National Park Service
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Natural Resource Stewardship and Science

Vegetation Community Monitoring at Lincoln Boyhood National Memorial, Indiana

2011-2015

Natural Resource Data Series NPS/HTLN/NRDS—2016/1073

ON THE COVER
Photograph of Plant Community monitoring site at Lincoln Boyhood National Memorial.
Photograph courtesy of the National Park Service Heartland Inventory and Monitoring Network.

Vegetation Community Monitoring at Lincoln Boyhood National Memorial, Indiana

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Sherry A. Leis

National Park Service
Heartland Inventory and Monitoring Network
6424 W Farm Road 182
Republic, MO 65738

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Abstract

The woodlands at LIBO have undergone significant landuse changes from logging to restoration. We monitored four woodland sites during 2011 and 2015 to document the status of the vegetation community with an interest in non-native species. Two years of monitoring demonstrate that the woodland at LIBO generally reflects the historic overstory composition described by Pavlovic and White (1989). White oak was more dominant historically and maples less dominant than in the current forest. The forest canopy consistently represents a closed canopy forest with multiple layers. Tree density and basal area were similar across years. Likewise, regeneration was similar between years. Regeneration species were dominated by maples and few hardwoods were recruited to the large sapling stage. While species diversity of the understory was similar across years, there appeared to be a reduction in cover of some guilds in 2015. Notably non-native vines had lesser mean cover in 2015. Non-native species made a greater contribution than natives to understory cover. Specifically, common periwinkle and Japanese honeysuckle were abundant.

Acknowledgments

I would like to acknowledge the contributions of previous team members, K. James and K. Mlekush, who collected and processed this data. Some basic language from the previous report (introduction and methods in particular based on James et al. 2009 and James 2011) by K. James was utilized in this manuscript.

Introduction

Lincoln Boyhood National Memorial (LIBO) includes 200 acres of old fields and hardwood forest. The Memorial aims to restore the cultural landscape to mature hardwood forest in an effort to interpret the landscape that the Lincoln family would have experienced. As such, cultural landscape goals drive natural resource objectives at the Memorial. This report builds on the initial 2011 monitoring effort (James 2011) by describing the woodland community and assessing changes between 2011 and 2015.

Methods

Sampling design

Vegetation community monitoring sites were established at LIBO in 2011. Four monitoring sites were installed within the southern area of the park and sampled in 2011 and 2015 (Figure 1).

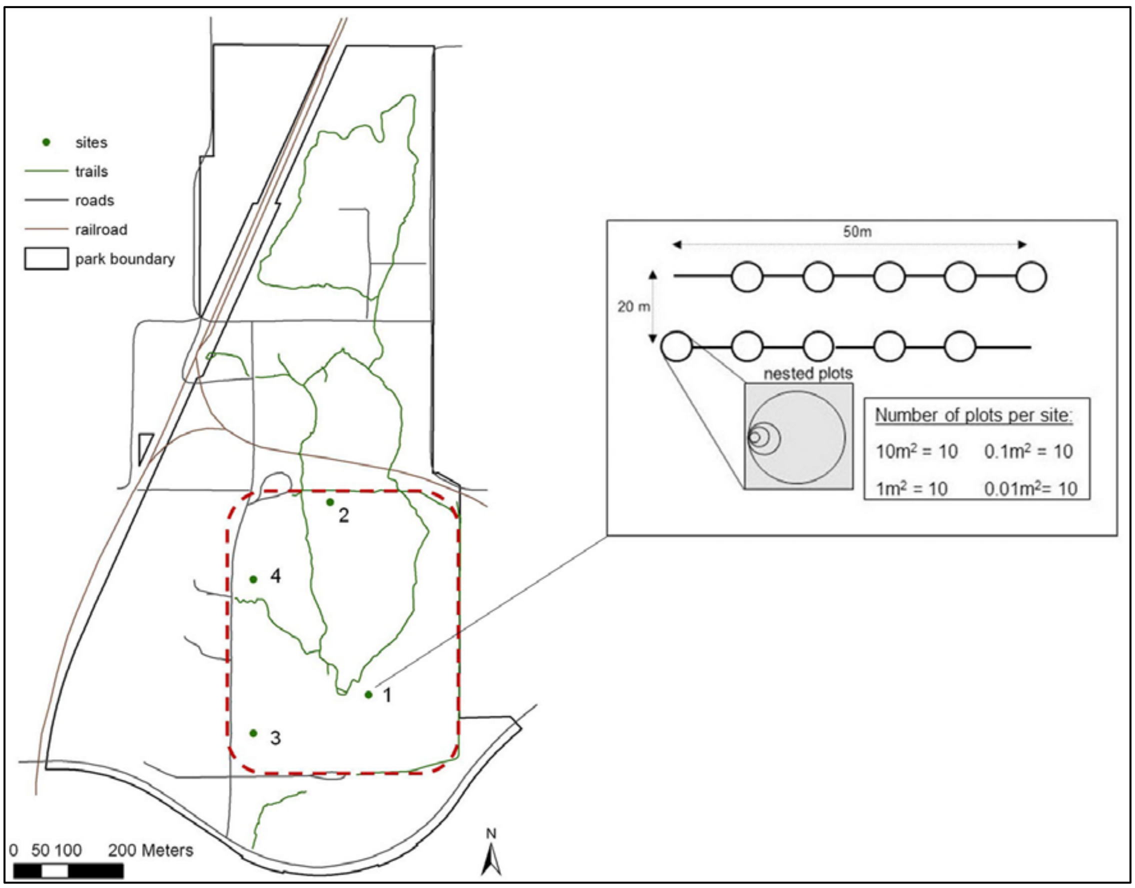

Figure 1. Map of Heartland Inventory and Monitoring Network vegetation monitoring sites (n=4) at Lincoln Boyhood National Memorial, Indiana. Area within the red dashed line box is the focus of monitoring. Site configuration is shown on the right.

The four monitoring sites at LIBO were characterized as forest. Monitoring methods follow the woodland standard operating procedures outlined in the Heartland Inventory and Monitoring (HLTN) vegetation monitoring protocol (James et al. 2009). Generally, monitoring sites were 50 m x 20 m (0.1 ha) in size with the two transects bounding the site on the 50-m sides (Figure 1). Woodland monitoring consists of a suite of sampling methods including overstory trees, canopy cover, regeneration, understory species, and ground cover.

Overstory trees were sampled within each 0.1 ha site. Diameter at breast height (DBH) was recorded for each tree >5.0 cm DBH along with species names, status, and canopy position. The remaining elements were assessed along two 50-m transects that bound the site. A system of nested hoops comprised 10 10-m^2 plots along the two transects used to collect understory vegetation data. Species were recorded in the nested plots including a class assignment for foliar cover. Values were averaged across the 10 plots to represent site abundance. Tree species < 5 cm DBH were recorded and tallied in the 10-m^2 plots as seedlings, small and large saplings to reflect the regeneration component. Data were summarized to the site level.

Data Summary and Analysis

Data collected from all plots within a site were 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 below for the community rather than sites. Foliar cover estimates collected for understory species within a plot were the basis of field data used in subsequent analyses.

Forest overstory

Overstory tree composition in the forest was based on individual tree counts for each species and DBH measurements. Snags were removed from the dataset for overstory analysis unless specified in results. Basal area and stem density were calculated as described in James et al. (2009). Proportion of basal area was also calculated by canopy position class to better understand the structure of the community. Understory trees and the regeneration layer (seedlings and saplings) were summarized by individual species counts and scaled to hectare. Taken together, all tree metrics were used to describe the forest composition and structure for the park focus area. Overstory tree counts were 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 was tallied in the 10 10-m^2 plots and 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 but ≥ 2.5 tall and < 5.0cm DBH. The formula used to scale species regeneration to ha was: Total number of stems/4(sites monitored) * 100 (scaling factor to convert to ha)

Forest understory

Understory species diversity

Species were separated by their nativity status (native or introduced) prior to diversity calculations. 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) were calculated. Richness represents the number of species recorded, H_e represents a measure of diversity, while D_e refers to dominance within the community. Mean foliar cover estimates for each species in a site are used to determine these elements. PC-ORD was used to calculate the diversity indices (McCune and Medford 2011).

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

$$\text{Shannon's Index: H}' = -\sum_{i=1}^{n} p_i \ln p_i$$

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

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

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.

Interpretation: 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 rare species and decreasing number of abundant species. See Jost (2006) and James and Rowell (2009) for a complete explanation and implementation of species diversity measures, respectively.

Understory guild abundance

Understory species were also summarized by guilds, aka functional groups, (as per the USDA Plants database) to provide insight into the composition of the community. Guild assignments are: grasses, forbs, sedges/rushes, ferns and woody species. Species were separated by nativity status prior to being summed by guild. A complete species list along with guild assignment was provided in Appendix A.

Paired T-tests were used to determine whether significant differences existed between elements of the flora between the two years monitored (canopy cover, regeneration, and diversity). Repeated measures ANOVA was used to assess changes in basal area over time. SPSS statistical software (Version 20) was used for analyses (IBM 2011) and significance was evaluated at the alpha = 0.05 level. PC-Ord (Version 6) was used for calculation of diversity indices (McCune and Mefford 2011).

Results

Overstory structure

The forest in our target monitoring area of the Memorial has a relatively closed canopy (Table 2). There was no significant difference in canopy cover between sample events (Paired T-test P = 0.80, t = -0.274, df = 3).

Table 2. Overstory canopy cover at Lincoln Boyhood Memorial 2011-2015.

Year	N	Mean Canopy Cover (%)	Std error
2011	4	95.6	1.23
2015	4	95.2	0.51

While the canopy layers are evident, the greatest proportion of basal area in each year was of codominant trees (Table 3). Dominant canopy trees tended to be large trees in this community. Only a small proportion of basal area was characterized in the subcanopy layer.

Table 3. Proportion of total basal area attributed to each canopy layer observed during monitoring at Lincoln Boyhood Memorial 2011-2015.

Year	Dominant basal area (%)	Co-dominant basal area (%)	Intermediate basal area (%)	Subcanopy basal area (%)
2011	20.2	64.8	14.9	0.1
2015	25.8	58.1	14.2	1.9

Basal area is a common way to consider the volume of trees in a place of interest. At LIBO large trees made up the greatest mean basal area (Figure 2). While there was no difference in basal area between years (repeated measures ANOVA: P = 0.96, F = 0.002, df = 1), there was a significant difference between classes (P = 0.001, F = 8.98, df = 4) meaning that basal area was unevenly distributed across size classes. There was no interaction between year and class, however (P = 0.97, F = 0.138, df = 4).

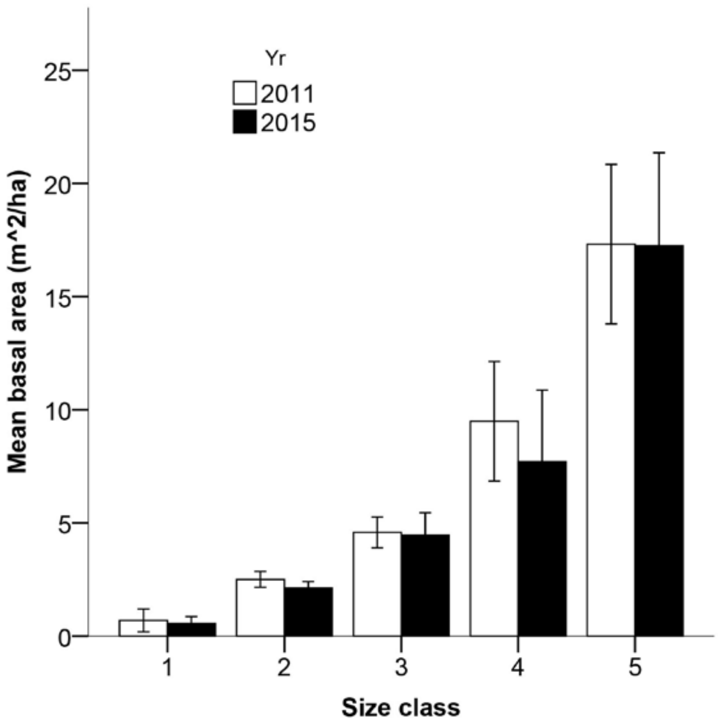

Figure 2. Basal area (m2/ha) of overstory trees at Lincoln Boyhood National Memorial by size class and year. The largest trees are category 5. Error bars are ±1 SE of the mean.

Density (stems/ha) also describes the amount of trees in a target area. Density of tree stems was very similar between sampling years at LIBO (Figure 3).

Snags or standing dead trees are an important component of woodlands. At LIBO, snags made up 12.8% (2011) and 13.9% (2015) of the total tree basal area observed (Figure 4). Site 3 had a greater amount of standing dead trees than the other sites.

The mean number of tree species declined from seven in 2011 to six in 2015. There was a similar slight decline in effective number of species for Shannon and Simpson's indices (2011: H_e= 4.6, D_e = 3.9; 2015: H_e = 3.7, D_e= 3.2). It appears that in 2015 red maples may have been misidentified as sugar maples causing some of the small differences between the two years. Northern red oak had the most basal area in both years but sugar maples had the greatest stem density (Table 4).

Oaks and maples were dominant species observed. Hardwood species indicative of the pre-settlement hardwood community included oak species (*Quercus* spp.) and shagbark hickory (*Carya ovata*). The dominant canopy trees included black oak (*Quercus velutina*), sycamore (*Platanus occidentalis*), tulip tree (*Liriodendron tulipifera*), and sweet gum (*Liquidambar styraciflua*). In the intermediate and subcanopy layers, flowering dogwood (*Cornus florida*) was the most common species.

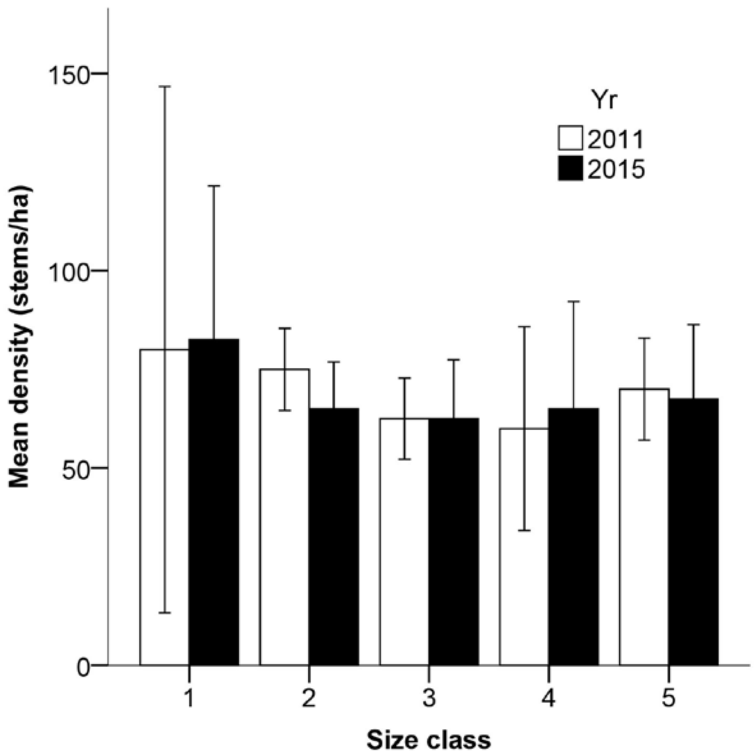

Figure 3. Mean density of overstory trees (stems/ha) by size class at Lincoln Boyhood National Memorial. The largest trees are category 5. Error bars are ±1 SE of the mean

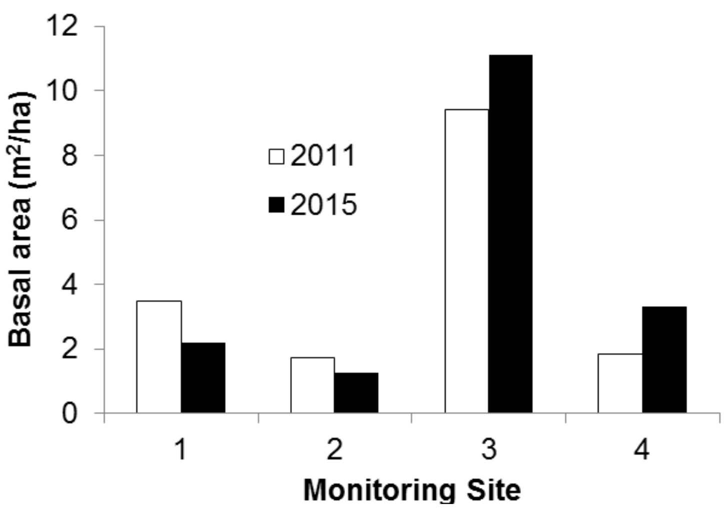

Figure 4. Basal area (m^2/ha) of snags at Lincoln Boyhood National Memorial observed in 2011 and 2015.

Table 4. Overstory tree species density (stems/ha) and basal area (m^2/ha) at Lincoln Boyhood National Memorial. SE = 1 standard error. Negative change in stems indicates fewer stems per monitoring site in 2015. *Red maples in 2011 may have been misidentified as sugar maples in 2015.

Species	Mean basal area (m^2/ha) (SE)		Mean density (stems/ha) (SE)		Change in number of stems
	2011	2015	2011	2015	
American hornbeam	0.3	0	2.5 (2.5)	0	-1
American sycamore	0.4 (0.4)	0.5	10.0 (10)	10.0 (10)	0
black oak	0.6	0.7	7.5 (7.5)	7.5 (7.5)	0
black walnut	0.02	0.02	2.5 (2.5)	2.5 (2.5)	0
blackgum	0.03	0.02	2.5 (2.5)	15.0 (15)	5
eastern white pine	0.01 (0.01	0	2.5 (2.5)	0	-1
eastern redcedar	0	0.01(0.1)	0	2.5 (2.5)	1
flowering dogwood	0.02	0.01	42.5 (42.5)	22.5 (22.5)	-8
northern red oak	2.9 (2.1)	3.1 (2.3)	5.0 (2.9)	5 (2.9)	0
*red maple	1.0 (0.4)	0	65.0 (39.3)	0	-26
sassafras	0.01 (0.01)	0	2.5 (2.5)	0	-1
shagbark hickory	0.1	0.8	7.5 (7.5)	12.5 (12.5)	2
shingle oak	0.2	0	2.5 (2.5)	0	-1
slippery elm	0.2 (0.1)	0.6 (0.4)	7.5 (4.8)	10.0 (4.1)	1
*sugar maple	0.7 (0.1)	0.9 (0.1)	142.5 (48.4)	205.0 (44.8)	25
sweetgum	0.8 (0.4)	0.7 (0.4)	30 (14.7)	35.0 (17.6)	2
tuliptree	0.6 (0.4)	0.6 (0.6)	7.5 (7.5)	7.5 (4.8)	0
white ash	0.9 (0.6)	0.7 (0.3)	5.0 (2.9)	7.5 (2.5)	1
white oak	0.05	0	2.5 (2.5)	0	-1

Regeneration

Regeneration includes seedlings, small saplings, and large saplings. Individuals in all phases were represented, but recruitment into later phases is minimal (Figure 5, Table 5). There was no significant difference in regeneration phases between years (Paired T-test: seedlings: $P = 0.14$, $t = -2.00$ $df = 3$; small saplings: $P= 0.86$, $t = -0.20$, $df = 3$; large saplings $P = 0.16$, $t = -1.85$, $df = 3$).

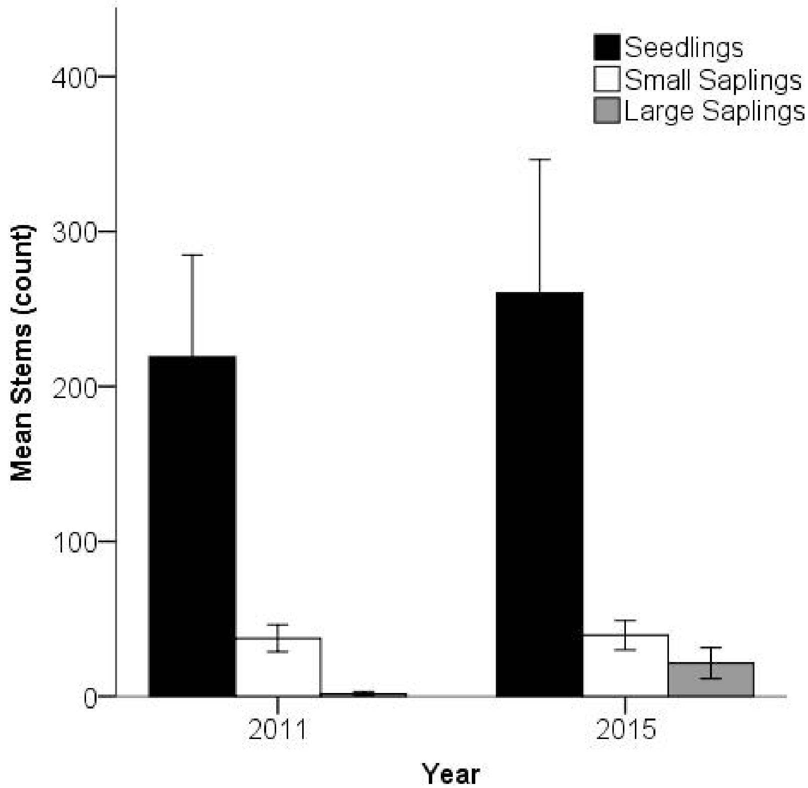

Figure 5. Abundance (stem counts/0.1-ha site) of regeneration phase trees at Lincoln Boyhood National Memorial in 2011 and 2015. Error bars are ±1 standard error of the mean.

Species composition of the regeneration layer largely reflected the overstory (Table 5). Interestingly, eastern redbud was present as seedlings and both small and large saplings but not present in the overstory. Sugar maple was the most abundant in all regeneration phases. However, it appears that red maples identified in 2011 may have been grouped with sugar maples in 2015. Similarly, there may have been differences in identification of *Staphylea trifolia* (American bladdernut) as it was observed in 2015 and not 2011.

Table 5. Regeneration phase stem density (stems/ha) for Lincoln Boyhood National Memorial. Percentage change values indicate the difference from 2011 so that negative values indicate fewer stems in 2015. *indicates species where identification might have been inconsistent between years.

	Mean stems/ha 2011			Mean stems/ha 2015			% change		
Species	Seedling	Small Sapling	Large Sapling	Seedling	Small Sapling	Large Sapling	Seedling	Small Sapling	Large Sapling
*American bladdernut	0	0	0	700	175	125			
American hornbeam	100	0	0	0	0	0	-100.0		
black cherry	100	50	0	200	50	25	100.0	0.0	
blackgum	475	0	0	125	0	0	-73.7		
common hackberry	75	0	0	25	0	0	-66.7		
common persimmon	425	0	0	175	0	0	-58.8		
eastern redbud	2750	200	0	3125	175	25	13.6	-12.5	
elm (native)	675	0	0	150	0	0	-77.8		
flowering dogwood	425	0	25	25	0	25	-94.1		0.0
hickory	675	150	0	850	0	25	25.9	-100.0	
northern spice bush	0	0	0	25	0	0			
oak	225	50	0	250	0	0	11.1	-100.0	
*red maple	850	50	0	0	0	0	-100.0	-100.0	
roughleaf dogwood	0	0	0	100	0	0			
sassafras	0	75	0	1575	250	200		233.3	
Siberian elm	0	0	0	25	0	0			
*sugar maple	10225	1825	100	10050	2375	1275	-1.7	30.1	1175.0
sweetgum	125	25	25	125	50	50	0.0	100.0	100.0
tuliptree	100	150	25	575	75	25	475.0	-50.0	0.0
white ash	4675	1175	0	7800	775	375	66.8	-34.0	
white mulberry	0	0	0	125	25	0			

Forest understory

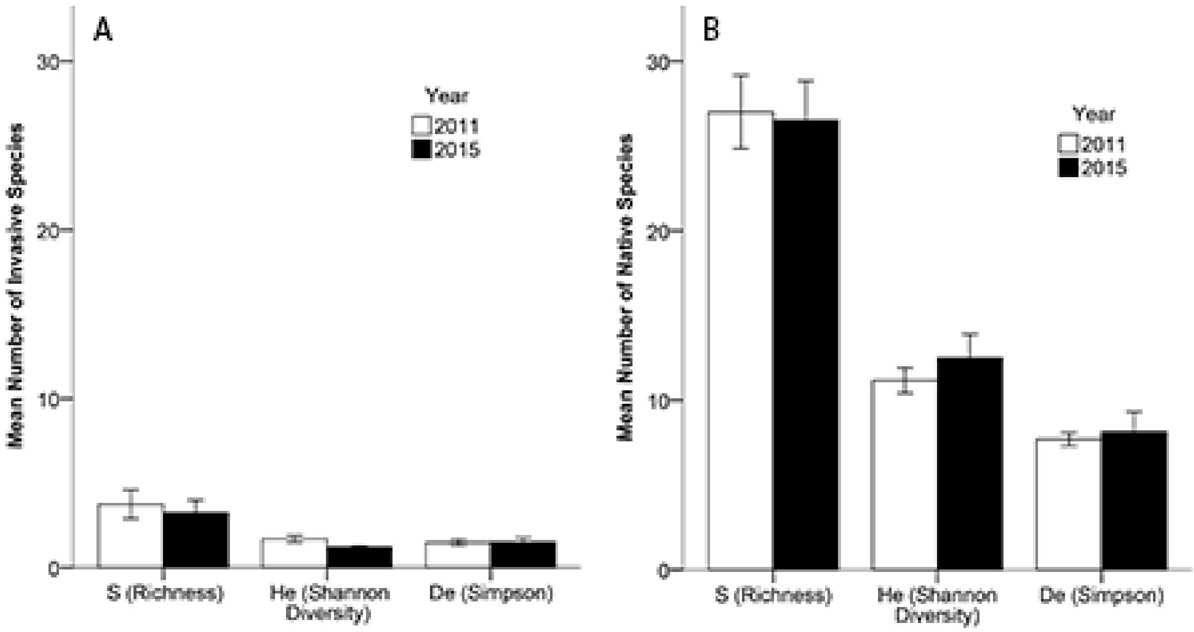

Figure 6. Mean number of A. non-native (invasive) and B. native understory species within a site as measured by species richness (S) and effective number of species for two diversity measures (Shannon number, He; and Simpson's number, De). Error bars are ±1 SE.

The understory of the four forest sites are characterized by a modest number of native species (48 in 2011, 46 in 2015). About half of the species are relatively rare. Even fewer species are dominant (<10) Figure 6B). This pattern in species diversity measures is reflected in non-native species as well. There are few non-native species but Shannon's and Simpson's indices indicate that an even smaller number of species dominates the pool (Figure 6A). Common periwinkle (*Vinca minor*) and Japanese honeysuckle (*Lonicera japonica*) drive the species composition of nonnative species. Measures of diversity richness, Shannon's, and Simpson's were not significantly different between years (Table 6).

Table 6. Paired T-test results for understory community analysis. No significant differences were found for diversity elements between the two sampling years for native or invasive plants.

Factor	P	t	df
Non-native S	0.50	0.78	3
Native S	0.70	0.42	3
Non-native H_e	0.32	1.20	3
Native H_e	0.38	-1.02	3
Non-native D_e	0.27	1.34	3
Native D_e	0.74	-0.36	3

Analysis of species by guild or functional group shows an overall reduction in species abundances in 2015. It also demonstrates that invasive species make up a notable amount of the total foliar cover at LIBO. Of particular note is the reduction of non-native woody species and native forbs (Figure 7).

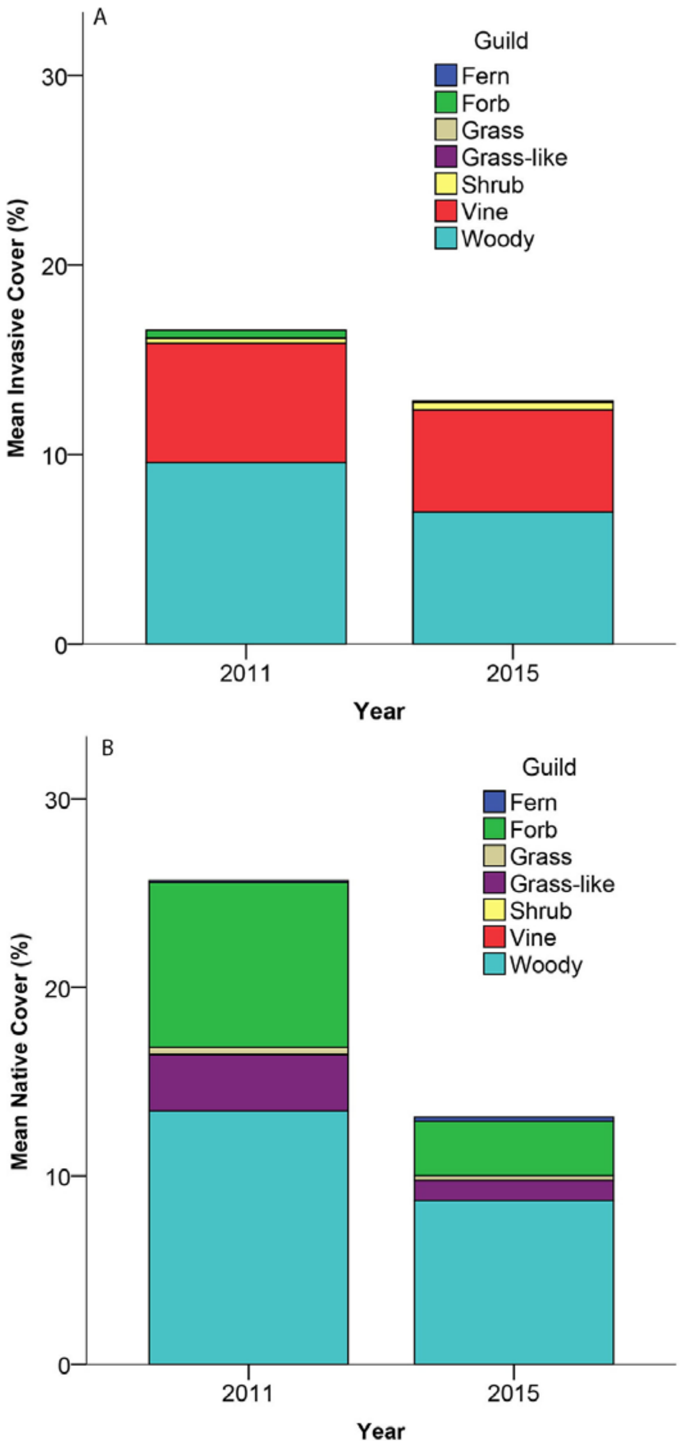

Figure 7. Mean foliar cover (± 1 standard error of the mean) for plant guilds in the understory of the successional forest (N=4). A. nonnative species (invasive) and B. native species by guild.

Discussion

The woodlands at LIBO have undergone significant landuse changes from logging to restoration. Two years of monitoring demonstrate that the woodland at LIBO generally reflects the historic overstory composition described by Pavlovic and White (1989). White oak was more dominant historically and maples less dominant than in the current forest. The forest canopy consistently represents a closed canopy forest with multiple layers. Density and basal area were similar across years. Likewise, regeneration was similar between years. Regeneration species were dominated by maples and few hardwoods were recruited to the large sapling stage. While species diversity of the understory was similar across years, there appeared to be a reduction in cover of some guilds in 2015. Notably non-native vines had lesser mean cover in 2015. Non-native species made a greater contribution to understory cover than native species. Two exotic species, common periwinkle and Japanese honeysuckle, continue to persist.

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Appendix A

Species recorded during monitoring events at LIBO 2011-2015. Origin values: N (native) I (introduced).

Species	Common Name	Origin	Guild
Acalypha virginica	Virginia threeseed mercury	N	forb
Acer rubrum	red maple	N	woody
Acer saccharum	sugar maple	N	woody
Ageratina altissima	white snakeroot	N	forb
Amphicarpaea bracteata	American hogpeanut	N	forb
Arisaema dracontium	green dragon	N	forb
Aristolochia serpentaria	Virginia snakeroot	N	forb
Asplenium platyneuron	ebony spleenwort	N	fern
Aster spp.	aster	N	forb
Berberis thunbergii	Japanese barberry	I	woody
Bidens	beggarticks	N	forb
Boehmeria cylindrica	smallspike false nettle	N	forb
Botrychium virginianum	rattlesnake fern	N	fern
Campanulastrum americanum	American bellflower	N	forb
Campsis radicans	trumpet creeper	N	Woody
Carex spp.	sedge	N	grass-like
Carpinus caroliniana	American hornbeam	N	woody
Carya ovata	shagbark hickory	N	woody
Celastrus scandens	American bittersweet	N	woody
Cinna arundinacea	sweet woodreed	N	grass
Clematis virginiana	devil's darning needles	N	woody
Conoclinium coelestinum	blue mistflower	N	forb
Cornus florida	flowering dogwood	N	woody
Corylus americana	American hazelnut	N	woody
Desmodium paniculatum	panicledleaf ticktrefoil	N	forb
Dichanthelium	rosette grass	N	grass
Dioscorea quaternata	fourleaf yam	N	forb
Elymus virginicus	Virginia wildrye	N	grass
Fraxinus americana	white ash	N	woody
Galium aparine	stickywilly	N	forb
Galium circaezans	licorice bedstraw	N	forb
Galium concinnum	shining bedstraw	N	forb
Geum canadense	white avens	N	forb
Hydrastis canadensis	goldenseal	N	forb
Hypericum densiflorum	bushy St. Johnswort	N	forb
Impatiens capensis	jewelweed	N	forb
Juglans nigra	black walnut	N	woody
Juniperus virginiana	eastern redcedar	N	woody

Species	Common Name	Origin	Guild
Leersia virginica	Whitegrass	N	grass
Ligustrum vulgare	European privet	I	shrub
Lindera benzoin	northern spicebush	N	woody
Liparis liliifolia	brown widelip orchid	N	forb
Liquidambar styraciflua	sweetgum	N	woody
Liriodendron tulipifera	tuliptree	N	woody
Lonicera japonica	Japanese honeysuckle	I	woody
Menispermum canadense	common moonseed	N	woody
Microstegium vimineum	Nepalese browntop	I	grass
Morus alba	white mulberry	I	woody
Muhlenbergia schreberi	nimblewill	N	grass
Nyssa sylvatica	blackgum	N	woody
Oxalis spp.	woodsorrel	N	forb
Parietaria pensylvanica	Pennsylvania pellitory	N	forb
Parthenocissus quinquefolia	Virginia creeper	N	woody
Phryma leptostachya	American lopseed	N	forb
Phytolacca americana	American pokeweed	N	forb
Pilea pumila	Canadian clearweed	N	forb
Pinus strobus	eastern white pine	N	woody
Platanus occidentalis	American sycamore	N	woody
Podophyllum peltatum	mayapple	N	forb
Polygonum cespitosum	Oriental lady's thumb	I	forb
Polygonum virginianum	jumpseed	N	forb
Quercus alba	white oak	N	woody
Quercus imbricaria	shingle oak	N	woody
Quercus rubra	northern red oak	N	woody
Quercus velutina	black oak	N	woody
Rosa multiflora	multiflora rose	I	woody
Rubus spp.	blackberry	N	woody
Sanicula spp.	sanicle	N	forb
Sanicula canadensis	Canadian blacksnakeroot	N	forb
Sassafras albidum	sassafras	N	woody
Sassafras albidum	sassafras	N	woody
Smilax glauca	cat greenbrier	N	forb
Smilax tamnoides	bristly greenbrier	N	woody
Solidago spp.	goldenrod	N	forb
Staphylea trifolia	American bladdernut	N	woody
Symphoricarpos orbiculatus	coralberry	N	woody
Toxicodendron radicans	eastern poison ivy	N	woody
Trifolium campestre	field clover	I	forb
Triodanis perfoliata	clasping Venus' looking-glass	N	forb
Ulmus rubra	slippery elm	N	woody

Species	Common Name	Origin	Guild
Viburnum dentatum	southern arrowwood	N	woody
Viburnum prunifolium	blackhaw	N	woody
Vinca minor	common periwinkle	I	vine
Viola spp.	violet	N	forb
Vitis spp.	grape	N	woody

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

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National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov