Outcrop	15 - Right of Way	

11. Canopy Density %: Estimate the percent cover of forest canopy, or the percentage of the sky covered by the trees' leaves (**0, 1–5, 6–25, 26–50, 51–100**).
12. Location Description, Notes: Include a description of nearby landmarks, the name/number of photos taken at that point, recent disturbance (fire, downed trees, human impact, etc.), or other observations to help locate the site at a future date or to describe the nature of the infestation. This space may also be used to record the presence of additional invasive exotic plants within the site or indicate if any invasive plants were hand pulled at the time of inventory.

Figure S7.7. Incidental Observation Field form, page 2.

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 increased incrementally 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	November 2010	Fred Dieffenbach	Original	
1.01	December 2011	Fred Dieffenbach	Changes to adjust to recent EDDMapS changes	Broaden potential application
1.02	February 2012	Fred Dieffenbach	Add NAWMA data collection standards into protocol	NPS endorses NAWMA standards
1.03	May 2012	Fred Dieffenbach	Inclusion of simplified data forms for opportunistic data collection	
1.04	March 2014	Brian Mitchell	Revised introduction Replaced "Non-indigenous species" or NIS with "invasive species" Remove references to "hybrid" sampling or incidental observations followed by random sampling Remove references to NAWMA Remove detailed observation forms and information Numerous minor edits and formatting changes	Merge SOP with protocol revision Ensure compatibility with protocol "Hybrid" sampling is not statistically valid Could not find evidence that the organization exists. Procedures and forms unwieldy and not likely to be used Clarity and consistency with the rest of the protocol

Mountains Network (ERMN). In the event that a state or federal noxious weed or Animal Plant and Health Inspection Service--Plant Protection and Quarantine (APHIS-PPQ) plant pest is discovered in the ERMN, the following agencies must be contacted to report the new discovery (Table A.1).

Table A.1. State and federal contact information for reporting new noxious weed and plant pest occurrences.

[illegible]

Appendix B. Interagency contact list by state and taxa for the Northeast Temperate Network (NETN).

In the event that a state or federal noxious weed or Animal Plant and Health Inspection Service--Plant Protection and Quarantine (APHIS-PPQ) plant pest is discovered in the NETN, the following agencies must be contacted to report the new discovery (Table B.1).

Table B.1. State and federal contact information for reporting new noxious weed and plant pest occurrences.

Agency and Contact	State	Taxa
Department of Agriculture Bureau of Plant Industry		State and Federal Invasive and Noxious Plants: http://plants.usda.gov/java/noxComposite
Animal Plant and Health Inspection Service Plant Protection and Quarantine (APHIS-PPQ) http://www.aphis.usda.gov/services/report_pest_disease/report_pest_disease.shtml		Plant Pests Asian longhorned beetle emerald ash borer sirex woodwasp
Department of Agriculture Division of Plant Industry http://www.ct.gov/deep/cwp/view.asp?a=2702&q=323494&depNav_GID=1641 http://www.mass.gov/eea/agencies/agr/ http://www.maine.gov/dacf/animals/index.html http://www.agriculture.nh.gov/divisions/plant_industry/index.htm http://www.state.nj.us/agriculture/ http://www.agriculture.ny.gov/PI/PIHome.html http://agriculture.vermont.gov/plant_pest	CT MA ME NH NJ NY VT	Viburnum leaf beetle Before reporting this species, check the National Agricultural Pest Information System (NAPIS) web site to determine if this species has already been reported for the county of observation. http://pest.ceris.purdue.edu/index.php

Appendix C. Invasive Species Candidate Prioritization Process.

There are various tools available, predominately for plants, to assist with invasive species prioritization, categorization, and risk assessment. Invasive plant prioritization tools focus on criteria such as specific geographic regions (Mehrhoff 2000, Warner et al. 2003), current level of species impact, and feasibility of control (Hiebert and Stubbendieck 1993), while invasive pest prioritization can involve cost criteria (Moffitt and Osteen 2006), life history measures (Causton et al. 2006), or in the case of gastropods, criteria such as survivability in shipments and difficulty of pest detection through visual inspection (Floyd 2008). For example, U.S. Invasive Species Impact Ranks (I-Ranks) and the associated Invasive Species Assessment Protocol, which guides individuals through a series of questions to determine I-Rank, use extensive biogeographical information as criteria to rank plant invasiveness at local, regional, national, and global scales (Morse et al. 2004). The Invasive Plant Atlas of New England (IPANE) uses six specific biological criteria to prioritize or “track” specific invasive plants in New England (IPANE 2009). Each of these systems provides a well-conceived model for ranking invasive plants. Other less formal lists draw on experience across a range of resource management disciplines. As an example, state and federal noxious weed lists have historically targeted agricultural pest plants.

Although the aforementioned ranking and prioritization tools were referenced and employed for guidance, a more informal procedure for prioritizing early detection species was used to focus on each individual park and the critical habitats contained therein. Prioritization systems like I-Ranks viewed in NatureServe Explorer <http://www.natureserve.org/explorer/index.htm> were only helpful in certain situations where common and widespread species information was required or more general information regarding a particular species was desired. The Invasive Species Assessment Protocol is “configured for use for regions of interest that are contiguous, as opposed to those with two or more separate parts...” and it is not recommended that “a highly fragmented area (such as an assemblage of scattered land holdings of a single government agency) be used as a region of interest with this protocol, since only a small sampling of a species’ regional status, impacts, trends, and dispersal dynamics would be considered.” (Morse et al., 2004). For example, when considering a species such as purple loosestrife (*Lythrum salicaria*), NatureServe lists the I-Rank of purple loosestrife (*Lythrum salicaria*) as High. Although this is true for sites that contain wetland and riparian habitats, purple loosestrife was not prioritized as High in some of our parks due to the lack of significant habitat. Rejmanek (2000) maintains that attention should be directed towards habitat-specific predictions and that “all-inclusive indices (scores for screening) might be helpful, but really relevant information might be suppressed.” Word of mouth, knowledge of each individual park’s habitats, and local field testimonials were by far the most valuable tools utilized to prioritize species in this protocol.

The process for selecting a short list of invasive species for each park consisted of four main components: Review existing park datasets and literature and compile a list of all invasive species known or thought to occur in the parks; immediately eliminate all common and well-established species from this list; review existing invasive species data from nearby parks, towns, counties, and

states and add new invasive candidate species that are not already present in the parks; conduct more extensive species research and consult with park natural resource managers to narrow down and create the final park species lists.

Eastern Rivers and Mountains Network (ERMN)

Because of the dispersed locations of the ERMN parks across four states and differences in park size and natural resources, it was necessary to examine each park on an individual basis. The process of developing thorough priority early detection species lists began by reviewing existing natural resources inventory reports and databases (Table C.1) and compiling lists of all invasive species known or thought to occur in each park. All common and well-established species were then immediately eliminated from this list as early detection species candidates.

Table C.1. Resources reviewed for each park during the species prioritization process to build a list of all invasive species known to exist in each park in the Eastern Rivers and Mountains Network (ERMN).

Resources	ERMN Parks
Consultations with park Natural Resource Managers, EPMTs, park personnel and scientists familiar with park lands	All Parks
Exotic Plant Management Team (EPMT) Data sets-- Alien Plant Control and Management Database (APCAM).	All Parks
Eichelberger, B. A. and S. J. Perles. 2009. Determining the Status and Trends of Key Invasive Plant Species in the Delaware Water Gap National Recreation Area. Technical Report NPS/NER/NRTR—2009/DRAFT. National Park Service. Philadelphia, PA.	DEWA
Eichelberger, B. A. and S. J. Perles. 2009. Determining the Status and Trends of Key Invasive Plant Species in the Upper Delaware Scenic and Recreational River. Technical Report NPS/NER/NRTR—2009/DRAFT. National Park Service. Philadelphia, PA.	UPDE
Lieb, D. A., R. F. Carline, and H. M. Ingram. 2007. Status of Native and Invasive Crayfish in Ten National Park Service Properties in Pennsylvania. Technical Report NPS/NER/NRTR—2007/085. National Park Service. Philadelphia, PA.	ALPO, JOFL, FONE, FRHI, DEWA, UPDE
NPSpecies - The National Park Service Biodiversity Database. Secure online version. https://science1.nature.nps.gov/npspecies/web/main/start .	All Parks
Vegetation Classification and Mapping Report data	ALPO, JOFL, FONE, FRHI, DEWA, UPDE, NERI, BLUE
Zimmerman, E. March 2007. Distribution and abundance of nonnative plant species at Johnstown Flood National Memorial and Allegheny Portage Railroad National Historic Site. Technical Report NPS/NER/NRTR—2007/083. National Park Service. Philadelphia, PA.	ALPO, JOFL
Zimmerman, E. and J. Yoder. August 2006. Distribution and Abundance of Non-native Plant Species at Fort Necessity National Battlefield and Friendship Hill National Historic Site. Natural Resource Technical Report NPS/NER/NRTR--2006/053. National Park Service. Philadelphia, PA.	FONE, FRHI

Although the numbers varied by park, approximately 30 common and well-established species were eliminated. Examples include Queen Anne's lace (*Daucus carota*), autumn olive (*Elaeagnus umbellata*), and garden yellowrocket (*Barbarea vulgaris*). Both Queen Anne's lace and autumn olive were present in every park and garden yellowrocket was present in every park with the exception of Gauley River National Recreation Area (GARI). Background data was not available for GARI, but due to the general widespread distribution of garden yellowrocket, it is thought to occur there.

Once a list of species known or thought to occur in each park was created and all common and widespread species were removed, existing invasive species data from nearby parks, towns, counties, and states were reviewed and new invasive species threats not present in the parks were added to the candidate list. The following resources, among others, were utilized to complete a candidate list of early detection species lists for each park:

1. USDA PLANTS database <http://plants.usda.gov/>
2. The Biota of North America Program (BONAP) web-based U.S. County-Level Atlas of the Vascular Flora of North America <http://www.bonap.org/MapSwitchboard.html>
3. Early Detection and Distribution Mapping System (EDDMapS) <http://www.eddmaps.org/>
4. National Agricultural Pest Information System (NAPIS) <http://pest.ceris.purdue.edu/index.php>
5. Invasive Plant Atlas of New England (IPANE) <http://nbii-nin.ciesin.columbia.edu/ipane/>
6. USGS Non-indigenous Aquatic Species (NAS) <http://nas.er.usgs.gov/>
7. Western Pennsylvania Conservancy (WPC)
8. PA Department of Agriculture Animal and Plant Health (<http://www.agriculture.state.pa.us/agriculture/cwp/view.asp?a=3&q=149376>)
9. West Virginia Wildlife Diversity Program and Natural Heritage Program (<http://www.wvdnr.gov/Wildlife/DirtyDozen.shtm>)
10. NatureServe Explorer <http://www.natureserve.org/explorer/>
11. Pennsylvania Game Commission (PGC)
12. Pennsylvania Fish and Boat Commission (PFBC) <http://www.fish.state.pa.us/ais.htm>
13. Pennsylvania Department of Conservation and Natural Resources (DCNR)
14. Wayne Millington, NPS Northeast Region IPM Coordinator
15. Betsy Lyman, Northeast Exotic Plant Management Team (EPMT), Liaison
16. Northeast Aquatic Nuisance Species Panel (NEANS) <http://www.northeastans.org/>
17. Central Jersey Invasive Species Strike Team (CJISST) <http://www.cjisst.org/index.html>
18. iMapInvasives <http://www.imapinvasives.org/>
19. West Virginia Natural Heritage Program (WVNHP)
20. Leslie Mehrhoff, Director, Invasive Plant Atlas of New England (IPANE)
21. Communications with park personnel and contractors familiar with the parks.
22. Eichelberger, B. A. and S. J. Perles. 2009. Determining the Status and Trends of Key Invasive Plant Species in the Delaware Water Gap National Recreation Area. Technical Report NPS/NER/NRTR—2009/DRAFT. National Park Service. Philadelphia, PA.
23. Eichelberger, B. A. and S. J. Perles. 2009. Determining the Status and Trends of Key Invasive Plant Species in the Upper Delaware Scenic and Recreational River. Technical Report NPS/NER/NRTR—2009/DRAFT. National Park Service. Philadelphia, PA.

Once the invasive species candidate list was constructed each species was then researched and prioritized. During this process, each park natural resource manager, the Regional Integrative Pest Management Coordinator and Exotic Plant Management Team Liaison were consulted for input. Initially, due to time constraints, species were marked as “priority” and “low priority.” The following questions were asked during the species prioritization process:

1. Does the species have an invasive history? “A species is likely to become invasive in a new habitat if it has a prior history of invasion elsewhere” (Rejmanek 2000, National Research Council 2002).
2. What is the species current distribution and have there been any recent outbreaks? What is the species proximity to the park? If aquatic, does it occur up or downstream of the park?
3. Does the species have the potential to become naturalized in the park?
4. Does species have the potential to establish in minimally managed habitats?
5. What is the species’ habitat suitability (e.g., wetland or upland forest)? A wetland species is not as high a threat to a park that does not contain wetland habitat.
6. Are there host species present (pests and diseases only)?
7. Is the species a significant threat to park resources and communities of ecological significance (bogs, river scour communities, cliff communities etc.)?
8. Does the species negatively affect forest crop production, commercial agriculture or human health?
9. Does the species possess reproductive strategies and dispersal mechanisms that enable it to disperse rapidly and widely? A species that reproduces by seed and is dispersed by animals is more likely to be a threat than a species that reproduces only by vegetative means.
10. Does the species have a competitive ability? For example, if the species is a plant, does it have an advantage over native plants when acquiring resources like water, light, and nutrients?
11. If the species already exists in the park, have there been any disturbances or changes in the park landscape that would alter or enhance the species’ invasibility?
12. What are the individual parks desires? For example, didymo might be impossible to currently control, but species tracking and spread prevention via public education might be important to the park.
13. What is the NatureServe Explorer Invasive Species Impact Rank (I-Rank) if available? I-Rank was only be used for guidance during the prioritization process. “Species for which I-Rank information is currently available do not represent a random sample of species exotic in the United States; available assessments may be biased toward those species with higher-than-average impact.” (NatureServe 2009).

Mid-Atlantic Network (MIDN) and Northeast Coastal & Barrier Network (NCBN)

Because of the dispersed locations of the MIDN and NCBN parks across the Northeast Region and differences in park size and natural resources, it was necessary to examine each park on an individual basis. This model may be applicable to other parks that are comprised of multiple units. The process of developing thorough priority early detection species lists began by reviewing existing MIDN /NCBN indicator invasive database and network park plant species lists and compiling lists of all invasive species known or thought to occur in each park. All indicator invasive, common and well-established species present within the parks were then immediately eliminated from this list as early detection species candidates. Once a list of species known or thought to occur in each park was created and all common and widespread species were removed, existing invasive species data from nearby parks, towns, counties, and states were reviewed and new invasive species threats not present in the parks, or present at low levels, were added to the candidate list. The following resources, among others, were utilized to complete a candidate list of early detection species lists for each park:

1. Communications with park personnel and contractors familiar with the parks.
2. USDA PLANTS database <http://plants.usda.gov/>
3. Early Detection and Distribution Mapping System (EDDMapS) <http://www.eddmaps.org/>
4. National Agricultural Pest Information System (NAPIS) <http://pest.ceris.purdue.edu/index.php>
5. Mid-Atlantic Exotic Plant Management Team (EPMT), Brian Lockwood - Liaison
6. Invasive Plant Atlas of the United States (IPANE) <http://www.invasiveplantatlas.org/distribution.html>
7. NatureServe Explorer <http://www.natureserve.org/explorer/>
8. Virginia Department of Conservation & Recreation (VDCR) http://www.dcr.virginia.gov/natural_heritage/invspdflist.shtml
9. Pennsylvania Department of Conservation and Natural Resources Invasive Plants Watchlist <http://www.dcnr.state.pa.us/forestry/plants/invasiveplants/index.htm>
10. Mid-Atlantic Invasive Plant Council (MAIPC) <http://www.maipc.org/>

Approximately 50 invasive species currently absent from MIDN / NETN parks were added to the initial candidate list.

Once a good invasive species candidate list was constructed, each candidate species was then researched and prioritized. During this process, each park natural resource manager, I&M network staff and Exotic Plant Management Team Liaison was consulted for input. The following questions were asked during the species prioritization process:

1. Does the species have an invasive history? “A species is likely to become invasive in a new habitat if it has a prior history of invasion elsewhere” (Rejmanek 2000, National Research Council 2002).
2. What is the species current distribution and have there been any recent outbreaks? What is the species proximity to the park? If aquatic, does it occur up or downstream of the park?
3. Does the species have the potential to become naturalized in the park?
4. Does species have the potential to establish in minimally managed habitats?
5. What is the species’ habitat suitability (i.e. wetland or upland forest)? A wetland species is not as high a threat to a park that does not contain wetland habitat.
6. Are there host species present (pests and diseases only)?
7. Is the species a significant threat to park resources and communities of ecological significance (bogs, river scour communities, cliff communities etc.)?
8. Does the species negatively affect forest crop production, commercial agriculture or human health?
9. Does the species possess reproductive strategies and dispersal mechanisms that enable it to disperse rapidly and widely? A species that reproduces by seed and is dispersed by animals is more likely to be a threat than a species that reproduces only by vegetative means.
10. Does the species have a competitive ability? For example, if the species is a plant, does it have an advantage over native plants when acquiring resources like water, light, and nutrients?
11. If the species already exists in the park, have there been any disturbances or changes in the park landscape that would alter or enhance the species’ invasibility?
12. What are the individual parks desires? For example, didymo might be impossible to currently control, but species tracking and spread prevention via public education might be important to the park.
13. What is the Virginia Natural Heritage Invasiveness Level if available? Levels range from highly to occasional.
14. What is the NatureServe Explorer Invasive Species Impact Rank (I-Rank) if available? I-Rank should only be used for guidance during the prioritization process. “Species for which I-Rank information is currently available do not represent a random sample of species exotic in the United States; available assessments may be biased toward those species with higher-than-average impact.” (NatureServe 2009).

Northeast Temperate Network (NETN)

Because of the dispersed locations of the NETN parks across the Northeast Region and differences in park size and natural resources, it was necessary to examine each park on an individual basis. In the case of Boston Harbor Islands National Recreation Area (BOHA), each accessible island that currently sustains plant life was examined individually. This model may be applicable to other parks that are comprised of multiple units. The process of developing thorough priority early detection species lists began by reviewing existing natural resources inventory reports and databases (Table C.2) and compiling lists of all invasive species known or thought to occur in each park. All common and well-established species were then immediately eliminated from this list as early detection species candidates.

Table C.2. Resources reviewed for each park during the species prioritization process to build a list of all invasive species known to exist in each park in the Northeast Temperate Network (NETN).

Resources	NETN Parks
Agius, B. December 2003. Forging Changes in an American Landscape: Invasive Plant Species at the Saugus Iron Works National Historic Site. Technical Report NPS/NER/NRTR—2005/010. National Park Service. Woodstock, VT.	SAIR
Agius, B. December 2003. Revolutionary Changes to an American Landscape: Invasive Plant Species at the Minute Man National Historical Park. Technical Report NPS/NER/NRTR—2005/009. National Park Service. Woodstock, VT.	MIMA
Consultations with park Natural Resource Managers, EPMTs, park personnel and scientists familiar with park lands	All Parks
Exotic Plant Management Team (EPMT) Data sets--Alien Plant Control and Management Database (APCAM).	All Parks
Elliman, T. 2005. Boston Harbor Islands Botanical Inventory. 165 p.	BOHA
Greene, C.W., J.E. Weber, S.C. Rooney, K.B. Anderson. December 2004. Invasive Plant Distribution and Abundance in Acadia National Park. Technical Report NPS/NER/NRTR—2004/003. National Park Service. Boston, MA.	ACAD
NPSpecies - The National Park Service Biodiversity Database. Secure online version. https://science1.nature.nps.gov/npspecies/web/main/start .	All parks
Redstart Forestry Consulting. 2008. MABI 2008 Invasives monitoring, assessment and treatment report.	MABI
Trocki, C. and P. Paton. 2007. Study Design for Assessing the Effects of Knapweed Control on Grassland Birds at Saratoga National Historical Park. Natural Resources Report NPS/NER/NRR--2007/015. National Park Service. Boston, Massachusetts.	SARA
Vegetation Classification and Mapping Report data	ACAD, MIMA, MORR, SAIR, SARA, WEFA

Although the numbers varied by park, approximately 50 common and well-established species were eliminated from NETN parks and approximately 20 were eliminated from BOHA. Examples include Queen Anne's lace (*Daucus carota*), dame's rocket (*Hesperis matronalis*), and sulphur cinquefoil (*Potentilla recta*). Both Queen Anne's lace and dame's rocket were present in every park and sulphur cinquefoil was present in every park with the exception of Roosevelt-Vanderbilt National Historic Sites (ROVA). Sufficient background data was not available for ROVA, but due to the general widespread distribution of sulphur cinquefoil, it is thought to occur there.

Once a list of species known or thought to occur in each park was created and all common and widespread species were removed, existing invasive species data from nearby parks, towns, counties, and states were reviewed and new invasive species threats not present in the parks were added to the candidate list. The following resources, among others, were utilized to complete a candidate list of early detection species lists for each park:

1. USDA PLANTS database <http://plants.usda.gov/>
2. The Biota of North America Program (BONAP) web-based U.S. County-Level Atlas of the Vascular Flora of North America <http://www.bonap.org/MapSwitchboard.html>
3. Early Detection and Distribution Mapping System (EDDMapS) <http://www.eddmaps.org/>
4. National Agricultural Pest Information System (NAPIS) <http://pest.ceris.purdue.edu/index.php>
5. Invasive Plant Atlas of New England (IPANE) <http://nbii-nin.ciesin.columbia.edu/ipane/>
6. iMapInvasives <http://www.imapinvasives.org/>
7. USGS Non-indigenous Aquatic Species (NAS) <http://nas.er.usgs.gov/>
8. Massachusetts Office of Coastal Zone Management Potential Invaders list (<http://www.mass.gov/czm/czm.htm>)
9. Invasive Species Watch List for Vermont <http://www.uvm.edu/mastergardener/invasives/invasivesdocuments/watchlist.pdf>
10. Vermont Department of Environmental Conservation (VDEC)
11. Connecticut Invasive Plant Working Group (CIPWG) <http://www.hort.uconn.edu/cipwg/>
12. Massachusetts Invasive Plants Advisory Group (MIPAG) <http://www.massnrc.org/mipag/>
13. New Hampshire Department of Agriculture, Markets and Food http://www.nh.gov/agric/divisions/plant_industry/plants_insects.htm
14. NatureServe Explorer <http://www.natureserve.org/explorer/>
15. Wayne Millington, NPS Northeast Region IPM Coordinator
16. Betsy Lyman and Brian McDonnell, Northeast Exotic Plant Management Team (EPMT), Liaison
17. Northeast Aquatic Nuisance Species Panel (NEANS) <http://www.northeastans.org/>
18. Sea Grant: New York <http://nyis.info/Default.aspx>
19. Invasive Plant Council of New York State (IPC) <http://www.ipcnys.org/>
20. Central Jersey Invasive Species Strike Team (CJISST) <http://www.cjisst.org/index.html>
21. Leslie Mehrhoff, Director, Invasive Plant Atlas of New England (IPANE)
22. Communications with park personnel and contractors familiar with the parks.

Once a good invasive species candidate list was constructed, each candidate species was then researched and prioritized. During this process, each park natural resource manager, the Regional Integrative Pest Management Coordinator and Exotic Plant Management Team Liaison was consulted for input. In the case of BOHA, the NETN coordinator, BOHA Natural Resource Manager, Invasive Species Early Detection Coordinator (ISED) and Les Mehrhoff, former Director of IPANE, participated in a conference call to prioritize species for each island. Initially, due to time constraints, species were marked as “priority” and “low priority.” The following questions were asked during the species prioritization process:

1. Does the species have an invasive history? “A species is likely to become invasive in a new habitat if it has a prior history of invasion elsewhere” (Rejmanek 2000, National Research Council 2002).
2. What is the species current distribution and have there been any recent outbreaks? What is the species proximity to the park? If aquatic, does it occur up or downstream of the park?
3. Does the species have the potential to become naturalized in the park?
4. Does species have the potential to establish in minimally managed habitats?
5. What is the species’ habitat suitability (e.g., wetland or upland forest)? A wetland species is not as high a threat to a park that does not contain wetland habitat.
6. Are there host species present (pests and diseases only)?
7. Is the species a significant threat to park resources and communities of ecological significance (bogs, river scour communities, cliff communities etc.)?
8. Does the species negatively affect forest crop production, commercial agriculture or human health?
9. Does the species possess reproductive strategies and dispersal mechanisms that enable it to disperse rapidly and widely? A species that reproduces by seed and is dispersed by animals is more likely to be a threat than a species that reproduces only by vegetative means.
10. Does the species have a competitive ability? For example, if the species is a plant, does it have an advantage over native plants when acquiring resources like water, light, and nutrients?
11. If the species already exists in the park, have there been any disturbances or changes in the park landscape that would alter or enhance the species’ invasibility?
12. What are the individual parks desires? For example, didymo might be impossible to currently control, but species tracking and spread prevention via public education might be important to the park.
13. What is the NatureServe Explorer Invasive Species Impact Rank (I-Rank) if available? I-Rank should only be used for guidance during the prioritization process. “Species for which I-Rank information is currently available do not represent a random sample of species exotic in the United States; available assessments may be biased toward those species with higher-than-average impact.” (NatureServe 2009).

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Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be increased incrementally 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	December 2013	Douglas Manning and Jesse Wheeler	Updated invasive species status and removed ISED candidate status tables	Reduce the need to annually update species tables in protocol

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 962/125698, August 2014

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