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Distribution and Abundance of Non-native Plant Species at Fort Necessity National Battlefield and Friendship Hill National Historic Site

Natural Resources Technical Report NPS/NER/NRTR--2006/053



ON THE COVER

Japanese stiltgrass (*Microstegium vimineum*) dominates the groundcover of the sycamore river floodplain community type along the Monongahela River, Friendship Hill National Historic Site. Photograph by Ephraim Zimmerman.

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Executive Summary

Non-native plant species were inventoried at Fort Necessity National Battlefield (FONE) and Friendship Hill National Historic Site (FRHI) during vegetation mapping and classification activities.

Sixty-four non-native plant species were documented at FONE. The two most widespread non-native plants were multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*) and Morrow's honeysuckle (*Lonicera morrowii*). All three species occurred at more than half of the 97 survey points. Several other non-native plants were prevalent in successional old fields, successional forests, and cultural community types. Oak-dominated community types (white oak-mixed hardwood forests and northern red oak-mixed hardwood forests) contained the fewest non-native plants. In contrast, successional old-field types, red maple-black cherry successional forests and tuliptree forests exhibited the highest abundance. In general, non-native plants exhibited a greater percent cover at points beneath open canopies than along roads and trails beneath a closed canopy. Along roads, trails, and transportation rights-of-way, the highest numbers of non-native plant species occurred along paved roadsides in open or disturbed community types (successional old field and tuliptree forest community types) and cultural vegetation patches.

Sixty-six non-native plants were documented at Friendship Hill National Historic Site (FRHI). The three most common species were multiflora rose, Japanese honeysuckle (*Lonicera japonica*) and Japanese stiltgrass (*Microstegium vimineum*) each occurring in nearly half of the 84 plots surveyed and were present in nearly every community type. Tree-of-heaven (*Ailanthus altissima*), Japanese knotweed/giant knotweed (*Polygonum cuspidatum/P. sachalinense*) and reed canarygrass (*Phalaris arundinacea*), though not widely distributed at FRHI, are serious problems where populations occur, often forming dense colonies and/or monocultures. Similar to FONE, successional old-field community patches and successional hardwood types, such as tuliptree - beech - maple and sycamore floodplain forests had the greatest number of invasive species at FRHI. Likewise, oak-dominated community patches had few non-native species. Mixed forb marsh community patches were near monocultures of reed canarygrass or Japanese stiltgrass. Maintained grasslands and developed patches shared many of the same species found in successional old fields; periodic mowing prevents growth of shrubs and trees. Trails through open habitats, such as developed land and successional old fields, possess a species composition similar to that of the patch. Along smaller trails and paths through closed canopied forests, oriental ladythumb (*Polygonum caespitosum*) and Japanese stiltgrass were exceedingly abundant.

Management plans should be developed for each community type, in particular for successional old fields and pine plantations. For conifer plantations, nonnative pines and spruces should be removed and these areas should be replanted with native species. Control efforts in oak dominated types should focus along trails, roadsides and near forest edges. For any road building, forestry, or maintenance activities, equipment should be thoroughly cleaned prior to use and cleaned in the area following the activity. Construction, expansion, and upgrading of roads should be limited in mature, closed-canopy forests. When new road construction is unavoidable, it should be routed through already-invaded habitat such as successional fields.

The results of the inventory suggest that the invasive species composition is a symptom of human disturbance, both past and present, as more disturbed or successional plant community types exhibited a substantially higher number of non-native plant species at FONE and FRHI. Differences between the FRHI and FONE sites, in the invasive species present, their density, and their distribution among the plant communities, are likely due to differences in community fragmentation and disturbance history at the two sites.

Keywords: non-native species, vegetation mapping, Fort Necessity National Battlefield, Friendship Hill National Historic Site

Introduction

The introduction and naturalization of non-native invasive plant species into native plant communities has emerged as a problem of primary importance for natural areas management. Both deliberate and intentional non-native introductions have long been associated with human movement, but the rate of artificial introductions has increased dramatically in the wake of European colonization and the increased ease of transoceanic transport over the past two centuries (Mack et al. 2000). Non-native invasive plants can spread quickly and aggressively in the absence of co-adapted herbivores, pests, and parasites (Blossey and Notzold 1995). Plants which are far from dominant in their natural communities can overwhelm the competition in their new homes, altering community structure, changing nutrient cycling, slowing succession, and interfering with the fire regime in fire-adapted systems (Mack et al. 2000, Tu 2003, Gordon 1998, Myster and Pickett 1995).

Disturbed, successional, and fragmented habitats are significantly more vulnerable to invasion than intact later successional types (Cadenasso and Pickett 2001, Robertson et al. 1994, Szymstad 2000), and therefore invasive plant control is of much greater importance in smaller areas, with high perimeter to area ratios, large areas of successional habitat, or highly heterogeneous vegetative communities. The National Parks Service (NPS) units in western Pennsylvania (Allegheny Portage Railroad National Historic Site [ALPO], Johnstown Flood National Memorial [JOFL], Fort Necessity National Battlefield [FONE], and Friendship Hill National Historical Site [FRHI]) are well described by these qualifications for invasion. All are roughly 500 hectares or smaller, with varying degrees of habitat heterogeneity; many habitat patches are recovering from varying degrees of human disturbance, and all four units are surrounded by development. Control of invasive plant species should be a significant consideration in management of these four units.

Previous Studies by Western Pennsylvania Conservancy in Western Pennsylvania NPS Units

From 2001-2002, the Western Pennsylvania Conservancy (WPC) conducted an inventory of special concern species and delineated plant communities in the four western Pennsylvania NPS units. Plant communities were inventoried and mapped for each property through field assessment and aerial photo interpretation. WPC ecologists found that non-native species were well established in many areas and made up a significant proportion of the vegetative composition of many plant communities in the four NPS units. However, non-native plant populations were not the focus of that study.

WPC and The Nature Conservancy (TNC) are currently involved in a quantitative, plot-based, plant community-mapping project in the four NPS properties in Western Pennsylvania as part of a national vegetation community classification and mapping program sponsored by NPS, United States Geological Survey, and NatureServe (Perles et. al Dec. 2005a, 2005b). The goal of the mapping effort at the NPS units is to produce an up-to-date digital geospatial vegetation database for the park and to provide a plant species list, a dichotomous key for vegetation associations, and descriptions of the vegetation associations in the park. To ensure that vegetation mapping is standardized across the NPS, The Nature Conservancy, in conjunction with NatureServe, the Federal Geographic Data Committee, and the Ecological Society of America Vegetation

Subcommittee, developed a protocol for creating vegetation maps in national parks. This protocol was adopted by the United States Geological Survey (USGS)/NPS Vegetation Mapping Program as the standard (The Nature Conservancy and Environmental Systems Research Institute 1994a, 1994b, 1994c) and has been implemented at the four NPS units in Western Pennsylvania by the Pennsylvania Natural Heritage Program.

Baseline information on plant community composition and rarity is critical to developing desired conditions and park management goals relating to native plant communities, nonnative plant and insect species, and effects of deer browse and other disturbances. Plot sampling for the vegetation mapping project began in 2003 at FONE and will continue in the other park units through 2006. This mapping effort provides an opportunity to evaluate the presence, absence and/or abundance of non-native plant species at points within each delineated community patch and to identify areas of high non-native plant species abundance.

Goals and Objectives

The goal of this study was to inventory the non-native plant populations in each of the four NPS units between 2004 and 2006 using the NPS vegetation mapping plots and accuracy assessment points. This report details the results of the inventory in FONE and FRHI, which took place in 2004-2005. This inventory will contribute to a general understanding of the non-native plant distributions, identify what species are most prevalent, and determine which plant community types are most impacted by non-native plant species. This report draws attention to survey points and vegetative communities with particularly dense populations of non-native plants and identifies them as targets for further study and management. A second report, detailing the distribution and abundance of non-native invasive plant species at JOFL and ALPO is scheduled to be completed in the fall of 2006.

The specific objectives of this study were to:

1. Provide a list of non-native plant species present in each NPS unit;
2. Provide a list of non-native plant species to target in more detailed surveys and control efforts (species listed as posing a moderate to severe threat to native plants and habitats in Pennsylvania: <http://www.dcnr.state.pa.us/forestry/wildplant/invasive.aspx>);
3. Provide a general understanding of which vegetative communities are most/least impacted by non-native plants; and
4. Provide information to help develop management recommendations and prioritize areas for detailed monitoring and management.

Methods

Field Methods

WPC ecologists followed a rapid inventory (rapid assessment) methodology developed and used by Pennsylvania Natural Heritage Program partner, TNC Pennsylvania Science Office (PSO), for Delaware Water Gap National Recreation Area to inventory non-native plant populations in delineated plant community polygons. Rapid assessment took place in conjunction with the NPS/NatureServe vegetative community mapping and accuracy assessment activities for FONE¹ and FRHI. A 1962m² (25m radius) circular plot was established at the center of each NPS/NatureServe community mapping plot and at each accuracy assessment point (Figures 1-4). In addition, there were several more points randomly established within community patches to increase the number of sample points. At each location, the abundance of all identifiable non-native species using a predetermined list created by PNHP with input from NPS resource managers (see Appendix for sampling form). Additional non-native species found during survey activities were added to the list. For each species present, an abundance code was assigned as follows:

A = abundant (very common, approximately >20% cover in a 25-m radius area)

O = occasional (scattered, approximately 1-20% cover in a 25-m radius area)

R = rare (one plant or very few widely scattered plants in a 25-m radius area)

Because roadsides, paths and trails often represent pathways of invasion for non-native plants, presence and abundance of non-native plant species were also assessed along 50 m-long stretches of trails throughout each Park unit (Figures 1 and 4). Sample sites consisted of 50 m linear stretches along three representative types of rights-of-way at FONE and FRHI: dirt paths (hiking trails), gravel two-tracks (accessible by park vehicles), and paved roads (accessed by park and visitor vehicles). The sites chosen represent the most common types of transportation rights-of-way in each NPS unit. Abundance along these rights-of-way was recorded using the same scale as above.

The location of each plot was recorded with a Trimble GeoXM global positioning system (GPS) unit, with the datum set to North American 1983 (Conus) and the coordinate system set to Universal Trans-Mercator (UTM) zone 17. The X-Y coordinates for both NPS units were differentially corrected using Trimble GPS Pathfinder Office and Shape Correct software with base station data from the CORS National Geodetic Survey Pittsburgh, PA base station (<http://www.ngs.noaa.gov/cgi-cors/corsage.prl?site=PIT1>).

When completed, park-specific abundance, cultivation, and management codes were assigned to each non-native species encountered according to guidelines presented in “NPSpecies Data Dictionary for Users: Field and Value Definitions, Version 2.”

¹ Since plot sampling for FONE was conducted in 2003, WPC ecologists revisited community-mapping plots and assigned an abundance code for all non-native plants based on the methodology above.

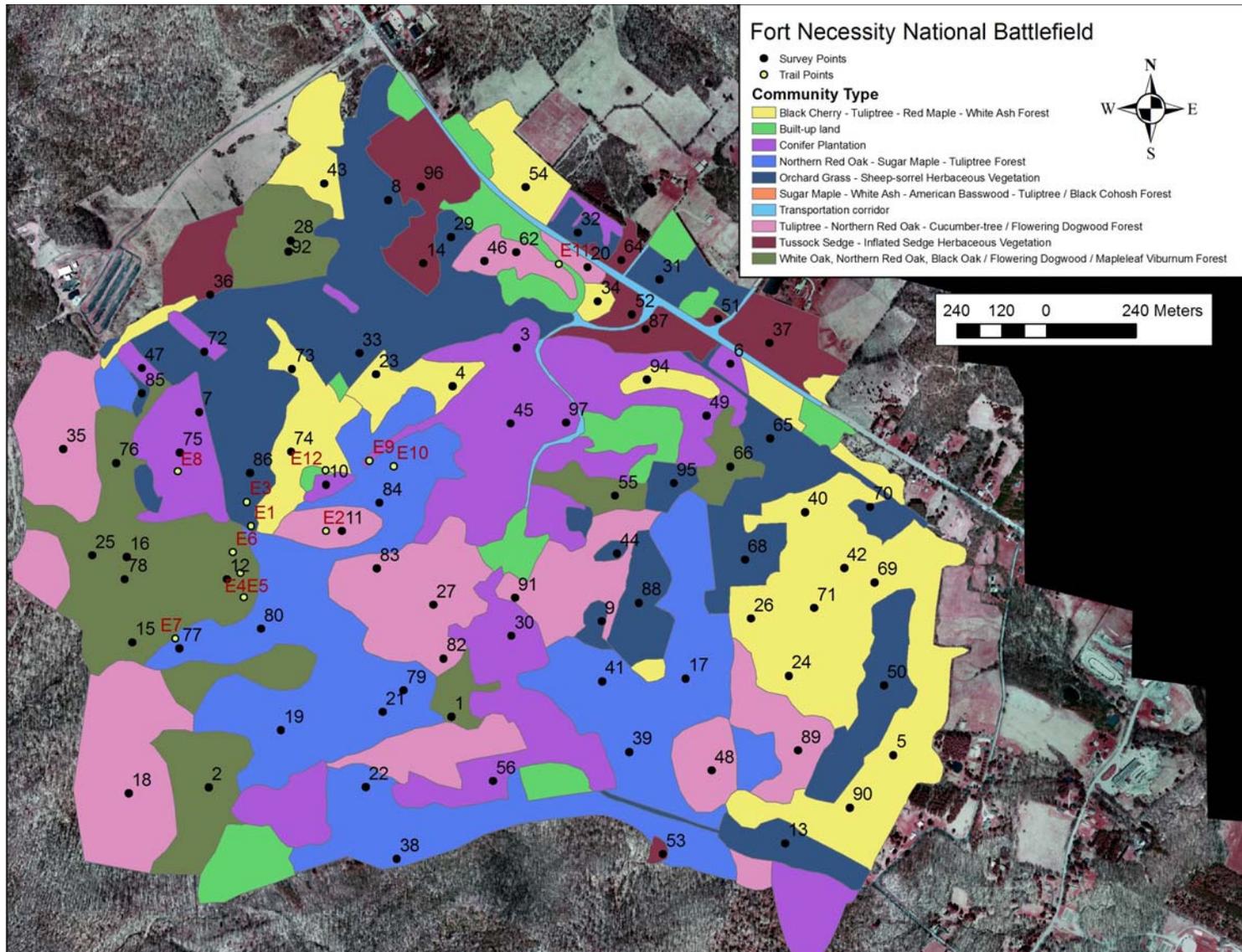


Figure 1. Locations of non-native plant monitoring points and points along rights-of-way within delineated vegetation community types, Fort Necessity National Battlefield.

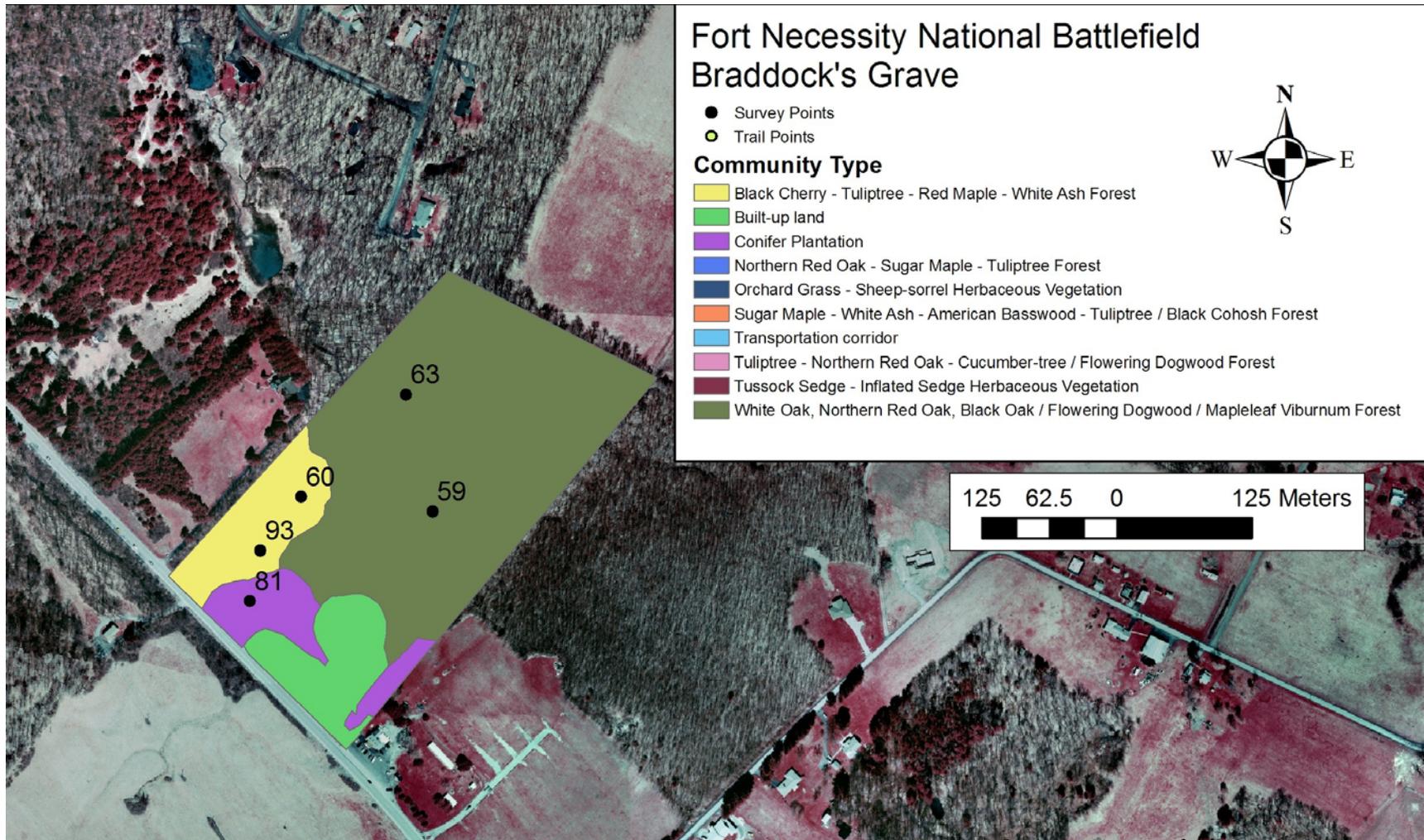


Figure 2. Locations of non-native plant monitoring points within delineated vegetation community types at Braddock's Grave, Fort Necessity National Battlefield.

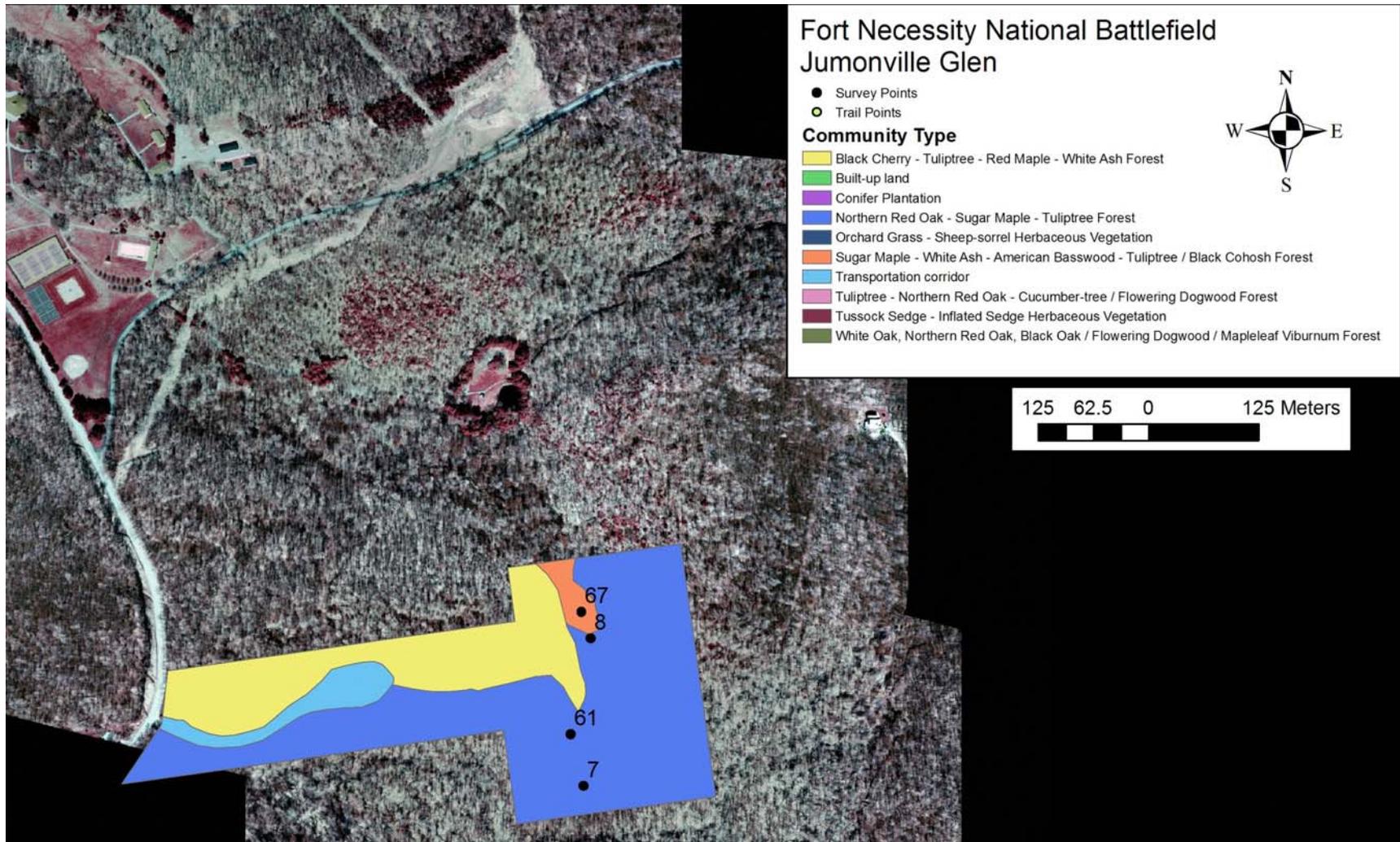


Figure 3. Locations of non-native plant monitoring points within delineated vegetation community types at Jumonville Glen, Fort Necessity National Battlefield.



Figure 4. Locations of non-native plant monitoring points and points along rights-of-way within delineated vegetation community types, Friendship Hill National Historic Site.

Data Analysis

Data were transcribed from field recording sheets, from points corresponding to vegetation survey plots and those along transportation rights-of-way, into a Microsoft Excel spreadsheet. To facilitate quantitative evaluation of the data, the abundance codes A, O, and R were translated to the values 60, 10, and 1, respectively, to represent the midpoint cover value. Data were then summarized by survey point, species, and community type and presented in Table 1 and Table 6.

Not all non-native species are considered to be “invasive,” or possessing the ability to aggressively spread and displace native vegetation, by the Pennsylvania Department of Conservation and Natural Resources (PA DCNR). Two lists of invasive species are currently distributed by PA DCNR. The first is list of noxious weeds developed by DCNR in 2000 as a brochure (<http://www.dcnr.state.pa.us/forestry/wildplant/invasive.aspx>) that identified noxious weeds and their threat to natural areas. The second, “DCNR Invasive Exotic Plant Tutorial for Natural Lands Managers,” developed in 2005 specifically as an educational tool for land managers (<http://www.dcnr.state.pa.us/forestry/invasivetutorial/List.htm>), is much more comprehensive. However, the level of threat was not addressed in the Tutorial. Therefore, in Tables 1 and 6, the non-native plants were designated as “invasive” when identified as invasive in the Exotic Plant Tutorial, and threat level was provided when information on threat was available through the DCNR Invasive Species in PA brochure.

The presence and coverage for each non-native species was reported at each survey point and totaled for all points within a community type in order to determine non-native species composition by specific community type. Similar values were calculated for sites along roads and trails.

Results and Discussion

Fort Necessity National Battlefield

Sixty-four non-native plant species were found among the 97 survey points and 12 points along transportation corridors at FONE, including red pine (*Pinus resinosa*) and blue spruce (*Picea pungens*), which are two species native to North America but not to southwestern PA (Table 1). Of the 64 non-native species, 15 were found at over ten percent of the plots surveyed at FONE. Thirteen species out of the 64 found at the park are listed as posing a moderate to serious threat to native plants and habitats in Pennsylvania according to the PA DCNR Invasive Species in Pennsylvania (<http://www.dcnr.state.pa.us/forestry/wildplant/invasive.aspx>). Three others, purple crownvetch (*Coronilla varia*), winged burning bush (*Euonymus alatus*), and tall fescue (*Festuca elatior*) were species considered invasive on the PA DCNR's Exotic Plant Tutorial for Natural Lands Managers: <http://www.dcnr.state.pa.us/forestry/invasivetutorial/List.htm>. The non-native bull thistle (*Cirsium vulgare*), found at FONE, was not listed on the DCNR Tutorial but is found on the Invasive Plants in Pennsylvania list.

The two most widespread non-native plants were multiflora rose (*Rosa multiflora*), which was present at 67 of 97 survey points (69.1%), and Japanese barberry (*Berberis thunbergii*), present at 62 of 97 points (63.9%) (Table 4). Both woody shrubs were present in every community except sugar maple-basswood forest, which was only represented by one community polygon in the park. A third woody shrub, Morrow's honeysuckle (*Lonicera morrowii*), was present at 53 points (54.6%) and in every community except northern red oak – mixed hardwood forest and sugar maple-basswood forest. Although all three species were primarily found in open, successional habitats, they can tolerate shade with reduced flowering and seed production (Rhoads and Block 2002e, 2002h, 2002i) and invade thinned forest edges and fragmented closed-canopy systems (Brothers and Spingarn 1992, Cadenasso and Pickett 2001). Their distribution across most community types at FONE suggests these species may be difficult to eradicate. Management activities should focus on control of these three species where large populations directly threaten rare plant populations and animal habitats.

The uneven distribution of sample plots among community types (Tables 2 and 3) influenced the results and interpretation of the results. While there tended to be more plots in more common types, and for the most part common types were well sampled, the non-native composition of plant community types with one or few sample points may not be representative of these types in the park or region. For example, a large number of successional old fields were sampled at FONE (n = 16), and therefore invasive species found in this type may appear to be more common in the park. However, many species found in this type were not present in any other type, as they require full sun, which is not available in closed canopy community types (see discussion of successional old fields below). In addition, only one patch of sugar maple – basswood forest was found at FONE, and was therefore only represented by one assessment point, not enough to truly assess the impact of non-native species in this type in the region. However, the closed canopy and later successional nature of this community type, as in the case with the oak dominated forests, suggests that Morrow's honeysuckle, Japanese barberry, and multiflora rose are less common here than in open or early-successional types.

Table 1. List of non-native plant species present at Fort Necessity National Battlefield with abundance and cultivation codes and invasive status as stated by PA Department of Conservation and Natural Resources.

Scientific Name	Common Name	Points Where Present	% of Points Present	Abundance ^a	Cultivation ^b	Invasive ^c	Threat (PA DCNR) ^d
<i>Rosa multiflora</i>	multiflora rose	67	69.1	Abundant	Not cultivated	Yes	Serious
<i>Berberis thunbergii</i>	Japanese barberry	62	63.9	Abundant	Not cultivated	Yes	Moderate
<i>Lonicera morrowii</i>	Morrow's honeysuckle	55	56.7	Abundant	Not cultivated	Yes	Serious
<i>Anthoxanthum odoratum</i>	sweet vernalgrass	48	49.5	Abundant	Not cultivated	No	No
<i>Holcus lanatus</i>	common velvetgrass	37	38.1	Abundant	Not cultivated	No	No
<i>Dactylis glomerata</i>	orchardgrass	32	33.0	Abundant	Not cultivated	No	No
<i>Polygonum persicaria</i>	spotted ladysthumb	31	32.0	Abundant	Not cultivated	No	No
<i>Chrysanthemum leucanthemum</i>	oxeye daisy	29	29.9	Abundant	Not cultivated	No	No
<i>Poa pratensis</i>	Kentucky bluegrass	17	17.5	Abundant	Not cultivated	No	No
<i>Prunella vulgaris</i>	common selfheal	18	18.6	Common	Not cultivated	No	No
<i>Cirsium vulgare</i>	bull thistle	15	15.5	Common	Not cultivated	Yes	Serious
<i>Festuca elatior</i>	tall fescue	12	12.4	Common	Not cultivated	Yes	No
<i>Picea abies</i>	Norway spruce	12	12.4	Common	Persistent	No	No
<i>Bromus inermis</i>	smooth brome	10	10.3	Common	Not cultivated	No	No
<i>Coronilla varia</i>	purple crownvetch	10	10.3	Common	Persistent	Yes	No
<i>Agrostis stolonifera</i>	creeping bentgrass	9	9.3	Common	Not cultivated	No	No
<i>Tussilago farfara</i>	coltsfoot	8	8.2	Uncommon	Not cultivated	No	No
<i>Cirsium arvense</i>	Canada thistle	8	8.2	Uncommon	Not cultivated	Yes	Serious
<i>Poa compressa</i>	Canada bluegrass	8	8.2	Uncommon	Not cultivated	No	No
<i>Euonymus alatus</i>	winged burning bush	7	7.2	Uncommon	Not cultivated	Yes	No
<i>Glechoma hederacea</i>	ground ivy	6	6.2	Uncommon	Not cultivated	No	No

Table 1. List of non-native plant species present at Fort Necessity National Battlefield with abundance and cultivation codes and invasive status as stated by PA Department of Conservation and Natural Resources (continued).

Scientific Name	Common Name	Points Where Present	% of Points Present	Abundance ^a	Cultivation ^b	Invasive ^c	Threat (PA DCNR) ^d
<i>Hieracium sp.</i>	hawkweed	6	6.2	Uncommon	Not cultivated	No	No
<i>Microstegium vimineum</i>	Japanese stiltgrass	6	6.2	Uncommon	Not cultivated	Yes	Serious
<i>Clinopodium vulgare</i>	wild basil	5	5.2	Uncommon	Not cultivated	No	No
<i>Arctium minus</i>	lesser burdock	5	5.2	Uncommon	Not cultivated	No	No
<i>Ligustrum obtusifolium</i>	obtuse-leaved border privet	5	5.2	Uncommon	Not cultivated	Yes	Moderate
<i>Lotus corniculatus</i>	bird's-foot trefoil	5	5.2	Uncommon	Not cultivated	No	No
<i>Phleum pratense</i>	timothy	5	5.2	Uncommon	Not cultivated	No	No
<i>Rumex crispus</i>	curly dock	5	5.2	Uncommon	Not cultivated	No	No
<i>Daucus carota</i>	Queen Anne's lace	4	4.1	Uncommon	Not cultivated	No	No
<i>Hieracium caespitosum</i>	king-devil	4	4.1	Uncommon	Not cultivated	No	No
<i>Rumex obtusifolius</i>	bitter dock	4	4.1	Uncommon	Not cultivated	No	No
<i>Elaeagnus umbellata</i>	autumn olive	3	3.1	Uncommon	Not cultivated	Yes	Serious
<i>Lonicera japonica</i>	Japanese honeysuckle	3	3.1	Uncommon	Not cultivated	Yes	Serious
<i>Rumex acetosella</i>	common sheep sorrel	3	3.1	Uncommon	Not cultivated	No	No
<i>Taraxacum officinale</i>	common dandelion	3	3.1	Uncommon	Not cultivated	No	No
<i>Veronica officinalis</i>	common gypsyweed	3	3.1	Uncommon	Not cultivated	No	No
<i>Dipsacus fullonum</i>	Fuller's teasel	3	3.1	Uncommon	Not cultivated	No	No
<i>Pinus sylvestris</i>	Scot's pine	3	3.1	Uncommon	Not cultivated	No	No
<i>Trifolium aureum</i>	large yellow hop-clover	3	3.1	Uncommon	Not cultivated	No	No
<i>Agrostis capillaris</i>	colonial bentgrass	2	2.1	Uncommon	Not cultivated	No	No

Table 1. List of non-native plant species present at Fort Necessity National Battlefield with abundance and cultivation codes and invasive status as stated by PA Department of Conservation and Natural Resources (continued).

Scientific Name	Common Name	Points Where Present	% of Points Present	Abundance ^a	Cultivation ^b	Invasive ^c	Threat (PA DCNR) ^d
<i>Ailanthus altissima</i>	tree-of-heaven	2	2.1	Uncommon	Not cultivated	Yes	Serious
<i>Alliaria petiolata</i>	garlic mustard	2	2.1	Uncommon	Not cultivated	Yes	Serious
<i>Forsythia sp.</i>	Forsythia	2	2.1	Rare	Persistent	No	No
<i>Larix kaempferi</i>	Japanese larch	2	2.1	Uncommon	Not cultivated	No	No
<i>Lathyrus latifolius</i>	perennial pea	2	2.1	Uncommon	Not cultivated	No	No
<i>Malus pumila</i>	apple	2	2.1	Uncommon	Persistent	No	No
<i>Melilotus officinalis</i>	yellow sweetclover	2	2.1	Uncommon	Not cultivated	No	No
<i>Pastinaca sativa</i>	wild parsnip	2	2.1	Uncommon	Not cultivated	Yes	Moderate
<i>Picea pungens</i>	blue spruce	2	2.1	Uncommon	Not cultivated	No	No
<i>Pinus resinosa</i>	red pine	2	2.1	Uncommon	Not cultivated	No	No
<i>Trifolium pratense</i>	red clover	2	2.1	Uncommon	Not cultivated	No	No
<i>Cichorium intybus</i>	chicory	1	1.0	Rare	Not cultivated	No	No
<i>Hypochaeris radicata</i>	hairy catsear	1	1.0	Uncommon	Not cultivated	No	No
<i>Paulownia tomentosa</i>	princesstree	1	1.0	Rare	Not cultivated	Yes	No
<i>Phalaris arundinacea</i>	reed canarygrass	1	1.0	Rare	Not cultivated	Yes	Moderate
<i>Ranunculus acris</i>	tall buttercup	1	1.0	Rare	Not cultivated	No	No
<i>Stellaria sp.</i>	chickweed	1	1.0	Rare	Not cultivated	No	No
<i>Vinca minor</i>	common periwinkle	1	1.0	Rare	Not cultivated	Yes	No
<i>Artemisia vulgaris</i> *	common wormwood	0	0	Rare	Not cultivated	No	No
<i>Galinsoga parviflora</i> *	gallant soldier	0	0	Rare	Not cultivated	No	No

Table 1. List of non-native plant species present at Fort Necessity National Battlefield with abundance and cultivation codes and invasive status as stated by PA Department of Conservation and Natural Resources (continued).

Scientific Name	Common Name	Points Where Present	% of Points Present	Abundance ^a	Cultivation ^b	Invasive ^c	Threat (PA DCNR) ^d
<i>Mentha villosa</i> *	mint	0	0	Rare	Not cultivated	No	No
<i>Plantago lanceolata</i> *	narrowleaf plantain	0	0	Rare	Not cultivated	No	No
<i>Trifolium arvense</i> *	white clover	0	0	Rare	Not cultivated	No	No

^a Abundance Codes: Abundant designation for species present at >10% of sample locations, Uncommon = species present between 2 and 10% of sample locations, Rare = species present at less than 1% of sample locations.

^b Cultivation codes: Designated as “cultivated” if species was purposely planted and maintained (e.g. agricultural crops), “not cultivated” if species was not planted, or “persistent” if plant species was once planted, but now not maintained (e.g. non-native pines in plantations) (National Park Service 1996).

^c Invasive: plant species listed as “invasive” by Pennsylvania Department of Conservation and Natural Resources (PA DCNR) Invasive Exotic Plant Management Tutorial for Natural Lands Managers:
<http://www.dcnr.state.pa.us/forestry/invasivetutorial/List.htm>.

^d Threat (PA DCNR): designation or threat posed by a species given by PA DCNR Invasive Species in Pennsylvania:
<http://www.dcnr.state.pa.us/forestry/wildplant/invasive.aspx>.

*indicates species was found along trails, but not at vegetation mapping points.

Table 2. Number of sample plots in each community type, Fort Necessity National Battlefield.

Community Type	Number of Sample Plots
Red maple – black cherry successional forest	18
Successional old field	16
White oak - mixed hardwood forest	14
Northern red oak - mixed hardwood forest	14
Conifer plantation	13
Tuliptree forest	12
Wet meadow	9
Sugar maple - basswood forest	1
Total Number of Sample Plots	97

Table 3. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Fort Necessity National Battlefield.

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
1	White oak - mixed hardwood forest	620746.6059	4407136.4135	2	20	10
12	White oak - mixed hardwood forest	620144.7787	4407505.1452	1	10	10
15	White oak - mixed hardwood forest	619891.1117	4407335.6882	1	10	10
16	White oak - mixed hardwood forest	619876.2532	4407564.9878	1	10	10
2	White oak - mixed hardwood forest	620096.0277	4406947.1467	---	---	---
25	White oak - mixed hardwood forest	619783.5845	4407568.9453	2	70	35
28	White oak - mixed hardwood forest	620316.7173	4408413.8460	1	1	1
55	White oak - mixed hardwood forest	621186.2480	4407728.9237	3	12	4
59	White oak - mixed hardwood forest	619852.0100	4410214.2224	---	---	---
63	White oak - mixed hardwood forest	619827.6626	4410322.3811	2	70	35
66	White oak - mixed hardwood forest	621495.6990	4407807.3681	4	40	10
76	White oak - mixed hardwood forest	619847.9962	4407816.9019	1	60	60
78	White oak - mixed hardwood forest	619870.7118	4407505.4164	2	2	1
92	White oak - mixed hardwood forest	620309.6655	4408383.9686	3	3	1
14	Wet meadow	620671.0202	4408352.4019	6	51	8.5
36	Wet meadow	620100.2546	4408267.7237	6	15	2.5
37	Wet meadow	621599.5056	4408138.7970	17	62	3.6
51	Wet meadow	621461.8014	4408202.8908	15	273	18.2
52	Wet meadow	621230.9637	4408215.2102	8	212	26.5
53	Wet meadow	621314.6536	4406767.6894	14	213	15.2
64	Wet meadow	621202.1278	4408360.9635	5	73	14.6

Table 3. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Fort Necessity National Battlefield (continued).

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
87	Wet meadow	621268.1407	4408175.4780	7	152	21.7
96	Wet meadow	620664.6733	4408558.1439	9	231	25.7
11	Tuliptree forest	620452.7868	4407634.3578	3	30	10
18	Tuliptree forest	619881.9193	4406930.9561	2	20	10
20	Tuliptree forest	621112.2387	4408342.0324	9	154	17.1
27	Tuliptree forest	620698.5638	4407436.6261	7	291	41.6
35	Tuliptree forest	619705.9031	4407853.9385	3	130	43.3
46	Tuliptree forest	620835.3103	4408358.5000	15	232	15.5
48	Tuliptree forest	621444.9073	4406992.4312	2	11	5.5
62	Tuliptree forest	620920.6686	4408381.5688	16	342	21.4
82	Tuliptree forest	620725.7410	4407292.5289	2	2	1
83	Tuliptree forest	620547.3435	4407534.4595	5	32	6.4
89	Tuliptree forest	621676.4147	4407045.7037	8	203	25.4
91	Tuliptree forest	620917.1502	4407455.3944	3	130	43.3
67	Sugar maple - basswood forest	616312.3612	4415385.3380	1	10	10
13	Successional old field	621641.4002	4406796.8866	7	320	45.7
29	Successional old field	620745.4842	4408422.8956	8	262	32.8
31	Successional old field	621304.7067	4408309.3460	14	86	6.1
32	Successional old field	621085.4968	4408434.9708	6	160	26.7
33	Successional old field	620500.0716	4408111.0840	12	161	13.4
44	Successional old field	621190.9483	4407573.9440	4	31	7.8

Table 3. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Fort Necessity National Battlefield (continued).

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
50	Successional old field	621906.8301	4407220.8523	8	130	16.3
8	Successional old field	620577.7090	4408522.0447	10	205	20.5
9	Successional old field	621150.2565	4407392.0675	7	270	38.6
65	Successional old field	621601.8956	4407882.6062	6	51	8.5
68	Successional old field	621533.7509	4407557.4205	11	310	28.2
70	Successional old field	621870.1034	4407698.9537	13	213	16.4
85	Successional old field	619917.2472	4408003.9929	9	113	12.6
86	Successional old field	620207.0012	4407790.1800	11	115	10.5
88	Successional old field	621249.5357	4407442.2130	13	371	28.5
95	Successional old field	621343.2366	4407762.8372	9	190	21.1
23	Red Maple – black cherry successional forest	620544.6111	4408054.1674	5	41	8.2
24	Red Maple – black cherry successional forest	621651.6272	4407246.2105	11	151	13.7
26	Red Maple – black cherry successional forest	621550.5504	4407399.1381	7	34	4.9
34	Red Maple – black cherry successional forest	621139.9286	4408250.6824	9	36	4
4	Red Maple – black cherry successional forest	620749.6745	4408022.6765	9	190	21.1
40	Red Maple – black cherry successional forest	621695.6605	4407685.4207	4	40	10
42	Red Maple – black cherry successional forest	621800.2094	4407535.3109	9	104	11.6
43	Red Maple – black cherry successional forest	620405.4287	4408566.3081	5	50	10
5	Red Maple – black cherry successional forest	621932.3488	4407033.8315	7	170	24.3
54	Red Maple – black cherry successional forest	620945.6770	4408556.4410	12	143	11.9
60	Red Maple – black cherry successional forest	619730.2169	4410227.4436	4	81	20.3

Table 3. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Fort Necessity National Battlefield (continued).

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
69	Red Maple – black cherry successional forest	621881.9659	4407496.7321	10	46	4.6
71	Red Maple – black cherry successional forest	621719.9636	4407427.7260	11	215	19.5
73	Red Maple – black cherry successional forest	620319.4675	4408069.3469	11	160	14.5
74	Red Maple – black cherry successional forest	620316.9018	4407847.1716	8	53	6.6
90	Red Maple – black cherry successional forest	621815.3173	4406892.5373	5	91	18.2
93	Red Maple – black cherry successional forest	619692.3819	4410177.9045	6	110	18.3
94	Red Maple – black cherry successional forest	621271.2906	4408040.7272	6	33	5.5
17	Northern red oak - mixed hardwood forest	621375.7799	4407239.0306	3	21	7.0
19	Northern red oak - mixed hardwood forest	620289.9553	4407100.3442	---	---	---
21	Northern red oak - mixed hardwood forest	620562.4407	4407148.7867	2	11	5.5
22	Northern red oak - mixed hardwood forest	620517.7903	4406948.1016	2	11	5.5
38	Northern red oak - mixed hardwood forest	620600.8615	4406755.1122	1	10	10
39	Northern red oak - mixed hardwood forest	621224.1490	4407041.9409	2	20	10
41	Northern red oak - mixed hardwood forest	621150.8355	4407231.4927	3	30	10
57	Northern red oak - mixed hardwood forest	616314.5347	4415187.2888	---	---	---
58	Northern red oak - mixed hardwood forest	616322.7365	4415354.9356	---	---	---
61	Northern red oak - mixed hardwood forest	616300.3081	4415246.3610	8	17	2.1
77	Northern red oak - mixed hardwood forest	620017.0100	4407319.2949	3	30	10
79	Northern red oak - mixed hardwood forest	620618.4676	4407206.9958	2	2	1
80	Northern red oak - mixed hardwood forest	620236.2070	4407372.0150	1	10	10
84	Northern red oak - mixed hardwood forest	620554.5428	4407710.2151	3	21	7

Table 3. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Fort Necessity National Battlefield (continued).

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
10	Conifer plantation	620410.5760	4407758.3927	9	322	35.8
3	Conifer plantation	620922.6189	4408125.7757	13	167	12.8
30	Conifer plantation	620908.2448	4407353.3225	9	63	7
45	Conifer plantation	620905.6761	4407922.9327	15	146	9.7
47	Conifer plantation	619916.8503	4408071.1397	4	140	35
49	Conifer plantation	621431.3369	4407944.0428	10	46	4.6
56	Conifer plantation	620858.6519	4406963.4445	4	22	5.5
6	Conifer plantation	621495.8235	4408082.4045	4	40	10
7	Conifer plantation	620070.9564	4407953.4886	5	73	14.6
72	Conifer plantation	620085.1689	4408115.6259	10	46	4.6
75	Conifer plantation	620018.7537	4407844.4503	6	251	41.8
81	Conifer plantation	619682.6125	4410130.9459	7	61	8.7
97	Conifer plantation	621053.8377	4407924.8120	10	132	13.2

Table 4. Non-native species summarized by plant community type, Fort Necessity National Battlefield.

Common Name	Scientific Name	Plots Invaded	%	Conifer Plantation				Red Maple – Black Cherry Successional Forest				Northern Red Oak – Mixed Hardwood Forest			
				Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Multiflora rose	<i>Rosa multiflora</i>	67	69.1	10	13	76.9	9.1	16	18	88.9	21.9	10	14	71.4	8.2
Japanese barberry	<i>Berberis thunbergii</i>	62	63.9	13	13	100.0	21.5	16	18	88.9	16.3	7	14	50.0	6.1
Morrow's honeysuckle	<i>Lonicera morrowii</i>	53	56.7	7	13	53.8	24.3	16	18	88.9	31.3	---	14	---	---
Sweet vernalgrass	<i>Anthoxanthum odoratum</i>	48	49.5	9	13	69.2	13.6	13	18	72.2	6.5	---	14	---	---
Common velvetgrass	<i>Holcus lanatus</i>	37	38.1	6	13	46.2	2.5	6	18	33.3	8.5	---	14	---	---
Orchardgrass	<i>Dactylis glomerata</i>	32	33.0	5	13	38.5	18.2	7	18	38.9	7.4	---	14	---	---
Spotted ladysthumb	<i>Polygonum persicaria</i>	31	32.0	6	13	46.2	5.5	12	18	66.7	8.5	4	14	28.6	5.5
Oxeye daisy	<i>Chrysanthemum leucanthemum</i>	20	29.9	3	13	23.1	7.0	4	18	22.2	3.3	---	14	---	---
Common selfheal	<i>Prunella vulgaris</i>	18	18.6	3	13	23.1	20.7	3	18	16.7	4.0	1	14	7.1	1.0
Kentucky bluegrass	<i>Poa pratensis</i>	17	17.5	2	13	15.4	1.0	5	18	27.8	8.2	1	14	7.1	1.0
Bull thistle	<i>Cirsium vulgare</i>	15	15.5	2	13	15.4	5.5	3	18	16.7	4.0	---	14	---	---
Tall fescue	<i>Festuca arundinacea</i>	12	12.4	1	13	7.7	1.0	2	18	11.1	1.0	---	14	---	---
Norway spruce	<i>Picea abies</i>	12	12.4	6	13	46.2	23.7	5	18	27.8	8.2	---	14	---	---
Smooth brome	<i>Bromus inermis</i>	10	10.3	2	13	15.4	1.0	3	18	16.7	1.0	---	14	---	---
Purple crownvetch	<i>Coronilla varia</i>	10	10.3	1	13	7.7	1.0	1	18	5.6	1.0	---	14	---	---
Creeping bentgrass	<i>Agrostis stolonifera</i>	9	9.3	1	13	7.7	1.0	1	18	5.6	10.0	---	14	---	---
Coltsfoot	<i>Tussilago farfara</i>	8	8.2	3	13	23.1	26.7	1	18	5.6	10.0	1	14	7.1	1.0
Canada thistle	<i>Cirsium arvense</i>	8	8.2	1	13	7.7	1.0	1	18	5.6	10.0	---	14	---	---
Canada bluegrass	<i>Poa compressa</i>	8	8.2	---	13	---	---	4	18	22.2	5.5	---	14	---	---
Winged burning bush	<i>Euonymus alatus</i>	7	7.2	1	13	7.7	1.0	3	18	16.7	7.0	---	14	---	---
Timothy	<i>Phleum pratense</i>	5	5.2	---	13	---	---	---	18	---	---	---	14	---	---
Lesser burdock	<i>Arctium minus</i>	5	5.2	1	13	7.7	1.0	1	18	5.6	1.0	---	14	---	---

Table 4. Non-native species summarized by plant community type, Fort Necessity National Battlefield (continued).

Common Name	Scientific Name	Plots Invaded	%	Conifer Plantation				Red Maple – Black Cherry Successional Forest				Northern Red Oak – Mixed Hardwood Forest			
				Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Ground ivy	<i>Glechoma hederacea</i>	6	6.2	2	13	15.4	5.5	---	18	---	---	1	14	7.1	1.0
Hawkweed	<i>Hieracium sp.</i>	6	6.2	1	13	7.7	1.0	2	18	11.1	5.5	---	14	---	---
Japanese honeysuckle	<i>Lonicera japonica</i>	3	3.1	---	13	---	---	1	18	5.6	10.0	---	14	---	---
Japanese stiltgrass	<i>Microstegium vimineum</i>	6	6.2	---	13	---	---	3	18	16.7	7.0	1	14	7.1	10.0
Wild basil	<i>Clinopodium vulgare</i>	5	5.2	2	13	15.4	30.5	---	18	---	---	2	14	14.3	5.5
Obtuse-leaved border privet	<i>Ligustrum obtusifolium</i>	5	5.2	1	13	7.7	1.0	2	18	11.1	5.5	---	14	---	---
Bird's-foot trefoil	<i>Lotus corniculatus</i>	5	5.2	---	13	---	---	---	18	---	---	---	14	---	---
Curly dock	<i>Rumex crispus</i>	5	5.2	1	13	7.7	10.0	---	18	---	---	---	14	---	---
Queen Anne's lace	<i>Daucus carota</i>	4	4.1	---	13	---	---	1	18	5.6	1.0	---	14	---	---
King-devil	<i>Hieracium caespitosum</i>	4	4.1	---	13	---	---	---	18	---	---	---	14	---	---
Bitter dock	<i>Rumex obtusifolius</i>	4	4.1	---	13	---	---	1	18	5.6	10.0	---	14	---	---
Autumn olive	<i>Elaeagnus umbellata</i>	3	3.1	---	13	---	---	---	18	---	---	---	14	---	---
Common sheep sorrel	<i>Rumex acetosella</i>	3	3.1	1	13	7.7	10.0	1	18	5.6	1.0	---	14	---	---
Common dandelion	<i>Taraxacum officinale</i>	3	3.1	1	13	7.7	1.0	1	18	5.6	10.0	1	14	7.1	1.0
Common gypsyweed	<i>Veronica officinalis</i>	3	3.1	3	13	23.1	7.0	---	18	---	---	---	14	---	---
Fuller's teasel	<i>Dipsacus fullonum</i>	3	3.1	---	13	---	---	---	18	---	---	---	14	---	---
Scot's pine	<i>Pinus sylvestris</i>	3	3.1	---	13	---	---	---	18	---	---	---	14	---	---
Large yellow hop-clover	<i>Trifolium aureum</i>	3	3.1	---	13	---	---	---	18	---	---	---	14	---	---
Colonial bentgrass	<i>Agrostis capillaris</i>	2	2.1	---	13	---	---	1	18	5.6	1.0	---	14	---	---
Tree-of-heaven	<i>Ailanthus altissima</i>	2	2.1	2	13	15.4	5.5	---	18	---	---	---	14	---	---
Garlic mustard	<i>Alliaria petiolata</i>	2	2.1	---	13	---	---	---	18	---	---	---	14	---	---
Forsythia	<i>Forsythia sp.</i>	2	2.1	---	13	---	---	---	18	---	---	---	14	---	---
Japanese larch	<i>Larix kaempferi</i>	2	2.1	2	13	15.4	30.5	---	18	---	---	---	14	---	---

Table 4. Non-native species summarized by plant community type, Fort Necessity National Battlefield (continued).

Common Name	Scientific Name	Plots Invaded	%	Conifer Plantation				Red Maple – Black Cherry Successional Forest				Northern Red Oak – Mixed Hardwood Forest			
				Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Perennial pea	<i>Lathyrus latifolius</i>	2	2.1	---	13	---	---	---	18	---	---	---	14	---	---
Apple	<i>Malus pumila</i>	2	2.1	---	13	---	---	---	18	---	---	---	14	---	---
Yellow sweetclover	<i>Melilotus officinalis</i>	2	2.1	---	13	---	---	---	18	---	---	---	14	---	---
Wild parsnip	<i>Pastinaca sativa</i>	2	2.1	---	13	---	---	---	18	---	---	---	14	---	---
Blue spruce	<i>Picea pungens</i>	2	2.1	2	13	15.4	5.5	---	18	---	---	---	14	---	---
Red pine	<i>Pinus resinosa</i>	2	2.1	2	13	15.4	60.0	---	18	---	---	---	14	---	---
Red clover	<i>Trifolium pratense</i>	2	2.1	---	13	---	---	1	18	5.6	10.0	---	14	---	---
Chicory	<i>Cichorium intybus</i>	1	1.0	---	13	---	---	---	18	---	---	---	14	---	---
Hairy catsear	<i>Hypochaeris radicata</i>	1	1.0	---	13	---	---	1	18	5.6	1.0	---	14	---	---
Princesstree	<i>Paulownia tomentosa</i>	1	1.0	1	13	7.7	1.0	---	18	---	---	---	14	---	---
Reed canarygrass	<i>Phalaris arundinacea</i>	1	1.0	---	13	---	---	---	18	---	---	---	14	---	---
Tall buttercup	<i>Ranunculus acris</i>	1	1.0	---	13	---	---	---	18	---	---	---	14	---	---
Chickweed	<i>Stellaria sp.</i>	1	1.0	---	13	---	---	---	18	---	---	---	14	---	---
Common periwinkle	<i>Vinca minor</i>	1	1.0	---	13	---	---	1	18	5.6	60.0	---	14	---	---

Table 4. Non-native species summarized by plant community type, Fort Necessity National Battlefield (continued).

Common Name	Successional Old Field				Sugar Maple – Basswood Forest				Tuliptree Forest				Wet Meadow				White Oak – Mixed Hardwood Forest			
	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Multiflora rose	10	16	62.5	19.1	---	1	---	---	10	12	83.3	39.1	3	9	33.3	10.0	8	14	57.1	6.6
Japanese barberry	7	16	43.8	7.4	---	1	---	---	12	12	100.0	20.2	1	9	11.1	1.0	6	14	42.9	5.5
Morrow's honeysuckle	14	16	87.5	31.4	---	1	---	---	6	12	50.0	32.0	9	9	100.0	26.7	1	14	7.1	60.0
Sweet vernalgrass	16	16	100.0	37.6	---	1	---	---	3	12	25.0	10.0	7	9	77.8	30.1	---	14	---	---
Common velvetgrass	14	16	87.5	30.8	---	1	---	---	3	12	25.0	10.0	8	9	88.9	16.9	---	14	---	---
Orchardgrass	10	16	62.5	13.2	---	1	---	---	3	12	25.0	7.0	7	9	77.8	6.1	---	14	---	---
Spotted ladysthumb	2	16	12.5	5.5	---	1	---	---	4	12	33.3	7.5	1	9	11.1	10.0	2	14	14.3	35.0
Oxeye daisy	13	16	81.3	12.5	---	1	---	---	2	12	16.7	5.5	7	9	77.8	8.7	---	14	---	---
Kentucky bluegrass	5	16	31.3	18.2	---	1	---	---	2	12	16.7	10.0	2	9	22.2	5.5	---	14	---	---
Common selfheal	5	16	31.3	4.6	---	1	---	---	2	12	16.7	10.0	3	9	33.3	4.0	---	14	---	---
Bull thistle	7	16	43.8	15.9	---	1	---	---	3	12	25.0	10.0	---	9	---	---	---	14	---	---
Tall fescue	4	16	25.0	3.3	---	1	---	---	1	12	8.3	10.0	4	9	44.4	5.5	---	14	---	---
Norway spruce	1	16	6.3	1.0	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Smooth brome	3	16	18.8	1.0	---	1	---	---	---	12	---	---	---	9	---	---	1	14	7.1	60.0
Purple crownvetch	4	16	25.0	7.8	---	1	---	---	---	12	---	---	4	9	44.4	22.5	---	14	---	---
Creeping bentgrass	4	16	25.0	47.5	---	1	---	---	---	12	---	---	2	9	22.2	30.5	1	14	7.1	1.0
Coltsfoot	---	16	---	---	---	1	---	---	---	12	---	---	3	9	33.3	7.0	---	14	---	---
Canada thistle	2	16	12.5	30.5	---	1	---	---	---	12	---	---	4	9	44.4	32.8	---	14	---	---
Canada bluegrass	1	16	6.3	10.0	---	1	---	---	2	12	16.7	1.0	---	9	---	---	1	14	7.1	10.0
Winged burning bush	1	16	6.3	10.0	---	1	---	---	2	12	16.7	35.0	---	9	---	---	---	14	---	---
Timothy	4	16	25.0	20.0	---	1	---	---	1	12	8.3	1.0	---	9	---	---	---	14	---	---
Lesser burdock	---	16	---	---	---	1	---	---	3	12	25.0	7.0	---	9	---	---	---	14	---	---

Table 4. Non-native species summarized by plant community type, Fort Necessity National Battlefield (continued).

Common Name	Successional Old Field				Sugar Maple – Basswood Forest				Tuliptree Forest				Wet Meadow				White Oak – Mixed Hardwood Forest			
	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Ground ivy	1	16	6.3	10.0	---	1	---	---	2	12	16.7	5.5	---	9	---	---	---	14	---	---
Hawkweed	---	16	---	---	---	1	---	---	3	12	25.0	4.0	---	9	---	---	---	14	---	---
Japanese honeysuckle	1	16	6.3	10.0	---	1	---	---	---	12	---	---	1	9	11.1	60.0	---	14	---	---
Japanese stiltgrass	---	16	---	---	1	1	100.0	10.0	---	12	---	---	1	9	11.1	10.0	---	14	---	---
Wild basil	1	16	6.3	1.0	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Obtuse-leaved border privet	---	16	---	---	---	1	---	---	2	12	16.7	10.0	---	9	---	---	---	14	---	---
Bird's-foot trefoil	3	16	18.8	10.0	---	1	---	---	---	12	---	---	2	9	22.2	5.5	---	14	---	---
Curly dock	---	16	---	---	---	1	---	---	---	12	---	---	4	9	44.4	3.3	---	14	---	---
Queen Anne's lace	2	16	12.5	10.0	---	1	---	---	---	12	---	---	1	9	11.1	1.0	---	14	---	---
King-devil	3	16	18.8	23.7	---	1	---	---	1	12	8.3	10.0	---	9	---	---	---	14	---	---
Bitter dock	---	16	---	---	---	1	---	---	3	12	25.0	7.0	---	9	---	---	---	14	---	---
Autumn olive	2	16	12.5	10.0	---	1	---	---	---	12	---	---	1	9	11.1	1.0	---	14	---	---
Common sheep sorrel	---	16	---	---	---	1	---	---	1	12	8.3	1.0	---	9	---	---	---	14	---	---
Common dandelion	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Common gypsyweed	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Fuller's teasel	1	16	6.3	1.0	---	1	---	---	---	12	---	---	2	9	22.2	5.5	---	14	---	---
Scot's pine	1	16	6.3	10.0	---	1	---	---	1	12	8.3	10.0	1	9	11.1	60.0	---	14	---	---
Large yellow hop-clover	1	16	6.3	1.0	---	1	---	---	---	12	---	---	2	9	22.2	5.5	---	14	---	---
Colonial bentgrass	---	16	---	---	---	1	---	---	1	12	8.3	60.0	---	9	---	---	---	14	---	---
Tree-of-heaven	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Garlic mustard	1	16	6.3	10.0	---	1	---	---	---	12	---	---	---	9	---	---	1	14	7.1	10.0
Forsythia	---	16	---	---	---	1	---	---	2	12	16.7	35.0	---	9	---	---	---	14	---	---
Japanese larch	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---

Table 4. Non-native species summarized by plant community type, Fort Necessity National Battlefield (continued).

Common Name	Successional Old Field				Sugar Maple – Basswood Forest				Tuliptree Forest				Wet Meadow				White Oak – Mixed Hardwood Forest			
	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Perennial pea	---	16	---	---	---	1	---	---	---	12	---	---	2	9	22.2	5.5	---	14	---	---
Apple	2	16	12.5	10.0	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Yellow sweetclover	2	16	12.5	60.0	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Wild parsnip	---	16	---	---	---	1	---	---	---	12	---	---	2	9	22.2	1.0	---	14	---	---
Blue spruce	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Red pine	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Red clover	1	16	6.3	10.0	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Chicory	---	16	---	---	---	1	---	---	---	12	---	---	1	9	11.1	1.0	---	14	---	---
Hairy catsear	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Princesstree	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---
Reed canarygrass	---	16	---	---	---	1	---	---	---	12	---	---	1	9	11.1	1.0	---	14	---	---
Tall buttercup	---	16	---	---	---	1	---	---	---	12	---	---	1	9	11.1	10.0	---	14	---	---
Chickweed	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	1	14	7.1	1.0
Common periwinkle	---	16	---	---	---	1	---	---	---	12	---	---	---	9	---	---	---	14	---	---

In addition to the species listed above, several non-native plants, common to successional old fields and anthropogenic community types were also present at levels greater than ten percent of the total plots surveyed. These species were found in at least one-quarter of all successional old field polygons surveyed (Table 4). The most common of these species were common velvetgrass (*Holcus lanatus*), orchardgrass (*Dactylis glomerata*), oxeye daisy (*Chrysanthemum leucanthemum*), Kentucky bluegrass (*Poa pratensis*), common selfheal (*Prunella vulgaris*), bull thistle (*Cirsium vulgare*), purple crownvetch (*Coronilla varia*) and smooth brome (*Bromus inermis*). Other non-native plants common to successional old fields are Canada thistle (*C. arvensis*), tall fescue (*Festuca elatior*), timothy (*Phleum pratense*), bitter dock (*Rumex obtusifolius*), lesser burdock (*Arctium minus*), Canada bluegrass (*Poa compressa*), wild basil (*Clinopodium vulgare*), Queen Ann's lace (*Daucus carota*), bird's-foot trefoil (*Lotus corniculatus*), curly dock (*Rumex crispus*), narrowleaf plantain (*Plantago lanceolata*), chicory (*Cichorium intybus*), clovers (*Trifolium pratense*, *T. aureum*, *T. arvensis*), Fuller's teasel (*Dipsacus fullonum*), hairy catsear (*Hypochaeris radicata*), creeping bentgrass (*Agrostis stolonifera*), colonial bentgrass (*A. capillaris*), common gypsyweed (*Veronica officinalis*), and common sheep sorrel (*Rumex acetosella*). While appearing to be widespread, the high number of occurrences of these species may be an artifact of sample intensity, because 16 of 97 (17%) points were located in successional old fields. None of these were listed as posing a moderate to severe threat to native plants in Pennsylvania and are often limited to open successional habitats. These species also made up the majority of non-native plants along roadsides throughout the park. While these species are prevalent in open successional community patches, they are often intolerant of heavy shade and are unable to form robust populations beneath closed canopy forests.

The conifer plantations at FONE, established in the 1930s and 1950s prior to the establishment of the park, contained between 4 and 15 species of non-native plants (Table 3) and included the planted non-native Norway spruce (*Picea abies*). Additionally, two other non-native conifers, planted at FONE are native to states further west: red pine (*Pinus resinosa*), blue spruce (*Picea pungens*). The number of non-native plants was much lower in dense spruce and pine-dominated stands than in more open pine stands due, presumably, to reduced light availability beneath the dense canopies (*personal observation*). Several pine stands were more successional in nature having been greatly impacted by an ice storm in 2002, which broke several pine tops allowing more light to the forest floor. Salvage logging further opened the canopy. While no distinction was made to map these types as different communities in plant community mapping activities, successional pine stands contained many more non-native "old field" species than did spruce patches.

Only five of the most prevalent non-native plant species (>10% of the total plots surveyed) were found in northern red oak-mixed hardwood forest in the white oak - mixed hardwood forest, compared with all 15 of the most common non-natives found at FONE in red maple – black cherry successional forests and 12 of the 15 in tuliptree forests. The low number of invasive plants and low coverage values of exotic populations in oak dominated forests (white oak-mixed hardwood forests and northern red oak-mixed hardwood forests) at FONE suggest these patches are less disturbed than other closed canopy forest types (modified successional and tuliptree forests). In general, these closed canopy communities are generally expected to resist exotic invasion (Cadenasso and Pickett 2001, Goldblum and Beatty 1999, Robertson et al. 1994, Brothers and Spingarn 1992, Parendes and Jones 2000), and Stover and Marks (1998) have

suggested that promoting succession to closed canopy forests may suppress shade-intolerant exotics (but see Myster and Pickett 1992 for evidence that invasives retard succession). Points in closed canopy types displaying a high non-native cover should be targeted for control efforts. For example, point 63 had a very high coverage value for Morrow's honeysuckle.

Prominent Non-native Species in Detail

Multiflora rose was present at nearly 90% of survey points within the red maple – black cherry successional forest type. It was also present at over 50% of the sample sites within most other types, with the exception of wet meadow and sugar maple basswood types. The size of the populations appeared to be related to successional state and canopy cover with populations averaging less than 10 % average cover (a figure calculated by summing the cover values of a species at all points and dividing by number of points sampled) in the oak types and conifer plantations and nearly 20 to 40% in all others (Table 4). The two communities with the largest populations were red maple – black cherry successional forest (21.9 % mean cover) and in tuliptree forest (39.1 % mean cover). Mowing of some successional old fields may have reduced the size of occurrences in this type. Multiflora rose's moderate mean coverage values and ubiquity in these two communities indicate significant and well-established invasion. This species thrives in early successional habitats, where it may inhibit the growth of later-successional woody species (Myster and Pickett 1990, 1992).

Japanese barberry was nearly as widely distributed throughout FONE as multiflora rose, appearing in 62 out of 97 points (63.9%). Like multiflora rose, it was present in all community types at FONE, except for the sugar maple-basswood forest patch. It was present at nearly 90% of the survey plots in the conifer plantation, tuliptree forest, and red maple – black cherry successional forest communities. Japanese barberry had the highest mean coverage values in the communities where it occurred at greatest frequency: tuliptree forest, modified successional forest, and conifer plantation types. This species is able to tolerate closed canopy conditions and unlike multiflora rose, populations beneath these closed canopy forest patches were robust. This invasion of closed-canopy systems is not unusual for Japanese barberry, which has been documented in established forests in eastern Pennsylvania, New York, and New Jersey (Ehrenfeld 1997).

Morrow's honeysuckle is most problematic in old fields throughout the park where it was present at nearly 90% of the points surveyed in modified successional forests and was abundant (>20% cover) in seven out of the 16 plots where it occurred this type. It also occurred at over 80 % of the plots surveyed in successional old fields and was abundant in seven out of the 15 plots where it occurred. Morrow's honeysuckle was present at only one out of 15 survey points in the white oak - mixed hardwood forest. In general, Morrow's honeysuckle was less common in closed-canopy communities than multiflora rose or Japanese barberry, but it was often present at high coverage values, indicating that where there is enough light for growth, it thrives.

This species has been the focus of removal activities in an eight-hectare area around the fort site and in experimental plots to the southwest of the Great Meadows established to restore habitat for American woodcock (*Scolopax minor*). Removal of this species through mechanical means has substantially reduced the species cover in these areas.

Tree-of-heaven (*Ailanthus altissima*) is not as widespread at FONE as the three species above. However, its presence at two out of the 99 sites, all occurring in conifer plantations, is of note. The presence of this species within storm-damaged conifer plantations suggests that it may have been introduced by logging equipment brought in remove storm-damaged trees. Neither of these occurrences is greater than one or two individuals, but because of its rapid rate of spread through successional habitats such as these pine plantations, these two occurrences should be targeted for eradication efforts. Princesstree (*Paulownia tomentosa*) was also present in one pine stand.

Japanese stiltgrass (*Microstegium vimineum*) was found at six out of 97 points ranging from modified early successional forests to northern red oak - mixed hardwood forests, sugar maple basswood forests, and wet meadow community patches. Its lack of habitat specificity suggests that it has a very high ecological amplitude. The largest population is located near the Peaceful Spot (see discussion of Roads and Trails) and should be a focus of control efforts.

Winged burning bush (*Euonymus alatus*) was found at seven out of 97 sites, occurring in conifer plantations, tuliptree forest, successional old fields, and modified successional forests and ranged from “Rare” (less than 1% cover) to occurrences of greater than 20% (“Abundant”).

Japanese honeysuckle (*Lonicera japonica*) was present at three out of 97 points, primarily in tuliptree forest and successional types. Road cut slopes on the east side of Highway 40, across the highway from Washington’s Tavern, contain what is probably the largest established population of Japanese honeysuckle at FONE. While this species was not widespread at FONE, managers should monitor for this species as it has the ability to spread aggressively into natural areas.

Autumn olive (*Elaeagnus umbellata*) was found at three sites: two in successional old fields and a site typed as wet meadow.

Garlic mustard (*Alliaria petiolata*) was only found at two sites, but may be more wide spread in early successional forest types.

Obtuse-leaved border privet (*Ligustrum obtusifolium*) was present around former home sites and successional forests where it was probably planted as a hedge. Its prolific production of fruit and dispersal by birds makes this species, like Japanese barberry, very problematic in management of natural areas.

Roads and Trails

Survey points along paved roads (n = 4) had the greatest number of non-native species of all sites along transportation corridors at FONE (n = 12), ranging from 13 to 26 non-native plant species (Table 5). Paved roads at FONE are concentrated in the cultural landscape areas (the Fort, Washington’s Tavern, and around the Visitors Center parking lot). The largest population of Japanese stiltgrass was observed along the paved roadside of the “Peaceful Spot,” (point E1, Table 5). The highest numbers of non-native plant species were along paved roadsides through open community types (successional old field, tuliptree forest community types) or cultural vegetation patches. In general, they exhibited a greater percent cover of these species than along roads beneath a closed canopy. Point E9, located on a stretch of paved road through a northern red oak - mixed hardwoods forest community patch, had the lowest number of non-native

Table 5. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species along transportation rights-of-way (ROW), Fort Necessity National Battlefield.

ROW Point	Community Type	Trail/Road Type	Location	UTM X	UTM Y	No. of Non-native Species
E2	Tulip tree forest	2-track gravel	Road near the Peaceful Spot	620410.9547	4407633.9261	8
E3	Successional old field	dirt trail	Trail near the Peaceful Spot	620198.1231	4407712.5456	11
E4	White oak-mixed hardwood forest	dirt trail	Picnic Loop	620181.5807	4407521.8728	1
E5	White oak-mixed hardwood forest	dirt trail	Picnic Loop	620189.8584	4407456.8361	3
E10	Northern red oak-mixed hardwood forest	dirt trail	Trail near the Peaceful Spot	620592.4606	4407807.6233	1
E6	White oak-mixed hardwood forest	gravel road	Picnic Loop	620160.5488	4407577.1909	10
E7	Northern red oak-mixed hardwood forest	gravel road	Road near the Peaceful Spot	620007.1938	4407345.9106	5
E8	Conifer plantation	gravel road	Picnic Loop	620013.0134	4407794.3953	10
E1	Successional old field	paved road	The Peaceful Spot	620209.9788	4407647.5864	23
E9	Northern red oak-mixed hardwood forest	paved road	Road near the Peaceful Spot	620527.1952	4407823.0416	13
E11	Developed	paved road	Roadside near Washington's Tavern	621035.6633	4408350.5438	26
E12	Developed	paved road	Maintenance area parking lot	620410.3397	4407797.3761	18

species along any stretch of paved road in the park [(13 species (Table 5)]. While periodic mowing along paved roadsides does limit the density of non-native invasive plants, these species, when allowed to grow, may become exceedingly dense, as at point E13 along a section of newly paved road in the cultural landscape near Washington's Tavern where the steep embankment prevents access to mowers. Natural resource managers should consider use of herbicides to limit non-native species colonization in areas too steep to allow mowing.

Sites along gravel roads had considerably fewer non-native species than along paved roads. The plant composition at survey points included between five and ten non-native plant species. Soil disturbance, and presence of waterbars and drainage culverts along the larger trails, in addition to increased light, facilitate invasion. Coltsfoot, present along most gravel roads was one such species found only at these sites and very rarely found beneath the canopy of the surrounding forest.

In general, sites along gravel roads in oak dominated forests had a markedly greater number of non-native plant species than did sites along dirt trails, which showed little difference in composition from that of the surrounding forests.

What appears to be a link between increased road width and an increased number of non-native plant species should be a concern to park managers. This is most important along gravel roads through the white and red oak dominated forests in the Picnic Loop Area, where road improvements may increase light to the forest understory, disturb the soil and increase runoff facilitating the spread of non-native species into the relatively undisturbed forests.

Friendship Hill National Historic Site

Sixty-six non-native plants were recorded in the 84 survey points and the nine points along trails and roadsides at FRHI (Table 6). Twelve species were present at more than ten percent of the plots surveyed across all community types at FRHI including those species limited to successional old fields, which were similar to old-field species at FONE (Table 6). The majority of the sample points were situated in the Tuliptree – beech – maple forest (n = 28, Tables 7 and 8). Ten points were situated in successional old fields, which may have skewed the overall abundance figures for the park unit. The high overall abundance of “old field species” was more of a function of the high number of sample points established in successional old field patches than the ability of this species to thrive in natural areas. Most of these species are limited to successional old fields and not able to persist beneath a canopy (see discussion of sample intensity at FONE). There were four points at which no invasive species were present at the survey point; all were red oak-mixed hardwood forest community patches (Table 9). As with FONE, not all are considered “invasive” by the Pennsylvania DCNR (Table 6). Of the 66 species found at the park, 15 are listed as posing a moderate to serious threat to native plants in Invasive Plants in Pennsylvania (<http://www.dcnr.state.pa.us/forestry/wildplant/invasive.aspx>) and 16 were listed as invasive on the PA DCNR's Exotic Plant Tutorial for Natural Lands Managers: <http://www.dcnr.state.pa.us/forestry/invasivetutorial/List.htm>. Purple crownvetch (*Coronilla Varia*), dames rocket (*Hesperis matronalis*), and tall fescue (*Festuca elatior*) were the three species not considered invasive on the first list. The non-native bull thistle (*Cirsium vulgare*), found at FRHI, was not listed on the DCNR Tutorial but is found on the Invasive Plants in Pennsylvania list.

Table 6. List of non-native plant species present at Friendship Hill National Historic Site with abundance and cultivation codes and invasive status as stated by PA Department of Conservation and Natural Resources.

Scientific Name	Common Name	Points Where Present	% of Points Present	Abundance ^a	Cultivation ^b	Invasive ^c	Threat (PA DCNR) ^d
<i>Rosa multiflora</i>	multiflora rose	66	78.6	Abundant	Not cultivated	Yes	Serious
<i>Lonicera japonica</i>	Japanese honeysuckle	46	54.8	Abundant	Not cultivated	Yes	Serious
<i>Microstegium vimineum</i>	Japanese stiltgrass	41	48.8	Abundant	Not cultivated	Yes	Serious
<i>Polygonum caespitosum</i>	oriental ladythumb	39	46.4	Abundant	Not cultivated	No	No
<i>Agrostis stolonifera</i>	creeping bentgrass	31	36.9	Abundant	Not cultivated	No	No
<i>Glechoma hederacea</i>	ground ivy	25	29.8	Abundant	Not cultivated	No	No
<i>Dactylis glomerata</i>	orchardgrass	16	19.0	Common	Not cultivated	No	No
<i>Holcus lanatus</i>	common velvetgrass	16	19.0	Common	Not cultivated	No	No
<i>Poa compressa</i>	Canada bluegrass	14	16.7	Common	Not cultivated	No	No
<i>Berberis thunbergii</i>	Japanese barberry	11	13.1	Common	Not cultivated	Yes	Moderate
<i>Ailanthus altissima</i>	tree-of-heaven	10	11.9	Common	Not cultivated	Yes	Serious
<i>Anthoxanthum odoratum</i>	sweet vernalgrass	9	10.7	Common	Not cultivated	No	No
<i>Barbarea vulgaris</i>	yellow rocket	8	9.5	Uncommon	Not cultivated	No	No
<i>Rumex obtusifolius</i>	bitter dock	8	9.5	Uncommon	Not cultivated	No	No
<i>Taraxacum officinale</i>	common dandelion	8	9.5	Uncommon	Not cultivated	No	No
<i>Cerastium glomeratum</i>	sticky chickweed	7	8.3	Uncommon	Not cultivated	No	No
<i>Daucus carota</i>	Queen Anne's lace	7	8.3	Uncommon	Not cultivated	No	No
<i>Elaeagnus umbellata</i>	autumn olive	7	8.3	Uncommon	Not cultivated	Yes	Serious
<i>Festuca elatior</i>	tall fescue	6	7.1	Uncommon	Not cultivated	Yes	No
<i>Phleum pratense</i>	timothy	6	7.1	Uncommon	Not cultivated	No	No
<i>Poa pratensis</i>	Kentucky bluegrass	6	7.1	Uncommon	Not cultivated	No	No

Table 6. List of non-native plant species present at Friendship Hill National Historic Site with abundance and cultivation codes and invasive status as stated by PA Department of Conservation and Natural Resources (continued).

Scientific Name	Common Name	Points Where Present	% of Points Present	Abundance ^a	Cultivation ^b	Invasive ^c	Threat (PA DCNR) ^d
<i>Agrostis gigantea</i>	redtop	5	6.0	Uncommon	Not cultivated	No	No
<i>Alliaria petiolata</i>	garlic mustard	5	6.0	Uncommon	Not cultivated	Yes	Serious
<i>Lonicera morrowii</i>	Morrow's honeysuckle	5	6.0	Uncommon	Not cultivated	Yes	Serious
<i>Polygonum hydropiper</i>	water-pepper	5	6.0	Uncommon	Not cultivated	No	No
<i>Rumex crispus</i>	curly dock	5	6.0	Uncommon	Not cultivated	No	No
<i>Arctium minus</i>	lesser burdock	4	4.8	Uncommon	Not cultivated	No	No
<i>Phalaris arundinacea</i>	reed canarygrass	4	4.8	Uncommon	Not cultivated	Yes	Moderate
<i>Picea abies</i>	Norway spruce	4	4.8	Uncommon	Persistent	No	No
<i>Silene vulgaris</i>	maidens tears	4	4.8	Uncommon	Not cultivated	No	No
<i>Stellaria media</i>	common chickweed	4	4.8	Uncommon	Not cultivated	No	No
<i>Trifolium pratense</i>	red clover	4	4.8	Uncommon	Not cultivated	No	No
<i>Clinopodium vulgare</i>	wild basil	3	3.6	Uncommon	Not cultivated	No	No
<i>Pinus sylvestris</i>	Scot's pine	3	3.6	Uncommon	Persistent	No	No
<i>Veronica officinalis</i>	common gypsyweed	4	4.8	Uncommon	Not cultivated	No	No
<i>Agrostis capillaris</i>	colonial bentgrass	2	2.4	Uncommon	Not cultivated	No	No
<i>Anaphalis margaritacea</i>	pearly everlasting	2	2.4	Uncommon	Not cultivated	No	No
<i>Hesperis matronalis</i>	dames rocket	2	2.4	Uncommon	Not cultivated	Yes	Moderate
<i>Arenaria serpyllifolia</i>	thymeleaf sandwort	2	2.4	Rare	Not cultivated	No	No
<i>Bromus inermis</i>	smooth brome	1	1.2	Rare	Not cultivated	No	No
<i>Calystegia sepium</i>	hedge false bindweed	1	1.2	Rare	Not cultivated	No	No
<i>Chrysanthemum leucanthemum</i>	oxeye daisy	1	1.2	Rare	Not cultivated	No	No

Table 6. List of non-native plant species present at Friendship Hill National Historic Site with abundance and cultivation codes and invasive status as stated by PA Department of Conservation and Natural Resources (continued).

Scientific Name	Common Name	Points Where Present	% of Points Present	Abundance ^a	Cultivation ^b	Invasive ^c	Threat (PA DCNR) ^d
<i>Cirsium arvense</i>	Canada thistle	1	1.2	Rare	Not cultivated	Yes	Serious
<i>Cirsium vulgare</i>	bull thistle	1	1.2	Rare	Not cultivated	No	Serious
<i>Galinsoga quadriradiata</i>	shaggy-soldier	1	1.2	Rare	Not cultivated	No	No
<i>Hieracium caespitosum</i>	king-devil	1	1.2	Rare	Not cultivated	No	No
<i>Lysimachia nummularia</i>	moneywort	1	1.2	Rare	Not cultivated	No	No
<i>Malus pumila</i>	apple	1	1.2	Rare	Persistent	No	No
<i>Morus alba</i>	white mulberry	1	1.2	Rare	Not cultivated	No	No
<i>Ornithogalum umbellatum</i>	star of Bethlehem	2	2.4	Rare	Not cultivated	Yes	Moderate
<i>Plantago lanceolata</i>	narrowleaf plantain	1	1.2	Rare	Not cultivated	No	No
<i>Polygonum cuspidatum</i> & <i>P. sachalinense</i>	Japanese knotweed & Giant knotweed	1	1.2	Rare	Not cultivated	Yes	Serious
<i>Prunella vulgaris</i>	common selfheal	1	1.2	Rare	Not cultivated	No	No
<i>Ranunculus acris</i>	tall buttercup	1	1.2	Rare	Not cultivated	No	No
<i>Rhamnus frangula</i>	glossy buckthorn	1	1.2	Rare	Not cultivated	Yes	Moderate
<i>Rumex acetosella</i>	common sheep sorrel	1	1.2	Rare	Not cultivated	No	No
<i>Stellaria graminea</i>	grasslike starwort	1	1.2	Rare	Not cultivated	No	No
<i>Stellaria sp.</i>	chickweed	1	1.2	Rare	Not cultivated	No	No
<i>Trifolium repens</i>	white clover	1	1.2	Rare	Not cultivated	No	No
<i>Trifolium sp.</i>	clover	1	1.2	Rare	Not cultivated	No	No
<i>Verbascum thapsus</i>	common mullein	1	1.2	Rare	Not cultivated	No	No
<i>Trifolium aureum</i>	golden clover	0	0	Rare	Not cultivated	No	No

Table 6. List of non-native plant species present at Friendship Hill National Historic Site with abundance and cultivation codes and invasive status as stated by PA Department of Conservation and Natural Resources (continued).

Scientific Name	Common Name	Points Where Present	% of Points Present	Abundance ^a	Cultivation ^b	Invasive ^c	Threat (PA DCNR) ^d
<i>Lotus corniculatus</i>	bird's-foot trefoil	0	0	Rare	Not cultivated	No	No
<i>Coronilla varia</i>	purple crownvetch	0	0	Rare	Persistent	Yes	No
<i>Setaria faberi</i>	Japanese bristlegrass	0	0	Rare	Not cultivated	No	No
<i>Tussilago farfara</i>	coltsfoot	0	0	Rare	Not cultivated	No	No

^a Abundance Codes: Abundant designation for species present at >10% of sample locations, Uncommon = species present between 2 and 10% of sample locations, Rare = species present at less than 1% of sample locations.

^b Cultivation codes: Designated as “cultivated” if species was purposely planted and maintained (e.g. agricultural crops), “not cultivated” if species was not planted, or “persistent” if plant species was once planted, but now not maintained (e.g. non-native pines in plantations) (National Park Service 1996).

^c Invasive: plant species listed as “invasive” by Pennsylvania Department of Conservation and Natural Resources (PA DCNR) Invasive Exotic Plant Management Tutorial for Natural Lands Managers: <http://www.dcnr.state.pa.us/forestry/invasivetutorial/List.htm>.

^d Threat (PA DCNR): designation or threat posed by a species given by PA DCNR Invasive Species in Pennsylvania: <http://www.dcnr.state.pa.us/forestry/wildplant/invasive.aspx>.

Table 7. Number of sample plots in each community type, Friendship Hill National Historic Site.

Community Type	Number of Sample Plots
Tuliptree- beech - maple forest	28
Successional old field	14
Sycamore - river floodplain forest	12
Early successional hardwood forest	10
Northern red oak - mixed hardwood forest	8
Mixed forb marsh	7
Grassland	2
Conifer plantation	2
Developed	1
Total Number of Sample Plots	84

Table 8. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Friendship Hill National Historic Site.

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
66	Conifer plantation	591920.8221	4403221	8	153	19.1
73	Conifer plantation	592422.2627	4403465	6	110	18.3
43	Developed	592520.921	4404535	6	201	33.5
22	Early successional hardwood forest	592117.3182	4403839	3	121	40.3
25	Early successional hardwood forest	591900.7392	4404020	5	141	28.2
29	Early successional hardwood forest	591713.5058	4402878	7	170	24.3
40	Early successional hardwood forest	592592.9936	4403143	8	330	41.3
42	Early successional hardwood forest	592240.9447	4403085	2	70	35
46	Early successional hardwood forest	591941.0597	4404027	11	401	36.5
60	Early successional hardwood forest	591680.5543	4402894	4	90	22.5
62	Early successional hardwood forest	591752.4249	4402560	9	281	31.2
64	Early successional hardwood forest	592739.4052	4403206	5	200	40
68	Early successional hardwood forest	592183.1312	4403568	3	180	60
28	Grassland	591926.802	4403887	5	250	50
30	Grassland	591691.0328	4403258	14	331	23.6
17	Mixed forb marsh	591567.2977	4404342	4	81	20.3
18	Mixed forb marsh	591939.9995	4403642	4	40	10
19	Mixed forb marsh	592305.3752	4402648	2	11	5.5
20	Mixed forb marsh	591989.0297	4403608	2	20	10
21	Mixed forb marsh	592361.5318	4402766	2	61	30.5

Table 8. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Friendship Hill National Historic Site (continued).

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
32	Mixed forb marsh	591501.5403	4404270	3	80	26.7
67	Mixed forb marsh	592286.7421	4402738	2	70	35
9	Red oak mixed hardwoods forest	591404.5316	4403562	9	281	31.2
31	Red oak mixed hardwoods forest	591629.7814	4404088	2	70	35
52	Red oak mixed hardwoods forest	592339.1308	4403243	5	150	30
53	Red oak mixed hardwoods forest	592483.3755	4403377	2	20	10
76	Red oak mixed hardwoods forest	591473.8777	4403245	0	0	0
77	Red oak mixed hardwoods forest	591615.026	4403022	0	0	0
78	Red oak mixed hardwoods forest	592288.974	4403158	0	0	0
79	Red oak mixed hardwoods forest	592783.7079	4402615	0	0	0
11	Successional old field	591730.8815	4402771	11	292	26.5
12	Successional old field	592432.9419	4402671	7	120	17.1
13	Successional old field	591521.9231	4404198	5	82	16.4
26	Successional old field	591997.0515	4403948	9	290	32.2
38	Successional old field	592034.1529	4403982	12	320	26.7
41	Successional old field	591463.0781	4404261	9	240	26.7
54	Successional old field	592134.6428	4403656	15	382	25.5
55	Successional old field	591960.6769	4402941	17	502	29.5
65	Successional old field	592450.7846	4402865	11	260	23.6
72	Successional old field	592475.696	4403225	13	421	32.4

Table 8. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Friendship Hill National Historic Site (continued).

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
80	Successional old field	592388.8853	4404083	16	347	21.7
81	Successional old field	591849.3171	4404085	8	203	25.4
82	Successional old field	592528.1306	4403091	9	163	18.1
84	Successional old field	592279.3596	4403401	12	175	14.6
7	Sycamore river floodplain forest	591506.6261	4402643	4	181	45.3
8	Sycamore river floodplain forest	591690.4416	4404407	5	100	20
10	Sycamore river floodplain forest	592165.2954	4404497	6	60	10
16	Sycamore river floodplain forest	591498.789	4404297	3	80	26.7
23	Sycamore river floodplain forest	591651.4918	4402536	3	12	4
24	Sycamore river floodplain forest	592053.2337	4404482	4	90	22.5
37	Sycamore river floodplain forest	591418.9978	4404219	6	101	16.8
39	Sycamore river floodplain forest	591305.4479	4403589	7	161	23
44	Sycamore river floodplain forest	591502.9148	4402478	3	21	7
61	Sycamore river floodplain forest	591537.4926	4404270	6	151	25.2
63	Sycamore river floodplain forest	592596.9156	4404493	5	100	20
75	Sycamore river floodplain forest	591798.534	4404447	9	290	32.2
1	Tuliptree beech maple forest	592229.9367	4402658	3	130	43.3
2	Tuliptree beech maple forest	592165.0422	4403287	3	30	10
3	Tuliptree beech maple forest	591761.8309	4401983	8	71	8.9
4	Tuliptree beech maple forest	591726.8741	4402976	3	21	7

Table 8. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Friendship Hill National Historic Site (continued).

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
5	Tuliptree beech maple forest	591528.6265	4404002	7	61	8.7
6	Tuliptree beech maple forest	591570.7152	4402083	4	90	22.5
14	Tuliptree beech maple forest	592163.5681	4402758	4	90	22.5
15	Tuliptree beech maple forest	592257.3415	4402906	8	103	12.9
27	Tuliptree beech maple forest	591804.3541	4403919	3	30	10
33	Tuliptree beech maple forest	592385.7835	4403362	5	200	40
34	Tuliptree beech maple forest	591859.3951	4403842	6	60	10
35	Tuliptree beech maple forest	592787.175	4402348	6	310	51.7
36	Tuliptree beech maple forest	592227.0984	4402833	3	30	10
45	Tuliptree beech maple forest	592129.0832	4403114	6	151	25.2
47	Tuliptree beech maple forest	592950.7841	4402594	5	150	30
48	Tuliptree beech maple forest	591822.5851	4404243	4	140	35
49	Tuliptree beech maple forest	592344.0178	4402825	2	70	35
50	Tuliptree beech maple forest	592389.185	4403654	5	141	28.2
51	Tuliptree beech maple forest	592109.76	4402865	4	81	20.3
56	Tuliptree beech maple forest	591444.6505	4403825	4	90	22.5
57	Tuliptree beech maple forest	591619.4738	4402173	5	200	40
58	Tuliptree beech maple forest	592819.0682	4402883	4	190	47.5
59	Tuliptree beech maple forest	591716.1518	4403894	6	101	16.8
69	Tuliptree beech maple forest	591787.8216	4402116	2	20	10

Table 8. Location (UTM X and Y coordinates), composition, and abundance of non-native plant species at vegetation survey plots (VSP), Friendship Hill National Historic Site (continued).

VSP	Community Type	UTM X	UTM Y	No. of non-natives	Total non-native cover	% non-native cover
70	Tuliptree beech maple forest	592733.4318	4402494	3	80	26.7
71	Tuliptree beech maple forest	592383.0041	4404348	9	231	25.7
74	Tuliptree beech maple forest	592083.2923	4403357	4	72	18
83	Tuliptree beech maple forest	592094.5909	4404320	2	20	10

Table 9. Non-native species summarized by plant community type, Friendship Hill National Historic Site.

Common Name	Scientific Name	Plots Invaded	%	Northern Red Oak - Mixed Hardwood Forest				Tuliptree, Beech, Maple Forest				Conifer Plantation				Developed			
				Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
				Multiflora rose	<i>Rosa multiflora</i>	66	78.6	4	8	50.0	20.3	26	28	92.9	22.9	1	2	50.0	10
Japanese honeysuckle	<i>Lonicera japonica</i>	46	54.8	2	8	25.0	10	21	28	75.0	28.2	2	2	100.0	35	1	1	100.0	1
Japanese stiltgrass	<i>Microstegium vimineum</i>	41	48.8	2	8	25.0	35	10	28	35.7	24.1	---	2	---	---	1	1	100.0	10
Oriental ladythumb	<i>Polygonum caespitosum</i>	39	46.4	2	8	25.0	35	18	28	64.3	32.2	1	2	50.0	60	---	1	---	---
Creeping bentgrass	<i>Agrostis stolonifera</i>	31	36.9	1	8	12.5	10	9	28	32.1	9	1	2	50.0	10	---	1	---	---
Ground ivy	<i>Glechoma hederacea</i>	25	29.8	---	8	---	---	5	28	17.9	8.2	---	2	---	---	1	1	100.0	60
Orchardgrass	<i>Dactylis glomerata</i>	16	19.0	---	8	---	---	1	28	3.6	1	---	2	---	---	---	1	---	---
Common velvetgrass	<i>Holcus lanatus</i>	16	19.0	2	8	25.0	35	---	28	---	---	---	2	---	---	---	1	---	---
Canada bluegrass	<i>Poa compressa</i>	14	16.7	---	8	---	---	6	28	21.4	10	---	2	---	---	---	1	---	---
Japanese barberry	<i>Berberis thunbergii</i>	11	13.1	---	8	---	---	6	28	21.4	18.2	1	2	50.0	10	1	1	100.0	10
Tree-of-heaven	<i>Ailanthus altissima</i>	10	11.9	---	8	---	---	4	28	14.3	47.5	1	2	50.0	1	---	1	---	---
Sweet vernalgrass	<i>Anthoxanthum odoratum</i>	9	10.7	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Yellow rocket	<i>Barbarea vulgaris</i>	8	9.5	1	8	12.5	10	1	28	3.6	1	1	2	50.0	10	---	1	---	---
Common dandelion	<i>Rumex obtusifolius</i>	8	9.5	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Bitter dock	<i>Taraxacum officinale</i>	8	9.5	---	8	---	---	---	28	---	---	1	2	50.0	1	---	1	---	---
Sticky chickweed	<i>Cerastium glomeratum</i>	7	9.5	---	8	---	---	3	28	10.7	43.3	---	2	---	---	---	1	---	---
Queen Anne's lace	<i>Daucus carota</i>	7	8.3	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Autumn olive	<i>Elaeagnus umbellata</i>	7	8.3	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Tall fescue	<i>Festuca elatior</i>	6	7.1	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Timothy	<i>Phleum pratense</i>	6	7.1	1	8	12.5	60	---	28	---	---	---	2	---	---	---	1	---	---
Kentucky bluegrass	<i>Poa pratensis</i>	6	7.1	---	8	---	---	2	28	7.1	5.5	---	2	---	---	---	1	---	---
Redtop	<i>Agrostis gigantea</i>	5	6.0	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Morrow's honeysuckle	<i>Lonicera morrowii</i>	5	6.0	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---

Table 9. Non-native species summarized by plant community type, Friendship Hill National Historic Site (continued).

Common Name	Scientific Name	Plots Invaded	%	Northern Red Oak - Mixed Hardwood Forest				Tuliptree, Beech, Maple Forest				Conifer Plantation				Developed			
				Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
				Water-pepper	<i>Polygonum hydropiper</i>	5	6.0	1	8	12.5	60	---	28	---	---	---	2	---	---
Curly dock	<i>Rumex crispus</i>	5	6.0	---	8	---	---	1	28	3.6	10	---	2	---	---	---	1	---	---
Garlic mustard	<i>Alliaria petiolata</i>	5	6.0	---	8	---	---	2	28	7.1	35	---	2	---	---	---	1	---	---
Reed canarygrass	<i>Phalaris arundinacea</i>	4	4.8	1	8	12.5	60	---	28	---	---	---	2	---	---	---	1	---	---
Norway spruce	<i>Picea abies</i>	4	4.8	---	8	---	---	3	28	10.7	26.7	1	2	50.0	10	---	1	---	---
Maidens tears	<i>Silene vulgaris</i>	4	4.8	---	8	---	---	1	28	3.6	10	---	2	---	---	1	1	100.0	60
Common chickweed	<i>Stellaria media</i>	4	4.8	---	8	---	---	2	28	7.1	35	1	2	50.0	10	---	1	---	---
Red clover	<i>Trifolium pratense</i>	4	4.8	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Lesser burdock	<i>Arctium minus</i>	4	4.8	---	8	---	---	1	28	3.6	1	---	2	---	---	---	1	---	---
Wild basil	<i>Clinopodium vulgare</i>	3	3.6	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Scot's pine	<i>Pinus sylvestris</i>	3	3.6	---	8	---	---	1	28	3.6	10	1	2	50.0	1	---	1	---	---
Common gypsyweed	<i>Veronica officinalis</i>	4	4.8	---	8	---	---	1	28	3.6	10	---	2	---	---	---	1	---	---
Colonial bentgrass	<i>Agrostis capillaris</i>	2	2.4	---	8	---	---	1	28	3.6	60	---	2	---	---	---	1	---	---
Pearly everlasting	<i>Anaphalis margaritacea</i>	2	2.4	---	8	---	---	1	28	3.6	10	---	2	---	---	---	1	---	---
Thymeleaf sandwort	<i>Arenaria serpyllifolia</i>	2	2.4	---	8	---	---	1	28	3.6	10	---	2	---	---	---	1	---	---
Dames rocket	<i>Hesperis matronalis</i>	2	2.4	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
White clover	<i>Trifolium repens</i>	2	2.4	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Smooth brome	<i>Bromus inermis</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Hedge false bindweed	<i>Calystegia sepium</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Oxeye daisy	<i>Chrysanthemum leucanthemum</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Canada thistle	<i>Cirsium arvense</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Bull thistle	<i>Cirsium vulgare</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---

Table 9. Non-native species summarized by plant community type, Friendship Hill National Historic Site (continued).

Common Name	Scientific Name	Plots Invaded	%	Northern Red Oak - Mixed Hardwood Forest			Tuliptree, Beech, Maple Forest			Conifer Plantation			Developed						
				Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Shaggy-soldier	<i>Galinsoga quadriradiata</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
King-devil	<i>Hieracium caespitosum</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Moneywort	<i>Lysimachia nummularia</i>	1	1.2	---	8	---	---	---	28	---	---	1	2	50.0	60	---	1	---	---
Apple	<i>Malus pumila</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
White mulberry	<i>Morus alba</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Star of Bethlehem	<i>Ornithogalum umbellatum</i>	2	2.4	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Narrowleaf plantain	<i>Plantago lanceolata</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Japanese knotweed & Giant knotweed*	<i>Polygonum cuspidatum</i> & <i>P. sachalinense</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Common selfheal	<i>Prunella vulgaris</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Tall buttercup	<i>Ranunculus acris</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Glossy buckthorn	<i>Rhamnus frangula</i>	1	1.2	---	8	---	---	---	28	---	---	1	2	50.0	10	---	1	---	---
Common sheep sorrel	<i>Rumex acetosella</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Grasslike starwort	<i>Stellaria graminea</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Chickweed	<i>Stellaria sp.</i>	1	1.2	1	8	12.5	10	---	28	---	---	---	2	---	---	---	1	---	---
Clover	<i>Trifolium sp.</i>	1	1.2	---	8	---	---	---	28	---	---	---	2	---	---	---	1	---	---
Common mullein	<i>Verbascum thapsus</i>	1	1.2	---	8	---	---	1	28	3.6	10	---	2	---	---	---	1	---	---

*Japanese knotweed (*Polygonum cuspidatum*) and giant knotweed (*P. sachalinense*) were combined for field survey and analysis

Table 9. Non-native species summarized by plant community type, Friendship Hill National Historic Site (continued).

Common Name	Mixed Forb Marsh				Sycamore – River Floodplain Forest				Early Successional Hardwood Forest				Successional Old Field				Grassland			
	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Multiflora rose	3	7	42.9	4	7	12	58.3	7.4	9	10	90.0	43.3	14	14	100.0	27.9	1	2	50.0	10
Japanese honeysuckle	1	7	14.3	10	4	12	33.3	10	6	10	60.0	35	9	14	61.5	22.3	---	2	---	---
Japanese stiltgrass	5	7	71.4	30	11	12	91.7	41	5	10	50.0	60	6	14	46.2	23.3	1	2	50.0	60
Oriental ladythumb	4	7	57.1	10	4	12	33.3	10	6	10	60.0	51.7	4	14	25.6	20.3	---	2	---	---
Creeping bentgrass	1	7	14.3	10	5	12	41.7	10	6	10	60.0	51.7	8	14	61.5	38.9	---	2	---	---
Ground ivy	---	7	---	---	5	12	41.7	40	3	10	30.0	10	10	14	76.9	28	1	2	50.0	10
Orchardgrass	1	7	14.3	10	---	12	---	---	2	10	20.0	5.5	10	14	69.2	22	2	2	100.0	60
Common velvetgrass	1	7	14.3	1	---	12	---	---	2	10	20.0	10	10	14	69.2	37	1	2	50.0	60
Canada bluegrass	---	7	---	---	4	12	33.3	22.5	2	10	20.0	35	2	14	15.4	5	---	2	---	---
Japanese barberry	---	7	---	---	3	12	25.0	10	---	10	---	---	14	---	---	---	---	2	---	---
Tree-of-heaven	---	7	---	---	2	12	16.7	10	1	10	10.0	60	1	14	7.7	21.3	---	2	---	---
Sweet vernalgrass	---	7	---	---	---	12	---	---	1	10	10.0	10	8	14	53.8	10	1	2	50.0	10
Yellow rocket	---	7	---	---	---	12	---	---	1	10	10.0	10	4	14	30.8	10	---	2	---	---
Common dandelion	---	7	---	---	---	12	---	---	3	10	30.0	20.7	4	14	30.8	3.7	1	2	50.0	10
Bitter dock	---	7	---	---	1	12	8.3	10	---	10	---	---	6	14	38.5	5.3	---	2	---	---
Sticky chickweed	---	7	---	---	1	12	8.3	60	1	10	10.0	10	2	14	15.4	10	---	2	---	---
Queen Anne's lace	---	7	---	---	---	12	---	---	---	10	---	---	5	14	38.5	5	1	2	50.0	10
Autumn olive	---	7	---	---	---	12	---	---	1	10	10.0	10	6	14	38.5	20	---	2	---	---
Tall fescue	---	7	---	---	---	12	---	---	---	10	---	---	4	14	30.8	8	2	2	100.0	60
Timothy	---	7	---	---	---	12	---	---	1	10	10.0	60	2	14	15.4	7.5	2	2	100.0	60
Kentucky bluegrass	---	7	---	---	1	12	8.3	1	1	10	10.0	10	3	14	15.4	30	---	2	---	---
Redtop	---	7	---	---	3	12	25.0	40.3	---	10	---	---	2	14	15.4	10	---	2	---	---
Morrow's honeysuckle	---	7	---	---	1	12	8.3	10	---	10	---	---	4	14	30.8	45	---	2	---	---

Table 9. Non-native species summarized by plant community type, Friendship Hill National Historic Site (continued).

Common Name	Mixed Forb Marsh				Sycamore – River Floodplain Forest				Early Successional Hardwood Forest				Successional Old Field				Grassland			
	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Water-pepper	1	7	14.3	10	2	12	16.7	10	---	10	---	---	1	14	7.7	10	---	2	---	---
Curly dock	---	7	---	---	---	12	---	---	1	10	10.0	10	3	14	23.1	2.5	---	2	---	---
Garlic mustard	---	7	---	---	2	12	16.7	35	---	10	---	---	---	14	---	---	---	2	---	---
Reed canarygrass	2	7	28.6	60	---	12	---	---	---	10	---	---	1	14	7.7	10	---	2	---	---
Norway spruce	---	7	---	---	---	12	---	---	---	10	---	---	---	14	---	---	---	2	---	---
Maidens tears	---	7	---	---	1	12	8.3	10	---	10	---	---	1	14	7.7	10	---	2	---	---
Common chickweed	---	7	---	---	---	12	---	---	1	10	10.0	10	---	14	---	---	---	2	---	---
Red clover	---	7	---	---	---	12	---	---	---	10	---	---	2	14	23.1	3.3	1	2	50.0	10
Lesser burdock	---	7	---	---	---	12	---	---	1	10	10.0	10	1	14	7.7	10	---	2	---	---
Wild basil	---	7	---	---	---	12	---	---	---	10	---	---	2	14	15.4	1	1	2	50.0	10
Scot's pine	---	7	---	---	---	12	---	---	1	10	10.0	10	---	14	---	---	---	2	---	---
Common gypsyweed	---	7	---	---	---	12	---	---	---	10	---	---	3	14	15.4	4	---	2	---	---
Colonial bentgrass	---	7	---	---	---	12	---	---	1	10	10.0	10	---	14	---	---	---	2	---	---
Dames rocket	---	7	---	---	1	12	8.3	10	---	10	---	---	---	14	---	---	---	2	---	---
White clover	---	7	---	---	---	12	---	---	---	10	---	---	2	14	15.4	5.5	---	2	---	---
Pearly everlasting	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	10	---	2	---	---
Thymeleaf sandwort	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	1	---	2	---	---
Smooth brome	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	10	---	2	---	---
Hedge false bindweed	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	10	---	2	---	---
Oxeye daisy	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	10	---	2	---	---
Canada thistle	---	7	---	---	---	12	---	---	---	10	---	---	---	14	---	---	1	2	50.0	10
Bull thistle	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	10	---	2	---	---

Table 9. Non-native species summarized by plant community type, Friendship Hill National Historic Site (continued).

Common Name	Mixed Forb Marsh				Sycamore – River Floodplain Forest				Early Successional Hardwood Forest				Successional Old Field				Grassland			
	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover	Pres.	Points (n)	% Occur	Avg. Cover
Shaggy-soldier	---	7	---	---	---	12	---	---	---	10	---	---	---	14	---	---	1	2	50.0	1
King-devil	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	10	---	2	---	---
Moneywort	---	7	---	---	---	12	---	---	---	10	---	---	---	14	---	---	---	2	---	---
Apple	---	7	---	---	---	12	---	---	1	10	10.0	1	---	14	---	---	---	2	---	---
White mulberry	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	1.0	---	2	---	---
Star of Bethlehem	---	7	---	---	2	12	16.7	1	---	10	---	---	---	14	---	---	---	2	---	---
Narrowleaf plantain	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	10	---	2	---	---
Japanese knotweed/Giant knotweed	---	7	---	---	1	12	8.3	60	---	10	---	---	---	14	---	---	---	2	---	---
Common selfheal	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	1	---	2	---	---
Tall buttercup	---	7	---	---	---	12	---	---	---	10	---	---	---	14	---	---	1	2	50.0	10
Glossy buckthorn	---	7	---	---	---	12	---	---	---	10	---	---	---	14	---	---	---	2	---	---
Common sheep sorrel	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	10	---	2	---	---
Grasslike starwort	---	7	---	---	---	12	---	---	---	10	---	---	1	14	7.7	60	---	2	---	---
Chickweed	---	7	---	---	---	12	---	---	---	10	---	---	---	14	---	---	---	2	---	---
Clover	---	7	---	---	---	12	---	---	---	10	---	---	---	14	---	---	1	2	50.0	10
Common mullein	---	7	---	---	---	12	---	---	---	10	---	---	---	14	---	---	---	2	---	---

The three most common species: multiflora rose, Japanese honeysuckle and Japanese stiltgrass were present in nearly half of the 84 plots surveyed and were present in nearly every community type except for the grassland and conifer types, which had a limited number of survey points (Table 9).

Successional old field community patches together had the greatest number of invasive species at FRHI, possessing a total of 41 non-native species, with the majority not considered as posing a threat to native plants and animals in Pennsylvania. As at FONE, these “old field” species include *Agrostis spp.* (bent grass and red top), velvet grass, non-native bluegrasses, curly docks, and Queen Ann’s lace, and others that are often common to successional old fields. Their abundance was, at times very high in these open canopy-community types. Morrow’s honeysuckle and autumn olive (*Elaeagnus umbellata*) were two woody species prominent in old fields, rated occasional to abundant where they were present (Table 9) suggesting that once established they quickly become dominant.

Successional hardwood forests, tuliptree - beech - maple forest, and sycamore floodplain forests also had a high number of non-native plants (23, 25, 20 species, respectively). Multiflora rose and Japanese barberry occurred between 25 and 100 percent of all survey points within these types. It appears that human activity has had substantial impact on natural systems at FRHI and facilitated colonization by non-native plants. Much of the property that now supports forests was originally cleared and mined for coal or planted in row crops, hay, orchards, tree nurseries, and Christmas trees (Roddy and Hammons 1986). The sycamore floodplain forest community type situated on the floodplain of the Monongahela River has experienced several anthropogenic disturbance events, in addition to natural period flooding events. The floodplain has supported boat landings and portions of a lock and dam. A railroad also ran along the Monongahela River for a period of time. After its construction, sparks and burning cinders from passing trains occasionally set fires to the Friendship Hill estate (Roddy and Hammons 1986).

In contrast to the plant communities described above, oak-dominated community patches had few non-native species (11 species). This suggests that these community patches are of a higher degree of quality, probably due to limited disturbance. Most oak-dominated patches occur only on steep slopes where harvesting the trees was difficult or in isolated woodlots that were not extensively timbered (Perles et al. 2005). At FRHI, oak-dominated patches were small and non-native plants were abundant at the patch edges. At times, edge areas fell within the survey area. For example, point 11, situated near the edge of the community patch and a mixed forb marsh type included species such as reed canarygrass, and water-pepper (*Polygonum hydropiper*), species common in the open wet meadow type but not present in other red oak - mixed hardwood forest patches.

The mixed forb marsh community patches, which are predominantly constructed wetlands established for remediation of acid mine drainage along Ice Pond Run (Perles et al. 2005) had only nine recorded non-native plants. Two of the three of these patches surveyed were nearly monocultures of reed canarygrass or Japanese stiltgrass. Maintained grasslands and developed patches shared many of the same species found in successional old fields. However, periodic mowing is most likely the major factor limiting the number of species.

Prominent Non-native Invasive Species in Detail

Multiflora rose, found in nearly 80% of the points surveyed, was clearly the most prevalent non-native plant species recorded at FRHI. Percent cover varied considerably across all types in which it was found. It was present in over 90% of the survey points in tuliptree -beech - maple forest, successional hardwoods forest, and successional old fields. Populations were substantial in successional old fields with individual plants growing over three meters tall (*personal observation*). It was found less consistently in the red oak - mixed hardwood forest, conifer plantation, mixed forb marsh, and sycamore floodplain forest community types. Its wide distribution across most vegetation community types indicates that this species is able to tolerate a wide range of ecological conditions. Its distribution also suggests that most areas at FRHI have received considerable human disturbance. Past farming, logging and mining of the area, and small size of the remaining woodlots, have resulted in the wide distribution of multiflora rose across all community types at FRHI.

Japanese honeysuckle was present in 43 of the 84 points (51%). It was present in over 75% of the tuliptree -beech - maple forest and conifer plantations, and over 50% of the sycamore floodplain forest, early successional hardwood forest, grassland, and developed patch types. Percent cover was greatest in survey points in sycamore floodplain forest, conifer plantation, and successional old-field patches. However, with less than two plots in conifer plantations, grasslands, and developed community types, it is difficult to assess the true impact of this species on these types.

Japanese stiltgrass was present at 39 points (46%) in all community types at FRHI except for the conifer plantation patches. It was most prevalent in assessment points in sycamore floodplain forest and mixed forb marsh community types (92% and 50% of the points surveyed, respectively), most likely benefiting from the slightly higher degree of soil moisture in these types than in upland forest and old field types. Percent cover varied throughout all community types at FRHI, but this species was on average exceedingly abundant at survey points along the Monongahela River (sycamore floodplain forest and wet meadow types) where it often dominated the herbaceous layer. In later successional, closed canopy forest types, the infestations were quite high where it was found. However it was noted that these high occurrences were often along trails and roads where soil disturbance, light, and soil moisture were usually higher (see discussion of roadsides and trails at FRHI below).

Tree-of-heaven, though not widely distributed throughout FRHI, is a problem where it is found, predominantly in tuliptree - beech - maple forest patches where it forms dense colonies, and out-competes native understory trees. At places it is a substantial part of the canopy. Its ability to rapidly colonize areas and its allelopathic qualities suggests it poses significant threat to community types where it has established (Mergen 1959, Hoshovsky no date). Out of the nine assessment points where it was found, four were situated in tuliptree - beech - maple forest patches, and cover values were on average greater than 20%. Because of its limited distribution, this species should be the target of control. Eradication may even be possible in some upland areas with a diligent effort. The locations along the Monongahela River may be more difficult because of limited access.

The following species, while not widely distributed at FHRI are considered to be threats to native flora. Japanese knotweed/giant knotweed (*Polygonum cuspidatum*/*P. sachalinense*), lumped together for the purposes of this report, were extremely abundant along the Monongahela River floodplain, often dominating the understory. Reed canarygrass (*Phalaris arundinacea*), also not widespread, often dominated the herbaceous layer of wet meadow types. Star of Bethlehem (*Ornithogalum umbellatum*), listed by the DCNR as posing a moderate threat to native plant species, was found along the Monongahela River.

Roads and trails

Roads and trails at FRHI, which are often greater than 3m wide, fragment the community patches and often serve as corridors of invasion for non-native and native opportunistic species. These wide roads and trails represent a substantial break in the forest canopy and allow a significant amount of light into the understory. The species composition of trails and roadsides often reflects that of the successional old field with several of the non-native “old field” grass species present (Table 10). In addition to these species, there were several plants found along trails that were not present at the assessment points: clovers, bird’s-foot trefoil, purple crownvetch, coltsfoot and Japanese bristlegrass (*Setaria faberi*).

Trails through open habitats, developed land, successional old fields, and periodically maintained rights-of-way possess a species composition similar to that of the patch type and include mostly old field grasses, herbs and shrubs. Purple crownvetch was prevalent along paths and roads at FRHI through open habitats and larger forest clearings (Table 10). This species, while a part of the successional old-field community types, was not recorded at the assessment points.

Along narrower trails and paths through closed canopied forests, oriental ladythumb (*Polygonum caespitosum*) and Japanese stiltgrass were exceedingly abundant. In addition, drainage ditches and culverts along the side of the trails and roads, intended to re-direct the flow, facilitate the spread of coltsfoot. As at FONE, coltsfoot was limited primarily to wetter sites and grew abundantly along drainage culverts along with Japanese stiltgrass and other species that respond favorably to the increased soil moisture. The disturbance to the soils, increased light and water along roads facilitates invasive species colonization.

More work should be done to assess the distance of invasion from trails and roads into closed canopy types. It is likely that non-native species are limited to trail and roadsides in relatively undisturbed closed canopy forests.

Table 10. Location (UTM X and Y coordinates), composition, and abundance of non-native species along transportation rights-of-way (ROW), Friendship Hill National Historic Site.

ROW Point	Community Type	Trail/Road Type	Location	UTM X	UTM Y	No. of Non-native Species
E1	Tuliptree beech maple forest	Gravel	Main loop trail	591491.6800	4403954.5499	11
E2	Grassland/Successional old field/Developed	Vegetated	Main loop trail	591576.7810	4404155.4084	21
E3	Tuliptree beech maple forest	Gravel	Main loop trail	591996.4719	4404378.2578	7
E4	Grassland/Successional old field/Developed	Vegetated	Upper trails around cultural landscape	591942.9355	4403079.2460	14
E5	Tuliptree beech maple forest	Gravel	Upper trails around cultural landscape	591968.6625	4403520.3519	3
E6	Developed land	Gravel	Maintenance area parkinglot	591689.8193	4403803.9158	22
E7	Tuliptree beech maple forest	Gravel	Slope of Monongahela river floodplain	591608.0024	4401916.9679	7
E8a	Sycamore river floodplain forest	Dirt trail	Monongahela Floodplain	591454.7270	4402486.2441	4
E8b	Sycamore river floodplain forest	Dirt trail	Monongahela Floodplain	591500.8780	4402631.7754	---
E9	Transportation Corridor (Rt. 166)	Paved	Highway 166	592173.7628	4402908.6654	20

Management Recommendations

General Management and Planning

The FONE and FRHI survey results demonstrate the difference in non-native species composition of closed-canopy, undisturbed forests, and open, disturbed fields and successional forests. As previously mentioned, the non-native species richness and diversity was reported for each survey point and totaled for all points within a community type in order to determine what non-native species were found in specific community types. This information should provide a list of species to “be on the lookout for” within each community type. Percent cover, (abundance) or the area occupied by each non-native species, is a measure of how robust the population is at each survey point. While this information was recorded at each point and summarized by community type in this report, it was difficult to compare the coverage values between communities because of the variation in composition among points within each type. Values appeared to be more of a function of canopy openness, soil disturbance, soil moisture and other ecosystem factors (such as soil texture, slope, aspect, etc.) than community type. The community types mapped may contain a wide range of these factors (e.g., see discussion of conifer plantations) and therefore community type alone is not the sole determining factor of “invadedness.”

The aim of our recommendations is to reduce disturbance of existing, relatively invasive-free communities and to control targeted invasive plant species populations. These recommendations should be tied together as part of the park resource management plan in which the overall goals and desired conditions for various sites within the parks are addressed.

In general, control efforts should focus on species identified by the PA DCNR as posing a moderate to severe threat to native plants, animals and natural communities in PA (see Management of specific invasive species, below).

Objectives for invasive species management should be developed for each community type described in the NPS 6 Parks Vegetation Community Mapping Project (see Perles et. al 2005), in particular for successional old fields and pine plantations. For successional old fields, management should either: 1) maintain areas as open fields, cultural landscapes or utility rights-of-way, or 2) conduct activities to promote succession toward native forest community types in uplands areas. For conifer plantations, nonnative pines and spruces should be removed and these areas should be replanted with native species. For both types, data collected in the NPS 6 Parks Mapping Project can be used as a model for restoration activities. For example, the local and global vegetation association descriptions as well as species lists and information collected in the plots (i.e. percent cover, dominance, etc.) can be used to provide models.

Long term monitoring points should be established to assess effectiveness of treatments and restoration activities in all community types.

Control efforts in oak-dominated types should focus on and near trails, roadsides and near forest edges.

For any road building, forestry, or maintenance activities, equipment should be thoroughly cleaned prior to use and cleaned in the area following the activity. For example, tires of vehicles used in brush removal and salvage logging should be cleaned before they enter relatively invasive-free communities. Tree-of-heaven and princess tree were found only in successional pine plantations at FONE, suggesting that these species were brought in on treads and tires of machinery used to salvage lumber; probably as seeds or fragments of plant matter adhering to the tires during travel through invaded areas.

Construction, expansion, and upgrading of roads should be limited in mature, closed-canopy forests. Road construction creates corridors of disturbance into the interior of invasion-resistant habitats, opening them to invasion (Parendes and Jones 2000). Widening and upgrading of existing one-lane gravel roads and hiking trails can create or widen openings in the canopy, admitting the direct sunlight preferred by many invasive understory species. When new road construction is unavoidable, it should be routed through already-invaded habitat such as successional fields. Clauses can be added into contracts requiring contractors to use weed-free fill and/or straw, to clean equipment, etc. Contract language should require the contractor to monitor their sites and come back to control any invasive plants that come in as a result of their work.

Roads and trails fragment community patches and often serve as corridors of invasion for non-native and native opportunistic species (Benninger-Truax, 1992). Data from this study suggested that several non-native species that were abundant along trails were not found at survey points. Trails through tuliptree - beech - maple forests, for example, are often lined with dense patches of multiflora rose, Japanese stiltgrass, and tree-of-heaven, whereas percent cover of these species was much lower at assessment points. This is consistent to the findings of Christen and Matlak (2005) who found that roads and corridors function to spread multiflora rose in the Wayne National Forest of Ohio. A concentrated effort to remove problem species within a buffer of 10 meters from the edge of the trail or road should therefore provide a substantial defense against the spread of these species in closed canopy forests. In tulip tree and successional forest types, control of multiflora rose, Japanese barberry, and Japanese stiltgrass should be focused along roads and trails through high quality oak dominated community patches at both park units. Special attention should be paid to culverts and waterbars that provide suitable habitat for some non-native plant species. Following construction of any new structure such as those previously mentioned, the plant composition of the disturbed area should be monitored and these areas should be targets for species control.

Management of Specific Invasive Species

General management recommendations for the most widespread invasives at FONE and FRHI are provided below. These short summaries do not attempt to include all of the management options for all the various site conditions.

Morrow's honeysuckle (*Lonicera morrowii*) are able to re-sprout from roots or remaining vegetation left behind after cutting or pulling; while these measures can be effective for small infestations, sites should be monitored afterwards to prevent reestablishment. The selective application of herbicides as foliar sprays or to cut stumps may be necessary to prevent

resprouting. Glyphosate and triclopyr are effective applied to the leaves in 2% solution or cut stems in 20-25% solution (Rhoads and Block 2002e; Batcher and Stiles, 2001).

Multiflora rose (*Rosa multiflora*) seedlings can be pulled by hand, but larger plants may require chains or cables and a tractor, and dense thickets will need heavy machinery; the roots must be removed to prevent resprouting. Regular mowing of populations in old fields can also be effective (Eckardt 1987). Herbicide treatment of cut stems (with glyphosate or triclopyr) is recommended as the most effective treatment by Rhoads and Block (2002f).

Japanese barberry (*Berberis thunbergii*) can be pulled, using gloves, and mowing will reduce proliferation but not prevent regrowth. Leaf application of 2% glyphosate or triclopyr, or application of a 25% solution of the same herbicides to cut stems is also recommended (Rhoads and Block 2002c). Complete removal of the root system renders herbicide application unnecessary (Brunelle and Lapin 1996).

Japanese knotweed/giant knotweed (*Polygonum cuspidatum*/*P. sachalinense*) spreads vegetatively as well as by wind and water dispersal of its small, buoyant seeds. Persistent cutting may be enough to control small infestations, but mechanical attempts at removal will not work in the long term because of the regenerative ability of knotweed rhizomes. NPS research at Penn State showed good results for foliar application of glyphosate plus sticker-spreader in early June followed by a second application in late August (Rhoads and Block 2002d).

Garlic mustard (*Alliaria petiolata*) may be controlled by hand pulling or cutting, though this is labor-intensive and less effective against large infestations. All plant materials should be removed from the site after cutting or pulling, since flowering plants can still produce seeds after being uprooted; mechanical removal must continue for several years until the seed bank is emptied. Annual mowing or prescribed burning are effective for larger populations (Rhoads and Block 2002b).

Obtuse-leaved border privet (*Ligustrum obtusifolium*) seedlings can be pulled by hand or a weed wrench can be used to remove larger plants. Mowing or cutting is effective, although it will resprout. Herbicides can be used effectively to control privet; glyphosate and triclopyr are recommended. Either can be used in water as a foliar application or to treat cut stumps. Treatment of the basal 12–15 inches of woody stems with 25% triclopyr in oil is another alternative (Rhoads and Block 2002j).

Autumn olive (*Elaeagnus umbellata*) seedlings and sprouts can be pulled by hand and the roots should be removed completely. Because cutting or fire alone results in thicker, denser growth upon resprouting, use of chemical herbicides are required to remove larger individuals. Glyphosate can be used to control larger plants. Foliar application of glyphosphate is effective. In areas where other desirable species are present, the herbicide should be applied to freshly cut stumps to minimize damage to other plants (Rhoads and Block 2002a).

Japanese honeysuckle (*Lonicera japonica*): Repeated pulling of entire vines and root systems may be effective. Hand pull seedlings and young plants when the soil is moist, holding low on the stem to remove the whole plant along with its roots. A 2.5% rate of glyphosate (e.g., Rodeo for wetlands; Roundup for uplands) mixed with water and an appropriate surfactant, to foliage

from spring through fall. Treatment in the fall, when many non-target plants are going dormant, is best. (<http://www.nps.gov/plants/alien/factmain.htm>)

Tree-of-heaven (*Ailanthus altissima*) can be best controlled by manual removal of young seedlings. However, the entire root must be removed or it may resprout. It may take several trimmings and cuttings to remove larger saplings. Girdling (manually cutting away bark and cambium tissues around the trunks) or basal bark treatment are effective and relatively inexpensive method for killing larger stems. Use of glyphosate, either sprayed onto the leaves or painted onto a freshly cut stump will kill the plant. (<http://www.nps.gov/plants/alien/factmain.htm>)

Japanese stiltgrass (*Microstegium vimineum*): Stiltgrass can be pulled by hand throughout the growing season, or mowed in late summer (i.e., August through September) when the plants are flowering preferably before seed is produced. For extensive stiltgrass infestations, application of a 2% solution of glyphosate (e.g., Roundup) or the formulation labeled for wetland areas (e.g., Rodeo) mixed with water (8 oz. per 3 gals. mix) and a surfactant in late summer is a more practical and effective method <http://www.nps.gov/plants/alien/fact/mivi1.htm>, (Tu 2000).

Conclusions

Invasive exotic plant species represent the main threat to the native vegetation at FONE and FRHI, particularly in the abandoned agricultural fields, on forest edges, and along trails. It should also be noted that the results of the inventory suggest that the invasive species composition is a symptom of human disturbance, both past and present, as more disturbed or successional plant community types exhibited a substantially higher number of non-native plant species. In general, tuliptree forests, sycamore floodplain forest, early successional forest community patches, and successional old fields have a greater number of non-native species than do oak dominated forest types. Most of these types were considerably more open and disturbed than oak forest types. Successional conifer plantations were also exceedingly invaded, possessing a very high number of invasive species at moderate to abundant levels of cover.

Forested communities at FRHI contain a considerably greater proportion of non-native species than do forested types at FONE and percent cover and distribution of species that are considered to pose a moderate to serious threat to native species are markedly greater. Successional old fields were similar in composition due to their similarity in history and environmental factors. Multiflora rose was the most widespread invasive plant species at both NPS units. This species is primarily dispersed by birds (Rhoads and Block 2002i) and therefore more likely to spread into areas with taller vegetation (McDonnell 1986). Its shade tolerance allows it to persist with reduced vigor as a successional area develops a closed canopy, or even to invade mature forest (Stover and Marks 1998, Rhoads and Block 2002h, 2002i).

Differences between the FRHI and FONE sites – in the invasive species present, their density, and their distribution among the plant communities – are likely due to differences in community fragmentation and disturbance history at the two sites. At both FONE and FRHI, points located in mature oak dominated forest types had fewer invasive species present than points located in old fields, early successional hardwoods forest, sycamore floodplain forests, and tuliptree - beech - maple forests. The low number of invasives in oak dominated types suggests that these patches are less disturbed than other types at the two NPS units. There was no difference between the number of non-native species among oak dominated community types at the two parks. However, oak forest patches at FONE are larger and are more isolated from pedestrian traffic than the small oak patches at FRHI, which actually serve as a park visitor destination. Control of non-natives in oak forest patches may be more difficult at FRHI given their smaller size, higher degree of pedestrian traffic and greater threat of colonization by species like tree-of-heaven and Japanese stiltgrass. More analysis should be done to determine differences in percent cover of non-natives, as results from this work suggested that coverage values were greater for the most abundant species, such as multiflora rose, in the oak dominated type at FRHI than in oak communities at FONE.

Since the successional old-field association contains particularly high abundances of invasive shrub species, which may threaten and impede the succession to a native forest type without proper management, the management of these former agricultural fields should be a priority for the park management at both units. Natural resource managers should develop management plans specifically tailored to these areas in the park that addresses the control of invasive species, designate desired future conditions (vegetation structure and composition), and outline

management actions to achieve the desired target conditions. The development and implementation of a management plan specifically for successional old field community types would facilitate the control of these invasive species and the restoration of natural vegetation associations.

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Appendix

Appendix. Field form used for rapid assessment of non-native plant species at Fort Necessity National Battlefield and Friendship Hill National Historic Site.

WPC NPS Invasive Species Rapid Assessment										Date: _____			
Plants within 50 m of point: A = abundant, O = occasional, R = rare										Observers: _____			
spp	plot	plot	plot										
Acer platanoides													
Agrostis capillaris													
Agrostis gigantea													
Agrostis stolonifera													
Ailanthus altissima													
Alliaria petiolata													
Anthoxanthum odoratum													
Arctium minus													
Berberis thunbergii													
Bromus inermis													
Celastrus orbiculatus													
Centaurea maculosa													
Chrysanthemum leucanthemum													
Cirsium arvense													
Cirsium vulgare													
Coronilla varia													
Dactylis glomerata													
Daucus carota													
Dipsacus fullonum													
Elaeagnus angustifolia													
Elaeagnus umbellata													
Euonymus alata													
Festuca arundinacea													
Glechoma hederacea													
Hedera helix													
Hieracium caespitosum													
Hieracium venosum													
Heracleum mantegazzianum													
Holcus lanatus													
Hypochoeris radicata													
Larix japonica													
Lathyrus latifolius													
Ligustrum obtusifolius													
Lonicera japonica													
Lonicera maackii													
Lonicera morrowii													
Lonicera tatarica													
Lotus corniculatus													
Lythrum salicaria													
Malus pumila													
Microstegium vimineum													
Myriophyllum spicatum													
Pastinaca sativa													
Paulownia tomentosa													
Phalaris arundinacea													
Phleum pratense													
Phragmites australis													

Appendix. Field form used for rapid assessment of non-native plant species at Fort Necessity National Battlefield and Friendship Hill National Historic Site (continued).

spp	plot											
<i>Picea abies</i>												
<i>Pinus sylvestris</i>												
<i>Plantago lanceolata</i>												
<i>Poa compressa</i>												
<i>Poa pratensis</i>												
<i>Polygonum caespitosa</i>												
<i>Polygonum cuspidatum</i>												
<i>Polygonum perfoliata</i>												
<i>Polygonum persicaria</i>												
<i>Polygonum sachalinense</i>												
<i>Prunella vulgaris</i>												
<i>Ranunculus acris</i>												
<i>Ranunculus ficaria</i>												
<i>Rhamnus cathartica</i>												
<i>Rhamnus divaricata</i>												
<i>Rhamnus frangula</i>												
<i>Rosa multiflora</i>												
<i>Rumex acetosella</i>												
<i>Rumex crispus</i>												
<i>Rumex obtusifolius</i>												
<i>Taraxacum officinale</i>												
<i>Trapa natans</i>												
<i>Trifolium aureum</i>												
<i>Trifolium pratense</i>												
<i>Tussilago farfara</i>												
<i>Vinca minor</i>												
others												

As the nation's primary conservation agency, the Department of the Interior has responsibility for most of our nationally owned public land and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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