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Vegetation Community Monitoring at Lincoln Boyhood National Memorial, Indiana

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Introduction

Established in 1962 to preserve and commemorate Abraham Lincoln's boyhood in Indiana, Lincoln Boyhood National Memorial includes nearly 200 acres of homesteads, old fields and varied hardwood forest communities. A specific goal of the park is to restore the cultural landscape to a mature hardwood forest as would have been encountered by the Lincoln family. Even though park staff did not directly identify plant communities as a vital sign to monitor, characterizing the current condition of a select portion of the successional forest contributes to the goal of restoring the cultural landscape. The aim of this initial work is to establish and sample a set of monitoring sites within a portion of the successional forest and provide information on the overstory structure and composition.

Methods

Data collection

The Heartland Inventory and Monitoring Network (HTLN) implemented vegetation community monitoring at LIBO in 2011 to characterize and measure baseline conditions to assess future change in the forest community within a portion of the park (see James et al, 2009 for detailed information on monitoring protocol). Monitoring sites were established and sampled in June 2011 (Fig. 1) within a 20 acre section in the southern portion of the park.

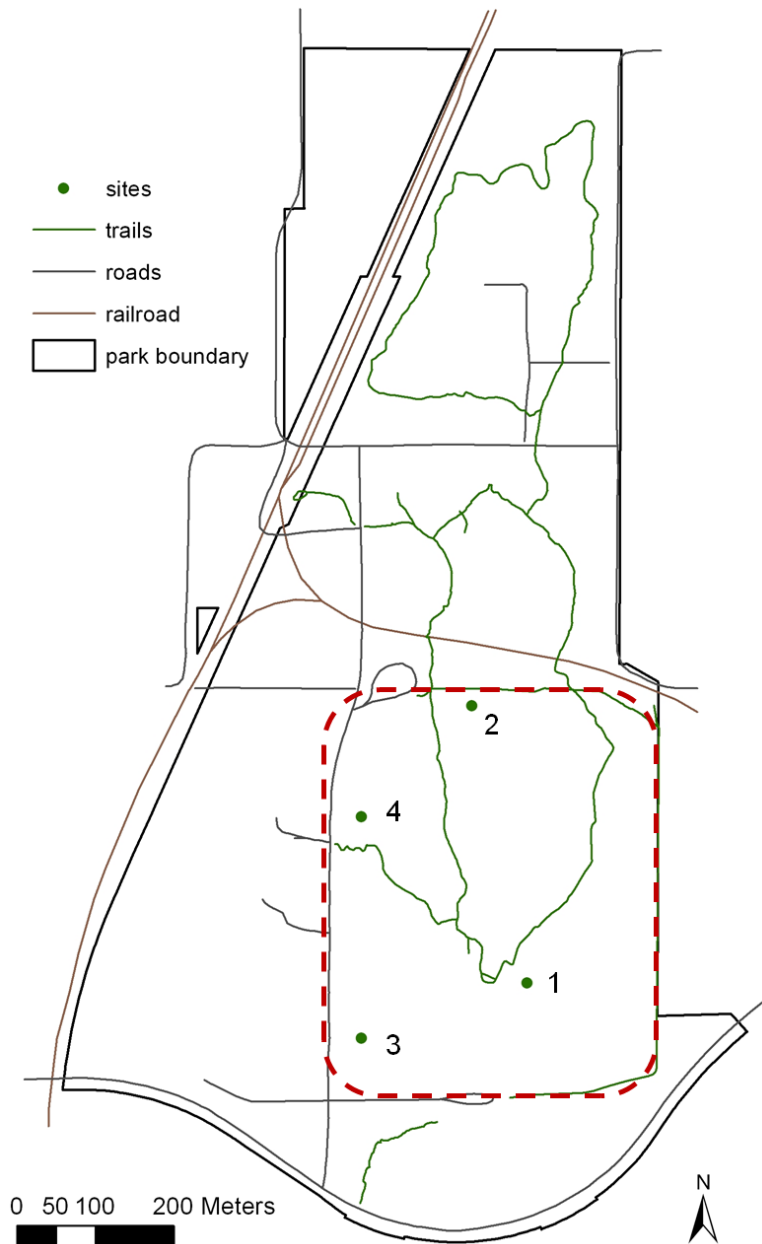


Figure 1. Location of Heartland Inventory and Monitoring Network vegetation monitoring sites (n=4) at Lincoln Boyhood National Memorial, Indiana. Area within the red dashed line box is the focus of monitoring.

Forest sites are monitored according to the revised 2009 protocol and are comprised of two parallel transects each containing five nested sample plots (Fig. 2). Species composition and foliar cover estimates for herbaceous plants and shrubs <1.5 m in height are collected from each plot and values are summarized to the individual site.

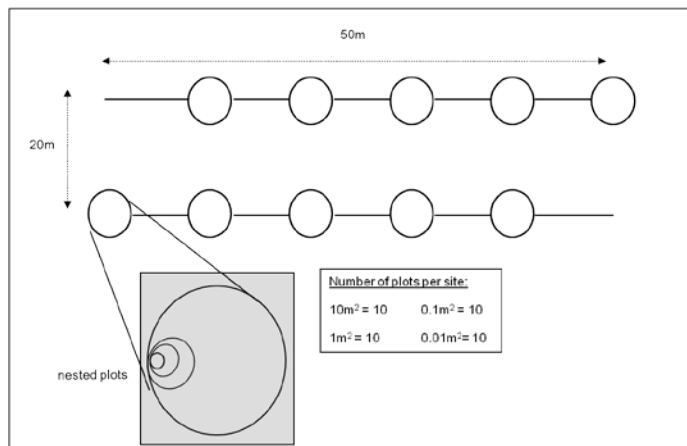


Figure 2. Heartland Inventory and Monitoring Network vegetation community sample design showing transects and plots including nested plots.

Individual species percent foliar cover was calculated for each site. Foliar cover serves as an estimate of abundance for herbaceous species. Cover class intervals are converted to median values to estimate percent cover for each herbaceous and shrub species. Mean percent cover is then calculated as the species percent cover for a site, averaged for all ten plots within the site.

Overstory sampling is based on the same monitoring protocol. In the 0.1ha space formed between the two parallel transects, overstory tree data are collected. Overstory trees greater than 5.0 cm diameter at breast height (dbh) are recorded along with their dbh and condition (live or dead). For all trees < 5.0 cm dbh, including seedlings and saplings, a simple count of individuals by species are tallied at the 10m² plot level along both transects. These data are summed to the site level.

Data Summary and Analysis

Data collected from all plots within a site are summarized by species to the site level. Mean site values along with a measure of among site variability (± 1 standard error of the mean) are presented for the community. Foliar cover estimates collected for each species within a plot are the basis of field data used in all subsequent analysis.

Understory species diversity

For each site within the community, species richness (S) along with the effective number of species derived from both Shannon diversity index (Shannon number or H_e) and Simpson's diversity index (Simpson's number or D_e) was calculated. Foliar cover estimates for each species in a site are used to determine each measure of species diversity in PC-ORD (McCune and Medford 1999).

Initial plant diversity for each site was calculated using the Shannon diversity index:

$$H' = - \sum_{i=1}^n p_i \ln p_i$$

where p_i is the relative cover of species i (Shannon 1948).

Simpson's index of diversity for an infinite population (D) was calculated by site (McCune and Grace 2002). It is the likelihood that two randomly chosen individuals from a site will be different species and emphasizes common species (McCune and Grace 2002). It is calculated by site using the complement of Simpson's original index of dominance:

$$\text{Simpson's index} = 1 - \sum_{i=1}^n p_i^2$$

Shannon and Simpson's index values were converted into effective number of species for each community (H_e and D_e , respectively). This allowed for both diversity measures to be compared directly to species richness of the sites (S) within and among sample years based on counts of distinct species in the community (Jost 2006). Shannon index was converted into effective number of species (H_e) using the following formula:

$$H_e = \exp^{(H)}$$

where H was the Shannon index value. The effective number of species based on Simpson's index (D_e) was the inverse of the index value or:

$$D_e = 1/(1-D)$$

where D was the Simpson's index value.

As S , H_e and D_e approach the same number, species begin to be equally abundant in the understory while large differences in the number of species between each measure reflect an increasing number of less abundant species and decreasing number of more abundant species. See Jost (2006) and James and Rowell (2009) for a complete explanation and implementation of species diversity measures, respectively.

Understory guild abundance

Species are grouped into functional guilds and foliar cover estimates are presented at the guild level for the understory. For each guild, foliar cover is totaled for each plot and then a mean site value is calculated from all ten plots. Guilds are first divided among native and non-native groups and then among grasses, forbs, sedges/rushes, ferns and woody species within each group. A complete species list along with guild assignment is provided in Appendix A.

Forest overstory

Overstory tree composition in the successional forest is based on individual tree counts for each species and diameter at breast height measurements (dbh). Understory trees and the regeneration

layer (seedlings and saplings) are summarized by individual species counts summarized to hectare. Taken together, all tree metrics are used to describe the successional forest composition and structure for the selected area of the park. Overstory tree counts are grouped by size class (Table 1).

Table 1. Diameter at breast height (dbh) measurement range (cm) and size class used to group overstory trees.

dbh (cm)	size class
5.0 - 14.9	1
15.0 - 24.9	2
25.0 - 34.9	3
35.0 - 44.9	4
≥ 45	5

The regeneration layer is reported in three size classes: (1) seedlings – stems <0.5m tall, (2) small saplings – stems ≥ 0.5m tall but < 2.5cm dbh and (3) large saplings – stems ≥0.5m tall but ≥ 2.5 and < 5.0cm dbh.

Results

Successional forest understory

The understory of the four forest sites are characterized by a larger number of native species that are represented by a few individuals and/or low foliar cover (species richness, Fig. 2), and a smaller number of species that occur frequently in large abundance (Shannon and Simpson number, Fig. 2). This pattern in species diversity measures is reflected in non-native species as well. Non-native species richness is low among the four sites. However both diversity measures (H_e and D_e) reflect a pattern of two abundant species, common periwinkle (*Vinca minor*) and Japanese honeysuckle (*Lonicera japonica*) in the understory (Fig. 2).

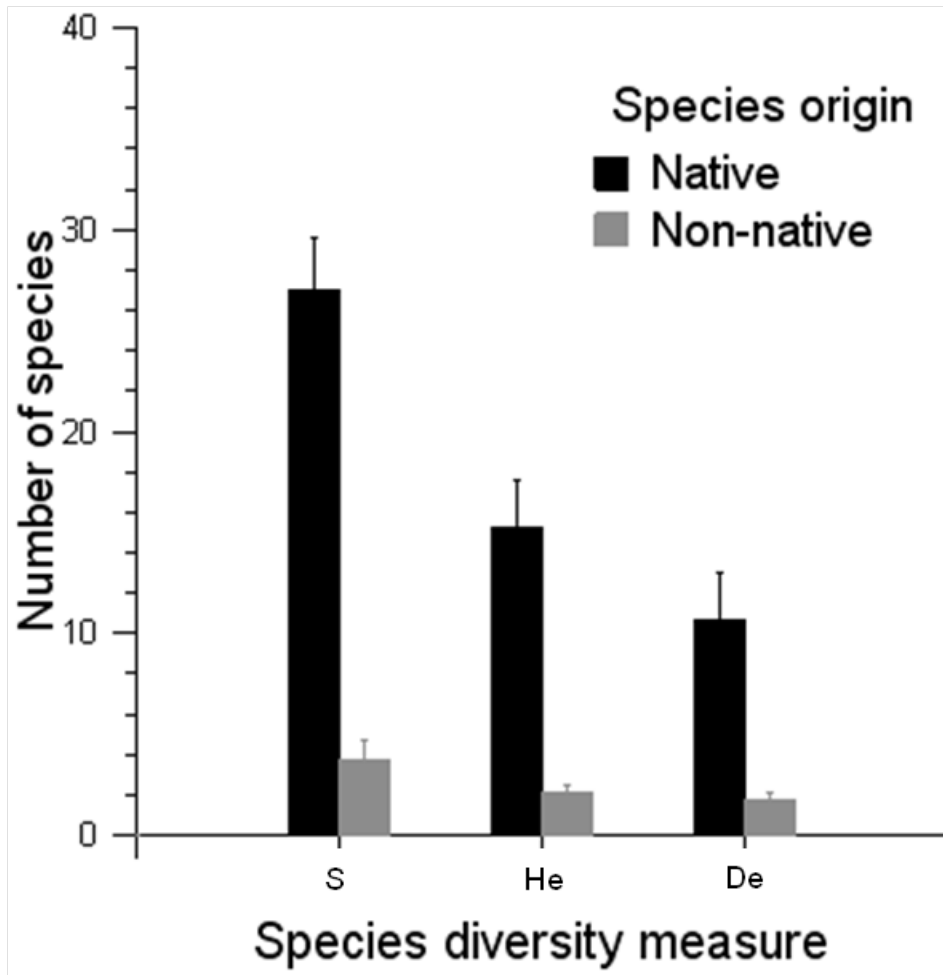


Figure 2. Mean number of understory species (native and non-native) within a site as measured by species richness (S) and effective number of species for two diversity measures (Shannon number, He; and Simpson's number, De). Error bars are ± 1 standard error of the mean.

Total foliar cover of guilds in the understory average about 60% for each of the four sites. Most native species in the understory belong to the woody (N_woody) and forb (N_forb, Fig. 3) guilds. In addition, most native species (regardless of native guild type) are evenly distributed among the four sites as indicated by shorter error bars in Fig. 3.

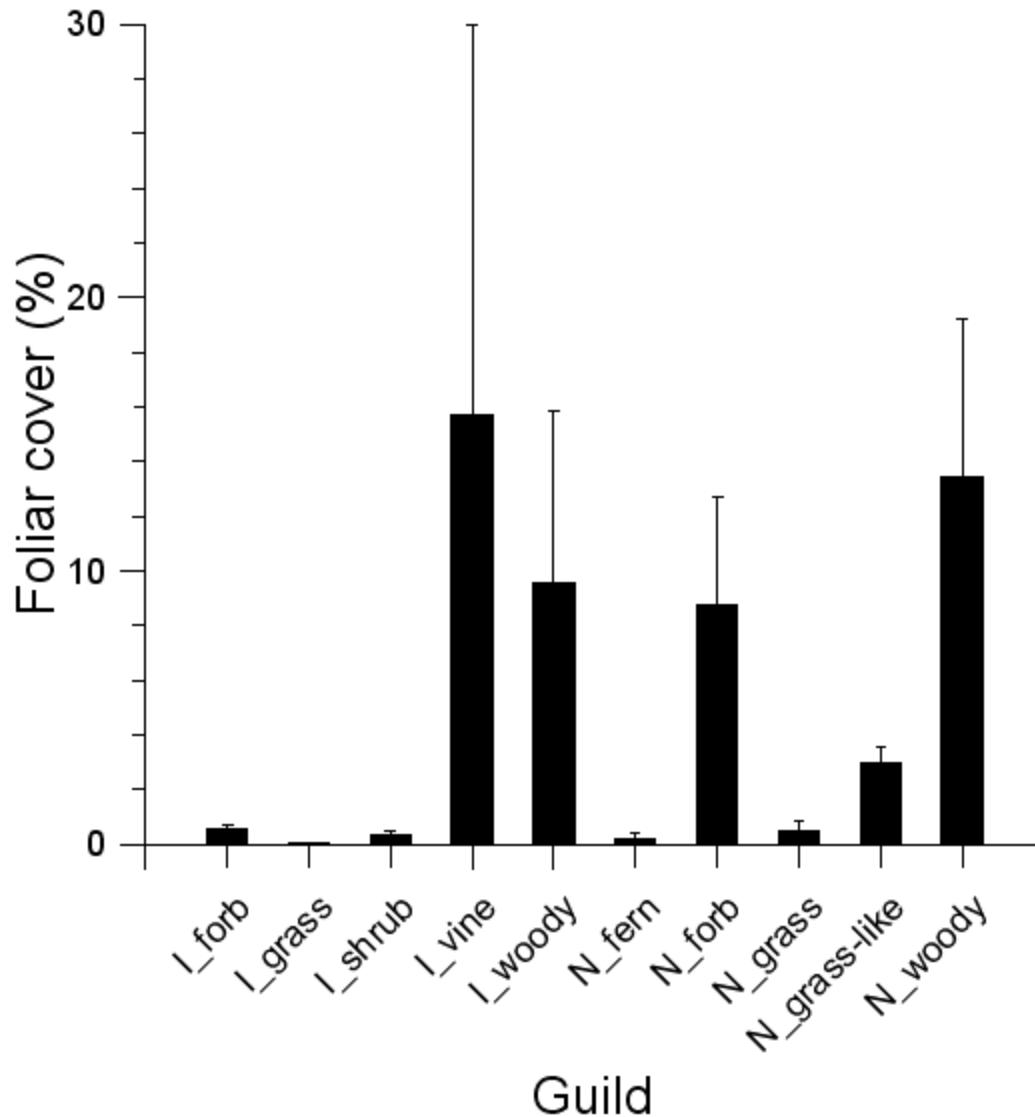


Figure 3. Mean foliar cover (± 1 standard error of the mean) for plant guilds in the understory of the successional forest (N=4). “I” indicates non-native species and “N” indicates native species membership for each guild.

The non-native vine guild has the greatest mean foliar cover as well as the largest standard error of the mean of any guild type (Fig. 3, I_vine). This guild is solely composed of common periwinkle, which is restricted to sites 3 and 4. Where common periwinkle is observed, it forms nearly continuous cover within the monitoring frames. Japanese honeysuckle contributes to the high foliar cover of the non-native woody guild (Fig. 3, I_woody), even though multiflora rose (*Rosa multiflora*) is detected on the site.

Successional forest overstory

Overstory structure

The successional forest in this portion of the park has a closed canopy with a mean canopy cover of 95.6% (± 2.5 standard deviation). Beneath the closed canopy, there are three canopy layers with most trees in the overstory occupying the upper two layers of the canopy with a few large

dominant trees extending above the canopy. This multi-layer forest structure of older trees is reflected in both density and basal area of trees in the larger size classes (Table 2).

Table 2. Overstory tree density (stems/ha) and basal area (m²/ha) by diameter as breast height size class.

Size class	Density	Basal area
1	80	0.7
2	75	2.5
3	62.5	4.6
4	60	7.1
5	70	17.3

Trees >45cm dbh (size class 5) have the greatest basal area in all four sites.

Overstory composition

The species composition of trees in the successional forest community in this portion of the park reflects both pre-settlement hardwood community and the disturbed successional forest. Sugar maple (*Acer saccharum*) occurs in both the greatest density and basal area along with red maple (*Acer rubrum*; Table 3). Flowering dogwood (*Cornus florida*) is the most abundant species in the lower canopy layer of these sites. Hardwood species indicative of the pre-settlement hardwood community include numerous oak species (*Quercus* spp.) and shagbark hickory (*Carya ovata*), however these species occur in lower density and basal area.

Table 3. Overstory tree species density (stems/ha) and basal area (m²/ha).

Overstory tree	Density	Basal area
American hornbeam	2.5	0.25
American sycamore	10	1.74
black oak	7.5	1.87
black walnut	2.5	0.02
blackgum	2.5	0.03
eastern white pine	2.5	0.01
flowering dogwood	42.5	0.36
northern red oak	5	2.86
red maple	65	6.98
sassafras	2.5	0.01
shagbark hickory	7.5	0.32
shingle oak	2.5	0.20
slippery elm	7.5	0.30
sugar maple	142.5	10.59
sweetgum	30	4.06
tuliptree	7.5	1.70
white ash	5	0.88
white oak	2.5	0.05

Regeneration

The species diversity observed in the overstory is similar to that of the regeneration layer. Like the overstory layer, a few species dominate the density estimates. Of the three regeneration layers, seedlings occur in the greatest density (Table 4). Sugar maple, white ash (*Fraxinus americana*) and eastern redbud (*Cercis canadensis*) are the most abundant, with sugar maple seedlings nearly equaling the density estimates of all other species combined. The same three species occur in highest densities of small saplings. Only seven large saplings were detected in the four sites.

Table 4. Seedling, small sapling and large sapling density (stems/ha) for each species in the regeneration layer.

Tree species	Seedling	Small sapling	Large sapling
American hornbeam	10	0	0
bitternut hickory	10	2.5	0
black cherry	10	5	0
blackgum	47.5	0	0
common hackberry	7.5	0	0
common persimmon	42.5	0	0
elm	45	0	0
estern redbud	275	20	0
flowering dogwood	42.5	0	2.5
hickory	57.5	7.5	0
mockernut hickory	0	5	0
red maple	85	5	0
red oak group	15	5	0
sassafras	0	7.5	0
shingle oak	2.5	0	0
slippery elm	22.5	0	0
sugar maple	1022.5	182.5	10
sweetgum	12.5	2.5	2.5
tuliptree	10	15	2.5
white ash	465	117.5	0
white oak	5	0	0

Even though there are a large number of seedlings established, recruitment into the larger regeneration layers is minimal.

Discussion

Monitoring sites described in this report are most closely resembling the upland successional forest describe by Pavlovic and White (1989). The forest structure and composition within these four sites reflect the past history of the land, ranging from presettlement forest components to logging and fire suppression and reforestation efforts. For complete forest community descriptions and analysis see Pavlovic and Forste (2004). Non-native species contribute the most to foliar cover in the understory, specifically common periwinkle and Japanese honeysuckle. In addition, overstory regeneration is dominated by sugar maple, which will impact the forest composition in time.

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Appendix

Appendix A. Species list compiled from all HTLN vegetation monitoring sites sampled in 2011. Origin corresponds to native species (N) and non-native species (I).

Scientific name	Common names	Guild	Origin
<i>Acalypha virginica</i>	Virginia threeseed mercury	Forb	N
<i>Acer rubrum</i>	red maple	Woody	N
<i>Acer saccharum</i>	sugar maple	Woody	N
<i>Ageratina altissima</i>	white snakeroot	Forb	N
<i>Arisaema dracontium</i>	green dragon	Forb	N
<i>Aristolochia serpentaria</i>	Virginia snakeroot	Forb	N
<i>Asplenium platyneuron</i>	ebony spleenwort	Fern	N
<i>Aster</i>	Aster	Forb	N
<i>Berberis thunbergii</i>	Japanese barberry	Woody	I
<i>Bidens</i>	beggarticks	Forb	N
<i>Boehmeria cylindrica</i>	smallspike false nettle	Forb	N
<i>Botrychium virginianum</i>	rattlesnake fern	Fern	N
<i>Campsis radicans</i>	trumpet creeper	Woody	N
<i>Carex</i>	sedge	grass-like	N
<i>Carpinus caroliniana</i>	American hornbeam	Woody	N
<i>Carya ovata</i>	shagbark hickory	Woody	N
<i>Cercis canadensis</i>	eastern redbud	Woody	N
<i>Clematis virginiana</i>	devil's darning needles	Woody	N
<i>Cornus florida</i>	flowering dogwood	Woody	N
<i>Corylus americana</i>	American hazelnut	Woody	N
<i>Desmodium paniculatum</i>	panickedleaf ticktrefoil	Forb	N
<i>Dichanthelium</i>	rosette grass	Grass	N
<i>Dioscorea quaternata</i>	fourleaf yam	Forb	N
<i>Elymus virginicus</i>	Virginia wildrye	Grass	N
<i>Fraxinus americana</i>	white ash	Woody	N
<i>Galium aparine</i>	stickywilly	Forb	N
<i>Galium circaezans</i>	licorice bedstraw	Forb	N
<i>Galium concinnum</i>	shining bedstraw	Forb	N
<i>Geum canadense</i>	white avens	Forb	N
<i>Hydrastis canadensis</i>	goldenseal	Forb	N
<i>Hypericum densiflorum</i>	bushy St. Johnswort	Forb	N
<i>Impatiens capensis</i>	jewelweed	Forb	N
<i>Juglans nigra</i>	black walnut	Woody	N
<i>Leersia virginica</i>	whitegrass	Grass	N
<i>Ligustrum vulgare</i>	European privet	Shrub	I
<i>Lindera benzoin</i>	northern spicebush	Woody	N
<i>Liparis liliifolia</i>	brown widelip orchid	Forb	N
<i>Liquidambar styraciflua</i>	sweetgum	Woody	N
<i>Liriodendron tulipifera</i>	tuliptree	Woody	N
<i>Lonicera japonica</i>	Japanese honeysuckle	Woody	I
<i>Microstegium vimineum</i>	Nepalese browntop	Grass	I
<i>Nyssa sylvatica</i>	blackgum	Woody	N
<i>Oxalis</i>	woodsorrel	Forb	N
<i>Parietaria pensylvanica</i>	Pennsylvania pellitory	Forb	N

Appendix A. Species list compiled from all HTLN vegetation monitoring sites sampled in 2011. Origin corresponds to native species (N) and non-native species (I) (continued).

Scientific name	Common names	Guild	Origin
<i>Parthenocissus quinquefolia</i>	Virginia creeper	Woody	N
<i>Phryma leptostachya</i>	American lopseed	Forb	N
<i>Phytolacca americana</i>	American pokeweed	Forb	N
<i>Pilea pumila</i>	Canadian clearweed	Forb	N
<i>Pinus strobes</i>	eastern white pine	Woody	N
<i>Platanus occidentalis</i>	American sycamore	Woody	N
<i>Podophyllum peltatum</i>	mayapple	Forb	N
<i>Polygonum cespitosum</i>	Oriental lady's thumb	Forb	I
<i>Polygonum virginianum</i>	jumpseed	Forb	N
<i>Quercus alba</i>	white oak	Woody	N
<i>Quercus imbricaria</i>	shingle oak	Woody	N
<i>Quercus rubra</i>	northern red oak	Woody	N
<i>Quercus velutina</i>	black oak	Woody	N
<i>Rosa multiflora</i>	multiflora rose	Woody	I
<i>Rubus</i>	blackberry	Woody	N
<i>Sanicula canadensis</i>	Canadian blacksnakeroot	Forb	N
<i>Sassafras albidum</i>	sassafras	Woody	N
<i>Smilax glauca</i>	cat greenbrier	Forb	N
<i>Smilax tamnoides</i>	bristly greenbrier	Woody	N
<i>Solidago</i>	goldenrod	Forb	N
<i>Staphylea trifolia</i>	American bladdernut	Woody	N
<i>Symphoricarpos orbiculatus</i>	coralberry	Woody	N
<i>Toxicodendron radicans</i>	eastern poison ivy	Woody	N
<i>Triodanis perfoliata</i>	clasping Venus' looking-glass	Forb	N
<i>Ulmus rubra</i>	slippery elm	Woody	N
<i>Viburnum prunifolium</i>	blackhaw	Woody	N
<i>Vinca minor</i>	common periwinkle	Vine	I
<i>Viola</i>	violet	Forb	N
<i>Vitis</i>	grape	Woody	N