



**REPORT ON THE TRENDS IN THE TREE AND SHRUB VEGETATION AT
LINCOLN BOYHOOD NATIONAL MEMORIAL, LINCOLN CITY, INDIANA:
DEVELOPMENT OF A VEGETATION MONITORING DATABASE**

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ABSTRACT

Vegetation data were collected in 1985, 1986, 1997, 2002, and 2003 at Lincoln Boyhood National Memorial in southern Indiana. The data were incorporated into a relational database to store and archive vegetation data for park management. The database includes data from the tree understory and overstory, shrub, and herb layers and includes tables concerning locations, times of sampling, canopy cover, soil chemistry, slope and aspect. The plants table includes standardized plant names and their code from Integrated Taxonomic Information System (ITIS), as well as all known synonyms, plant family, growth form and life form. A unique feature is the table to document and track unknown or unidentified specimens and species for future vegetation sampling.

In addition, we analyzed the tree and shrub data to examine vegetation changes from 1985 to 1997. The invasion of sugar maple (*Acer saccharum*), Japanese honeysuckle (*Lonicera japonica*), and exotic Asiatic bush honeysuckles (*Lonicera* spp.) continues to be a problem for the management of the upland hardwood forest and the park in general. Early successional habitats are increasing in diversity and basal area of woody species. In the absence of prescribed burning and presence of abundant deer and mesic understory shrubs and saplings, the persistence of oak and hickory is uncertain. If the park wishes to maintain the second growth upland hardwood forest and recreate it elsewhere intensive management will be required. Otherwise the forests will develop into mesophytic forests dominated by sugar maple, red maple (*Acer rubrum*), tulip tree (*Liriodendron tulipifera*) and other species.

INTRODUCTION

In the fall of 1983 Norman Henderson and I were invited to Lincoln Boyhood National Memorial (LIBO) to conduct a preliminary investigation of the forest vegetation. The purpose of the investigation was to provide information concerning condition of the forest vegetation, so that recommendations could be made concerning the management and restoration of the forest (Henderson and Pavlovic 1984). We set up and sampled three plots, and our results were summarized in Henderson and Pavlovic (1984). Subsequently, the superintendent, Norman Hellmers requested a more thorough and comprehensive vegetation survey. This project was funded in 1985 by the Midwest Regional Office and was conducted by Mark White and myself, and resulted in the report: "Forest restoration of Lincoln Boyhood National Memorial: presettlement, existing vegetation, and restoration management recommendations" (Pavlovic and White 1989).

Since then, resource management specialist Gia Wagner has resampled most of the plots in 1997 and several in 2003. Two additional plots were added in 2002 in preparation for prescribed burning in the upland hardwood forest surrounding the Cemetery Hill to the north. These two plots were not included in the analysis, since we lacked a complete dataset from 2002-2003. This report documents the changes in woody vegetation over the last 15 years, summarizes the structure of the vegetation management database, and recommends options for future forest restoration actions.

Study Objectives

- 1) Develop an Access database that will be used to input inventory and monitoring data.
- 2) Input data from three vegetation monitoring datasets. The datasets are currently in older databases and paper formats. The data are from the tree, shrub, and herb strata. Included are the soil data that were collected in 1985.
- 3). Locate, with a Global Positioning System, 48-50 permanent vegetation plots and input this data into the new Inventory and Monitoring Database.
- 4) Develop a vegetation-monitoring plan for the Memorial that utilizes the permanent vegetation plots.

METHODS

Vegetation Sampling

The vegetation sampling is discussed in Pavlovic and White (1989) and summarized here. A baseline transect was set up in 1985 along the north side of County Road (CR) B, which divides the "North Forty" from the southern 2/3 of the park. The east end was determined to be the imaginary intersection point between the north side of CR B and the line along the western ditch of the north-south running road. The width of the park along CR B was measured and divided into five equal portions, within which transect points were located using a random numbers table. Four transects were established. The north-south running transects were at 53, 123, 226, and 283 m west of the east end (Figure 1). Galvanized conduit stakes mark the transects on the north side of the road except for the transect at 226 m, which is staked on the south side of the road. Along the north part of the transects, plots were located randomly within 100 m units, which resulted in stratified random sampling. In the south 2/3 (south of CR B) of the transects, plots were randomly located in 150 m units since the vegetation pattern there was more uniform and less complex (Figure 1). One plot, in the bottomland forest remnant was subjectively located north and west of the site for the Lincoln cabin. Three plots were established in 1985 in an undisturbed Lincoln State Park (LSP) upland hardwood forest southwest of LIBO to serve as spatial disturbance controls. Only one of these LSP plots was sampled in 1997, so they are not compared in the temporal analysis.

A conduit stake marks the center of most plots. Plot 23 stake was lost during trail management in the late 1980's. In the 7.98 m radius circular plots, all trees and saplings >2.5 cm d.b.h. were tallied (Figure 2). The largest trees in the plot were cored to obtain minimum stand ages for the sites. Within a 5.64 m radius circular plot, all shrubs >1 m tall or <2.5 cm d.b.h. were tallied. A total of ten 1 X 0.5 m herbaceous plots were positioned to record the presence and frequency (from the 10 replicates) of the herbaceous species. Japanese honeysuckle (*Lonicera japonica*) and tree seedlings were included in this stratum. Finally soil samples were taken from each plot with a 2.54-cm-diameter

corer to a depth of 10 cm. A. & L. Agricultural Labs performed chemical analyses of the soils on a volume basis (Pavlovic and White 1989).

GPS Data

In 2001 and 2002, we visited LIBO to collect GPS data for all the sampling plots that were set up in 1985. We used a Trimble GeoExplorer 3 with external antenna and Beacon on a Box (BoB). Protected north slopes, high tree canopy, and poor satellite geometry all made collecting the position data difficult at times. In some instances, we had to hoist the external antenna and BoB up to the top of a 6.5 m staff. Some plots were not relocated because we could not find the conduit. Spatial data were recorded in the GeoExplorer (NAD83 16T) and were post processed on the fly when BoB was functioning or were post processed later in the office. The GPS data includes information about height of the antenna and usual accuracy information.

Database development

We developed an Excel spreadsheet to guide the development of the Access database. Each table was listed with its proposed fields, their types, and their links to other tables. As the database was developed, we made iterative modifications to the spreadsheet and database. The database incorporates some preliminary data calculations for analysis but does not incorporate complete analysis. For instance, basal areas of trees are calculated after tree diameters are entered and a query summarizes the herbaceous layer frequency by plot from the ten subplots. Data were entered from the original datasheets. In some instances, we modified the species determinations based on my (Pavlovic) knowledge of the vegetation and flora. We noted where we made changes to species identification by the use of a notes field in the Herbaceous, Shrub and Tree tables. All plot data from 1985, 1986, 1996, 1997, 2002, and 2003 are entered.

The Access database is relational, resulting in a variety of tables (see appendix for structure of tables). Central to this effort are the LocationID and EventID tables with standardized fields designated by the National Park Service. The system is flexible enough to allow the addition of other vegetation data types.

RESULTS:

The Vegetation of Lincoln Boyhood National Memorial

Pavlovic and White (1989) summarized the state of the vegetation of LIBO in 1985 (Figure 3). Then, we were concerned about the invasion of sugar maple into the understory of the upland hardwood forest and the general invasion of exotic non-indigenous plants. Here, we discuss the changes that have occurred in the tree and shrub layers since then, up to 1997, a twelve-year span. Some plots were further resampled in 2002 and 2003, but the coverage was incomplete, so these results are not analyzed, except in some unusual instances. The information on basal area and density was

collected at sites containing six different plant communities: Upland hardwood forest, upland successional forest, mixed maple/tuliptree forest, lowland successional forest, and razed former homesites and old fields. The bottomland hardwood forest was represented by one plot, consequently we did not examine the changes in the community. Elsewhere, the vegetation was divided into overstory trees (≥ 10 cm dbh) and understory layers (dbh < 10 cm). The general results of the overstory tree sampling followed a pattern of increased basal area, except in the upland hardwood forest and increased density except in the bottomland hardwood forest, mesic hardwood forest, mixed maple/tuliptree forest and upland successional forest (Table 1). In the understory basal area increased in the cedar glade, oldfields, razed homesites and upland hardwood forest and declined elsewhere. Understory density increased in the cedar glade, mesic hardwood forest, oldfields, razed homesites, and State Park upland hardwood forest.

The reliable ages of trees per habitat reveal approximately when stands were initiated (Table 2). The structurally complex upland hardwood forest was initiated in the 1870-80's, but one tree was born around 1838, about 20 years after the Lincolns arrived. Interestingly, the mixed maple/tulip tree forest dates on average from 1923, some years earlier than when the forest was presumably planted by the Civilian Conservation Corps. It is possible that this planting was done in 10 year old fields that included ten year old tree saplings. The mesic hardwood forest in the ravine on the west side of County Road A appears to have been cut over sometime in the 1910's and revegetated after then. The lowland successional forest appears to have been old field in the early to mid 1950's. The bottomland forest dominated by large pin oaks (*Quercus palustris*) appears to have grown up prior to 1940 based on a single unreliable core. The large size of the trees may be a result of the good growing conditions found in this low flatwoods.

Calculation of Sorenson's dissimilarity distance for aggregate density data by community for 1985 and 1997 revealed compositional similarity among communities and between sampling times (Table 3). The upland hardwood forest at LIBO was most similar to the upland hardwood forest at Lincoln State Park. Dissimilarity increased between the upland hardwood forest and the other communities as successional age decreased. Most dissimilar in woody composition were the old field - cedar glade and old field - hardwood forest (LIBO & LSP). Similar results were found for the aggregate basal area data. From 1985 to 1997 the community that experienced the most change was the old field, whereas the upland hardwood forest changed the least.

Overstory/Understory:

Upland Hardwood Forest – Cemetery Hill

The upland hardwood forest is the most mature stand at LIBO and it surrounds the cemetery where Abraham Lincoln's mother is believed to be buried. For the upland hardwood forest, the basal area for the overstory decreased, while the density increased (Table 4). The largest decrease in basal area is found in red oak (*Quercus rubra*), followed by black oak (*Quercus velutina*). Wind throw of canopy trees has occurred in the old growth forest since 1985, representing a complete loss of black oak in plot 31 and declines in density in plots 37 and 48. The increase in density was due, in part, by the influx of sassafras (*Sassafras albidum*). Although the basal area of sugar maple

decreased, there was an 18% increase in density in the overstory. In contrast, in the understory, sugar maple doubled in density, confirming that sugar maple is continuing to invade both layers of the canopy. In twelve years, the number of stems of sugar maple has more than doubled in the 2.5 to < 5 cm diameter class (Fig. 4), whereas there are small differences in size class frequency over all habitats (Fig. 5). The changes in basal area and density for hickories (*Carya* spp.) suggest there may be problems with identification. Nevertheless, for hickories overall, there is a decline in basal area and density.

The declines in understory density of redbud (*Cercis canadensis*), sassafras, and red elm (*Ulmus rubra*) density are partly explained by the growth of understory stems into the overstory over 12 years (Table 4). Dogwoods did not experience a decline but rather increased in basal area and density in the understory. The decrease in the density of old growth forest understory was due, in part, to the decrease in winged elm (*Ulmus alata*) density. Overall the understory is thinning.

Upland Successional Forest

These successional forests appear to represent succession on abandoned pastureland rather than tree planting by the Civilian Conservation Corps (CCC). The increasing basal area and decreasing overstory density indicate the trees are self thinning in this forest (Table 5). These stands are becoming more mature. The largest increase in basal area for upland successional forest came from red maple. Red maple almost tripled in density over 12 years. The decrease in density for the upland successional forest was a combination of three species with the largest absolute difference due to tulip tree (71.8 % decrease), followed by black cherry (*Prunus serotina*) (100% decrease), sassafras (50% decrease), and white pine (*Pinus strobus*) (100% decrease). The largest decrease in upland successional forest sub-canopy came from the total loss of two early successional species, red cedar (*Juniperus virginiana*) and sassafras.

Mixed Maple/Tuliptree Forest

The mixed maple/tulip tree forest stands are believed to be those that the CCC planted in the early 1930s. The mixed forest communities experienced an increase of basal area in the overstory (decrease in the understory) and decreasing densities overall (Table 6). White pine, sugar maple, and red maple had the greatest influence on the increased basal area for the mixed plant community. Numerous species showed modest declines in density, including green ash (*Fraxinus pennsylvanica*), black locust (*Robinia pseudo-acacia*), black walnut (*Juglans nigra*), and winged elm.

The density decrease in the understory was affected mostly by dogwood, and by the loss of sassafras (100% decrease), as well as green ash, red cedar, sweet gum (*Liquidambar styraciflua*), white pine, blue beech (*Carpinus caroliniana*), sassafras, and winged elm. Except for dogwood and blue beech most of these species are intolerant of shade, suggesting these early successional species are declining as a result of increased canopy cover and shade.

Lowland Successional Forest

The overstory in the lowland successional forest experienced an increase in both basal area and stem density whereas the converse was seen in the understory (Table 7). As relatively young successional areas, that lacked a mature canopy, the influx of trees to the area is to be expected. The increased basal area and number of trees in these areas are due to the colonization of a previously open canopy sites. Red maple contributed most to the increased overstory basal area and density for the lowland successional forest. There were three major contributors to the decrease of density between overstory and understory for low successional forest sub-canopy, these included red maple, sweet gum, and sassafras.

Mesic Hardwood Forest

Mesic hardwood forest occurs in the ravine system north of the Mission 66 houses (plots 17 and 18). This community is noted for its lack of sugar maple, rich vernal flora, and dominance of hickory and shingle oak (*Quercus imbricaria*). Overall basal area has increased in both the overstory and understory while density has declined in just the overstory (Table 8). The understory shows considerable turnover in species over 12 years.

Razed Homesites

Increases of both basal area and density were found in the razed homesites where open lawns are being replaced by young successional tree stands (Table 9). For the razed homesite, sweet gum and tuliptree (100% increase) had the largest increase in density, followed by red maple (81% increase). The razed homesites had the only sub-canopy that increased in density compared to the other communities. The area was originally an open canopy that incorporated conditions suitable for the colonization of the area by seedlings and saplings, which could allow for the eventual regeneration of forested lands. Red maple (94.5% increase) was the major tree species in the reclamation of this area by the tree community. There were also five species recorded that were not previously found for that site.

Old Fields

In 1985, the old fields were beginning to be invaded by trees (Table 10). By 1997, in the absence of fire, old fields became dominated by red cedar and sweetgum in the understory, with a dominance of dogwood and red maple in the overstory. Most of these old fields in the North 40 are now dominated by red maple in the overstory.

Shrub layer:

We noted that there were often greater densities of woody shrubs when sampled in 1997 compared to the 1985 and 2003 sampling. We suspect that all woody shrubs less than 2.5 cm dbh were counted, which caused such high totals. The definition of woody shrubs from the original study was stems > 1m tall and stems < 2.5 cm dbh. We reiterate below the variable definitions.

Trees: >2.5 cm dbh within 7.96 m radius plot (1/50 hectare)

Shrubs: > 1m tall and < 2.5 cm dbh in 5.64 m radius plot (1/100 hectare)

Herbs: all herbaceous species plus all woody species < 1m tall (tree seedlings and shrubs) in 1 by 0.5 m plots (N = 10). Future vegetation samplers should read and take note of the considerations that are important for repeated samplings of Midwestern forests (McCune and Menges 1986). For the reasons addressed here we do not discuss the quantitative changes in shrubs.

Upland Hardwood Forest

Shrub species richness increased from 1985 to 1997 (Table 11). Species that disappeared include box elder (*Acer negundo*), serviceberry (*Amelanchier* spp.), persimmon (*Diospyros virginiana*), and mock orange (*Philadelphus coronaries*). New species recorded were blue beech, hickory (*Carya glabra*), American ash (*Fraxinus americana*), tulip tree, white oak (*Quercus alba*), black oak, nannyberry (*Viburnum lentago*), Virginia creeper (*Parthenocissus quinquefolia*), and poison ivy (*Toxicodendron radicans*). Species that increased include redbud, dogwood, green ash, sassafras, spicebush (*Lindera benzoin*), and sugar maple. Black cherry was the only species to decline.

Upland Successional Forest

Shrubs that seem to have disappeared from the upland successional forest plots include hickory, privet (*Ligustrum vulgare*), and black cherry (Table 12). New species included spicebush, sweetgum, and sassafras. Sugar maple was the only species to increase, while dogwood and green ash declined.

Mixed Maple/Tuliptree Forest

New shrub species found in the mixed maple/tulip tree forests include several invasive exotic shrubs: privet, Asiatic bush honeysuckles (*Lonicera morowii*), black locust, and multiflora rose (*Rosa multiflora*) (Table 13). Native species that are invading include redbud, butternut (*Juglans cinerea*), pignut hickory (*Carya glabra*), American ash, black gum (*Nyssa sylvatica*), winged elm, American elm (*Ulmus americana*), and viburnum. We are not surprised that sugar maple is increasing, but probably not as much as implied by the numbers. Red maple, sugar maple, hornbeam, green ash, privet (*Ligustrum vulgare*), spicebush, black cherry, sassafras, bladderpod (*Staphylea trifoliata*), and red elm increased. Declining species included dogwood, red cedar, and tuliptree.

Lowland Successional Forest

The lowland successional forest shrubs increased in diversity over the 12 year interval (Table 14). New species include box elder, mockernut hickory (*Carya tomentosa*), pignut hickory, persimmon, American ash, spicebush, black gum, white oak, chestnut oak (*Quercus muehlenbergii*), black oak, rubus (*Rubus* spp.), willow (*Salix* spp.), poison ivy, and American elm. Hazel nut (*Corylus americana*), red oak, and nannyberry have disappeared from the sites. Species that increased in density include red maple, redbud, dogwood, green ash, tuliptree, sassafras, winged elm, and red elm. Density declined for sweet gum and black cherry.

Razed Homesites

In contrast of oldfields, razed homesite shrub density has increased not from the invasion of red maple, but from the invasion of many other species, including box elder, sugar maple, pignut hickory, persimmon, American ash, tulip tree, chokecherry (*Prunus virginiana*), red oak and winged elm (Table 15). Some of the species that have declined are early successional: staghorn sumac (*Rhus typhina*), black locust, and sassafras. American ash, green ash, and red maple are most dense. Green ash and red elm increased in density from 1985 to 1997.

Oldfields

In 1985, the old fields were open with a few scattered red cedars and other woody species. Today they are 3 to 5 m tall dense growth of predominantly red maple (Table 16). Red maple dominates because of abundant seed rain and because these old fields are low lying and have saturated soils in the spring. New species sampled in 1997 are mockernut hickory, pignut hickory, persimmon, tulip tree, sycamore (*Platanus occidentalis*), white oak, black oak, staghorn sumac, multiflora rose, sassafras, and American elm. Besides red maple, dogwood, red cedar, and sweet gum increased in density.

SUMMARY AND CONCLUSIONS

The Vegetation

The open and treeless communities at LIBO are undergoing succession to forest, whereas the forests are changing to a lesser degree. In 12 years the old fields have turned into a species rich and rank growth that is dominated by red maple. The shrub layers of most communities are becoming richer in species. Invasion by sugar maple and exotic Asiatic bush honeysuckles appear to be ongoing problems. As noted by Pavlovic and White (1989) Japanese honeysuckle continues to be a problem. Casual observation suggests this species is continuing to invade the mesic hardwood forest and may impact the rich vernal flora found there!

In the mid 1980's, former Superintendent Norman Hellmers envisioned the Lincoln Boyhood would someday be a mixture of cultural landscapes (allege, cemetery,

flag pole, visitor center, living history farm) and forest landscape. The forest landscape would be a mature forest something like that present in 1816. Thus the visitor could experience the features that focus on the boyhood home and pioneer life that Abraham Lincoln experienced, plus the forest primeval where his family struggled to make a living.

Pavlovic and White identified sugar maple invasion as being an impediment to forest restoration because maples would replace the oaks and hickories. This invasion of more mesic and shade-tolerant species is widespread and not limited to LIBO (Barton and Schmelz 1987; Shotola, Weaver et al. 1992). The results presented here show that advanced regeneration of oak is present but at low densities throughout the plant communities. Thus, restoration will require the introduction of oaks and the creation of conditions favorable to their survival.

The moderate declines in dogwood in the upland successional forest and mixed maple/tuliptree forest is probably not indicative of dogwood anthracnose, but resource management should be aware of this devastating disease (Dudt and Shure 1993; Hiers and Evans 1997).

Pavlovic and White (1989) recommended the introduction to fire, the removal of sugar maple, and the creation of canopy gaps to encourage oak and hickory regeneration if park management wanted to create something similar to the oak-hickory presettlement vegetation. These recommendations can now be modified based on more recent research (Loftis and McGee 1993). The problems of oak regeneration are multifactorial, but several key considerations are important (Lorimer 1992). Research has shown that oaks are slow-growing and lack the plasticity to increase growth when the environment changes in their favor (Hodges and Gardiner 1992). Oaks are most competitive at the driest sites. The presence of fire, large openings, and suppression of understory shade all favor the regeneration of oak (Sander and Graney 1992). Encouraging oaks is best done in sites where advanced regeneration exists but advanced reproduction is generally most prevalent on the driest sites. Creating canopy openings alone will not create oak regeneration, because much of the LIBO forests lack oaks in the understory, especially in the Mixed Maple/Tulip tree forests. Consensus is that the understory wherever oaks are being encouraged must be suppressed so that there is sufficient light and no competition from faster growing species. When advanced regeneration is lacking, the shelterwood method is employed, where 40-60% of the overstory is removed (perhaps in LIBO's case all), and the understory is cleared prior to a good mast year if oaks are nearby, otherwise oaks will have to be introduced. Ten years of understory clearing may be required for oaks to reach a sufficient size to allow them to eventually attain canopy size. Species such as tuliptree and maple which produce copious seed, will be a problem for regenerating oaks at LIBO. Planned prescribed fires may open the understory to aid in oak regeneration, but only monitoring data can show if this is correct.

Former Resource Management Specialist Don Adams initiated oak tree planting in the old field of the North 40 (Adams 1996). These efforts were stymied by intense grazing pressure from deer (*Odocoileus virginiana*) and rank growth of red maple. Prescribed burning would have alleviated the latter problem, but without reduction of the deer herd in the park and adjacent lands, the restoration of oak and hickory is unlikely, given the repeated browsing by deer.

Whether or not the park proceeds with oak-hickory restoration is a management decision. Whether or not oaks regeneration is encouraged, the park staff could continue to encourage the spring ephemeral flora at LIBO. Most communities, except the mixed hardwood forest, were depauperate in spring ephemeral herbs (Pavlovic and White 1989). Irrespective of the ultimate forest canopy composition, the spring ephemeral flora may persist once established as long as exotic invaders such as garlic mustard (*Alliaria petiolata*) are kept at bay.

Vegetation Monitoring Plan

The vegetation plots serve multiple purposes. They provide a benchmark for the evaluation of the successional trajectory of the vegetation. They provide a means for assessing fire effects on the vegetation, once prescribed burning is instituted. Fire has been recommended to promote the reproduction of oak and hickory and exclude the invasion of sugar maple and other mesophytic species. The fire management plan recommends prescribed burning to reduce fuel loads, reintroduce fire as an important ecological process, control the growth of exotic plant species, promote wildlife habitat and encourage the reproduction of oak and hickory species. In 2002, Amy Davies and Robin Keith resampled several plots on the Cemetery Hill and also added two new plots to increase the sample size for fire effects monitoring. We envision two scales of sampling: 1) in the absence of burning, plots should be sampled every 10 or 20 years and 2) in congruence with the Fire Effects Monitoring Plan, they should be sampled prior and 1, 2, 3, 5, and 10 years after the prescribed burn. A shorter time frame will cost more money but will provide rapid assessments of change. A longer interval will cost less, but will not allow a timely feedback between management actions and vegetation responses. Some plots will need to be sampled more frequently as prescribed fire is used as a management tools.

Tracking individual trees and their mortality would be improved by tagging individual trees. Such a procedure near trails can detract from the visitor experience. We recommend at least that plots away from trails have permanent tags installed. Less obtrusive methods of tagging might be investigated for those plots near trails. The disadvantage of tags on stems is that, if the stem is top killed and the tree resprouts, it can no longer be identified since the tag is no longer associated with a living stem. Recording direction and azimuth for each tree can alleviate this problem.

Prudent modification of the shrub layer sampling might provide an index of the severity of deer browse. One possibility would be to quantify the browsed and unbrowsed twigs (>1 cm in length) of last year's growth that has been browsed from a height of 0 to 1.25 m within the shrub subplot (Strole and Anderson 1992). This sampling would be done in March to mid-April prior to new growth when browse on last year's twigs could be detected. Strole and Anderson (1992) found that deer preferred white oak and shagbark hickory and browsed less than expected on sugar maple.

In entering the vegetation data, we found many instances of plants being identified to genus only or listed only by their common name. This means that the identity of the taxa was in doubt. In the database, we added a note field to record what was written on the data sheet as well as what we thought the species should be. We did not attempt to analyze the herbaceous data because of these difficulties. This problem

can be alleviated, not eliminated, by having herbaceous sampling done by botanists or resource management personnel that know the flora, including grasses and sedges.

Specific groups where we found problems include:

Carya spp., the hickories; number of leaflets, bud color, terminal leaf shape and bark type are all relevant characters that need to be examined to determine the species.

Fraxinus spp., American and green ash can be best identified based on the shape of the leaf scar. Bark color can also be used. Distinguishing this from persimmon when only examining the bark may be a problem.

Viburnum spp., we originally only recorded *V. prunifolium* from LIBO but subsequent samplers found *V. dentatum* and *V. lentago*. These are difficult species to identify.

Grasses and sedges: vegetative identification is difficult even with spikelets but can be accomplished when knowing the jargon and having the relevant references. Immature plants of all species.

I (Pavlovic) suspect that I misidentified a trailing euonymus in the herbaceous layer as the native *Euonymus americanus* rather than *E. fortunei*, an invasive exotic. This should be investigated by park staff. It might be a good species to target for the Exotic Plant Management Teams if this exotic species is present.

For tree identification, we recommend Edward A Cope's revision of "Muenscher's Keys to Woody Plants." The absence of a contemporary regional flora makes the plant identification difficult. Two indispensable sources are Gleason and Cronquist (1991) and Deam (1940). Useful in the field are Newcomb (1977), Peterson (1968), and Yakuskiyevych (2000). For those diligent and intrepid enough, the keys to identification of grasses are very helpful: (Looman 1982; Weishaupt 1985). For identification of orchids, Homoya (1993) is indispensable. We encourage the active use of the LIBO herbarium and the plant list when conducting vegetation sampling.

We have developed a procedure for documenting unknowns. When we have unknowns we collect a sample of a portion of the plant either from the plot or an individual outside the plot. We attach a piece of white tape to the specimen and label it with the date, the unique unknown number, and the sample plot number and subplot number if possible. We take the specimens, press them, and later attempt to make identifications. This information about each unknown is entered into the database for cross-reference and documentation.

The Access database will greatly aid the park in monitoring and managing the vegetation of the Lincoln Boyhood National Memorial. We encourage the park to continue to restore the understory spring ephemeral flora while managing the overstory. We hope that the maturing forest will become an inspiration to the park visitor whether or not a particular community develops.

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Table 1. Summary by year of overstory (O) and understory (U) of basal area and density of live trees by plant community at Lincoln Boyhood National Memorial.

Plant Community	Strata	Basal Area (m ² /ha)			Density (Stems/ha)		
		1985	1997	Change	1985	1997	Change
Bottomland Hardwood	O	60.7	69.0	+	550	500	-
	U	1.1	0.4	-	250	150	-
Cedar Glade	O	0.0	5.1	+	0	200	+
	U	0.3	4.1	+	200	1400	+
Lowland Successional	O	15.7±3.7	32.8±7	+	506±85	671±73	+
	U	3.3±0.3	2.2±0.4	-	1206±124	757±128	-
Mesic Hardwood Forest	O	26.1±7.2	34.9±11.4	+	450±0	400±50	-
	U	1.4±0.1	2±0.2	-	600±100	825±25	+
Mixed maple/tuliptree	O	25.7±2.9	35.5±4.9	+	417±35	375±37	-
	U	1.1±0.3	1±0.2	-	423±98	336±81	-
Oldfield	O	0±0	0.9±0.4	+	0±0	50±0	+
	U	0±0	2.1±1.4	+	17±17	1283±710	+
Razed Homesite	O	1.8±1.6	10.8±2	+	40±19	480±90	+
	U	0.6±0.5	2.7±0.7	+	400±254	1010±293	+
State Park Hardwood	O	36.5±11.2	40.8	+	250±29	450	+
	U	1.4±0.5	1.2	-	600±87	750	+
Upland Hardwood	O	39.4±6.5	36.9±8	-	239±33	267±26	+
	U	1.6±0.3	2.1±0.5	+	650±145	572±120	-
Upland Successional	O	32.7±10.5	37.5±13.6	+	550±76	417±60	-
	U	1.8±0.3	1.3±0.3	-	767±209	583±283	-

Table 2. Reliable and unreliable tree ages by habitat for trees of Lincoln Boyhood National Memorial

Habitat	Age Accuracy ¹	N	Mean	Range	Max.	Oldest Stand Year	Mean Stand Year
Bottomland forest	Unreliable	1	45	0	45	1940	1940
Lowland successional forest	Combined	9	27±3	23	40	1945	1958
	Reliable	2	30±1	1	31	1954	1955
	Unreliable	7	26±4	23	40	1945	1959
Mesic hardwood forest	Combined	4	57±5	22	70	1915	1928
	Reliable	2	61±9	18	70	1915	1924
	Unreliable	2	52±4	9	57	1928	1932
Mixed maple/tulip tree forest	Combined	12	54±2	22	65	1920	1931
	Reliable	3	62±1	3	63	1922	1923
	Unreliable	9	51±2	22	65	1920	1934
Upland Hardwood Forest	Combined	13	97±8	98	147	1838	1888
	Reliable	2	104±42	85	147	1838	1880
	Unreliable	11	96±7	98	147	1838	1889
Upland Successional Forest	Unreliable	2	42±12	25	55	1930	1942

¹unreliable ages are the result of rotten tree centers or failure of the increment core to extend through the tree center.

Table 3. Sorenson dissimilarity among communities in 1985 (upper) and between 1985 and 1997 (lower) at Lincoln Boyhood National Memorial. Diagonal elements in lower subtable are comparisons in time. Capital letters above columns are the first letters of the community names given in the left column.

	1985	BH	CG	LS	MH	MMT	OF	UH	RH	SPH
Bottomland Hardwood										
Cedar Glade		0.83								
Lowland Successional		0.79	0.74							
Mesic Hardwood		0.70	0.78	0.61						
Mixed Maple/Tuliptree		0.87	0.77	0.53	0.64					
Old Field		0.90	1.00	0.93	0.96	0.93				
Upland Hardwood		0.89	0.85	0.64	0.74	0.60	1.00			
Razed Homesites		0.67	0.75	0.73	0.78	0.81	0.83	0.86		
State Park Hardwood		0.91	0.76	0.66	0.63	0.68	1.00	0.38	0.90	
Upland Successional		0.91	0.87	0.56	0.61	0.48	0.93	0.66	0.88	0.70

	1985									
1997	BH	CG	LS	MH	MMT	OF	UH	RH	SPH	US
Bottomland Hardwood	0.29	0.89	0.86	0.78	0.93	1.00	0.92	0.74	0.96	0.97
Cedar Glade	0.85	0.78	0.50	0.55	0.65	0.94	0.80	0.78	0.71	0.57
Lowland Successional	0.79	0.72	0.39	0.71	0.59	0.88	0.58	0.70	0.67	0.64
Mesic Hardwood	0.85	0.90	0.72	0.33	0.67	1.00	0.54	0.83	0.49	0.57
Mixed Maple/Tuliptree	0.90	0.77	0.59	0.69	0.19	0.96	0.59	0.85	0.67	0.58
Old Field	0.90	0.87	0.44	0.65	0.63	0.93	0.78	0.82	0.74	0.52
Upland Hardwood	0.93	0.90	0.65	0.72	0.52	1.00	0.17	0.90	0.38	0.66
Razed Homesites	0.74	0.77	0.48	0.76	0.75	0.92	0.86	0.54	0.85	0.75
State Park Hardwood	0.86	0.93	0.80	0.72	0.86	1.00	0.56	0.86	0.41	0.85
Upland Successional	0.84	0.78	0.51	0.68	0.44	0.87	0.55	0.78	0.63	0.45

Table 4. Summary of changes in basal area and density of overstory (O) and understory (U) layers in the upland hardwood forest. Basal area for the understory is expressed as dm²/ha. All values are mean ± standard errors.

Strata	Species	Basal area (m ² /Ha:dm ² /Ha)			Density (#/Ha)		
		1985	1997	Change	1985	1997	Change
O	<i>Acer saccharum</i>	1.5±0.9	1.2±0.7	-	28±12	33±12	+
U		0.5±0.2	1.4±0.4	+	39±14	78±27	+
O	<i>Carya alba</i>	0.6±0.6	-	-	6±6	-	-
O	<i>Carya cordiformis</i>	0.9±0.6	0.5±0.5	-	11±7	6±6	-
O	<i>Carya glabra</i>	1±1	-	-	11±11	-	-
O	<i>Carya ovalis</i>	-	1.5±1.2	+	-	17±12	+
O	<i>Cercis canadensis</i>	0.3±0.1	0.5±0.2	+	28±12	39±16	+
U		4.6±1.5	5.2±1.9	+	200±68	172±46	-
O	<i>Cornus florida</i>	-	0.1±0.1	+	-	11±7	+
U		3.5±1.9	6.6±2.3	+	139±42	178±51	+
O	<i>Fraxinus pennsylvanica</i>	0.1±0.1	-	-	6±6	-	-
U		0.8±0.4	-	-	17±8	-	-
O	<i>Juglans nigra</i>	1.6±1.1	0.7±0.7	-	11±7	6±6	-
O	<i>Juniperus virginiana</i>	-	1.1±1.1	+	-	11±7	+
U		0.5±0.5	-	-	11±11	-	-
U	<i>Morus rubra</i>	0.8±0.5	-	-	11±7	-	-
U	<i>Prunus serotina</i>	-	-	-	6±6	-	-
O	<i>Quercus alba</i>	6.2±3.5	7.4±4.2	+	39±20	39±20	=
O	<i>Quercus muehlenbergii</i>	1.1±1.1	0.7±0.7	-	6±6	6±6	=
O	<i>Quercus rubra</i>	5.5±3.7	3.1±3.1	-	11±7	6±6	-
O	<i>Quercus velutina</i>	20.5±5.6	18.7±6.5	-	67±14	44±10	-
O	<i>Sassafras albidum</i>	0.1±0.1	0.4±0.3	+	6±6	28±22	+
U		2±2	0.3±0.3	-	39±39	6±6	-
U	<i>Ulmus alata</i>	2.7±2.1	3.3±2.9	+	189±159	139±127	-
O	<i>Ulmus americana</i>	-	0.1±0.1	+	-	6±6	+
O	<i>Ulmus rubra</i>	0.2±0.1	0.8±0.7	+	11±7	17±8	+
U		0.6±0.3	3.9±2.9	+	39±22	28±15	-
	Overstory Total	39.4±6.5	36.9±8	-	239±33	267±26	+
	Understory Total	1.6±0.3	2.1±0.5	+	650±145	572±120	-

Table 5. Changes in basal area and density of overstory (O) and understory (U) in the upland successional forest. All values are mean $\pm$ standard errors. Basal area for the understory is expressed as dm²/ha.

Strata	Species	Basal area (m ² /Ha:dm ² /Ha)			Density (#/Ha)		
		1985	1997	Change	1985	1997	Change
O	<i>Acer rubrum</i>	5.7 $\pm$ 5.7	10.7 $\pm$ 10.7	+	33 $\pm$ 33	83 $\pm$ 83	+
U		-	0.8 $\pm$ 0.8	+	-	33 $\pm$ 33	+
O	<i>Acer saccharum</i>	1 $\pm$ 0.7	0.3 $\pm$ 0.3	-	33 $\pm$ 17	17 $\pm$ 17	-
U		0.3 $\pm$ 0.3	-	-	17 $\pm$ 17	-	-
U	<i>Carya cordiformis</i>	-	0.1 $\pm$ 0.1	+	-	17 $\pm$ 17	+
U	<i>Carya glabra</i>	0.9 $\pm$ 0.9	1.1 $\pm$ 1.1	+	17 $\pm$ 17	17 $\pm$ 17	=
O	<i>Cornus florida</i>	1 $\pm$ 0.7	0.8 $\pm$ 0.6	-	50 $\pm$ 29	83 $\pm$ 60	+
U		10.4 $\pm$ 4.2	9.6 $\pm$ 3.5	-	500 $\pm$ 202	467 $\pm$ 267	-
O	<i>Fraxinus americana</i>	-	1.7 $\pm$ 1.7	+	-	17 $\pm$ 17	+
	<i>Fraxinus</i>						
O	<i>pennsylvanica</i>	1.1 $\pm$ 1.1	-	-	17 $\pm$ 17	-	-
O	<i>Juglans nigra</i>	-	1.2 $\pm$ 1.2	+	-	17 $\pm$ 17	+
U	<i>Juniperus virginiana</i>	2.3 $\pm$ 2.3	-	-	133 $\pm$ 133	-	-
	<i>Liquidambar</i>						
O	<i>styraciflua</i>	4.4 $\pm$ 2.2	4.6 $\pm$ 2.4	+	83 $\pm$ 44	67 $\pm$ 33	-
	<i>Liriodendron</i>						
O	<i>tulipifera</i>	12 $\pm$ 12	14.1 $\pm$ 14.1	+	117 $\pm$ 117	33 $\pm$ 33	-
O	<i>Pinus strobus</i>	0.1 $\pm$ 0.1	-	-	17 $\pm$ 17	-	-
O	<i>Prunus serotina</i>	3 $\pm$ 3	-	-	50 $\pm$ 50	-	-
U	<i>Quercus alba</i>	0.2 $\pm$ 0.2	0.5 $\pm$ 0.5	+	33 $\pm$ 33	33 $\pm$ 33	=
O	<i>Quercus velutina</i>	0.5 $\pm$ 0.5	0.8 $\pm$ 0.8	+	17 $\pm$ 17	17 $\pm$ 17	=
O	<i>Sassafras albidum</i>	2.6 $\pm$ 1.5	1.9 $\pm$ 1	-	100 $\pm$ 76	50 $\pm$ 29	-
U		3.2 $\pm$ 1.9	-	-	50 $\pm$ 29	-	-
O	<i>Ulmus alata</i>	0.3 $\pm$ 0.3	0.3 $\pm$ 0.3	=	17 $\pm$ 17	17 $\pm$ 17	=
U		1.1 $\pm$ 1.1	1.1 $\pm$ 1.1	=	17 $\pm$ 17	17 $\pm$ 17	=
O	<i>Ulmus americana</i>	1 $\pm$ 1	1.2 $\pm$ 1.2	+	17 $\pm$ 17	17 $\pm$ 17	=
	Overstory Total	32.7 $\pm$ 10.5	37.5 $\pm$ 13.6	+	550 $\pm$ 76	417 $\pm$ 60	-
	Understory Total	1.8 $\pm$ 0.3	1.3 $\pm$ 0.3	-	767 $\pm$ 209	583 $\pm$ 283	-

Table 6. Summary of changes in basal area and density by overstory (O) and understory (U) layer for the mixed maple/tulip tree forest stands at LIBO. All values are mean $\pm$ standard errors. Basal area for the understory is expressed as dm²/ha.

Strata Species		Basal area (m ² /Ha:dm ² /Ha)			Density (#/Ha)		
		1985	1997	Change	1985	1997	Change
O	<i>Acer rubrum</i>	3.2 $\pm$ 2	4.1 $\pm$ 2.4	+	40 $\pm$ 21	43 $\pm$ 23	+
U		0.2 $\pm$ 0.1	0.1 $\pm$ 0.1	-	7 $\pm$ 5	4 $\pm$ 4	-
O	<i>Acer saccharum</i>	8.1 $\pm$ 1.9	11.4 $\pm$ 3.2	+	147 $\pm$ 38	164 $\pm$ 41	+
U		0.8 $\pm$ 0.4	2.2 $\pm$ 1.5	+	20 $\pm$ 8	82 $\pm$ 53	+
U	<i>Betula nigra</i>	0.3 $\pm$ 0.3	-	-	3 $\pm$ 3	-	-
O	<i>Carpinus caroliniana</i>	0.2 $\pm$ 0.2	0.3 $\pm$ 0.3	+	10 $\pm$ 10	4 $\pm$ 4	-
U		0.5 $\pm$ 0.5	-	-	10 $\pm$ 10	-	-
O	<i>Carya glabra</i>	0.3 $\pm$ 0.3	0.8 $\pm$ 0.6	+	3 $\pm$ 3	11 $\pm$ 8	+
U		-	0.7 $\pm$ 0.7	+	-	14 $\pm$ 14	+
O	<i>Carya ovalis</i>	-	0.5 $\pm$ 0.5	+	-	4 $\pm$ 4	+
U		0.5 $\pm$ 0.5	-	-	13 $\pm$ 13	-	-
			<0.1 $\pm$ <0				
U	<i>Cercis canadensis</i>	0.1 $\pm$ 0.1	.1	-	3 $\pm$ 3	4 $\pm$ 4	+
O	<i>Cornus florida</i>	0.2 $\pm$ 0.1	0.2 $\pm$ 0.1	=	20 $\pm$ 10	14 $\pm$ 8	-
U		5.8 $\pm$ 1.6	5.6 $\pm$ 1.8	-	250 $\pm$ 67	200 $\pm$ 59	-
O	<i>Fraxinus americana</i>	0.5 $\pm$ 0.4	0.2 $\pm$ 0.2	-	10 $\pm$ 7	4 $\pm$ 4	-
O	<i>Fraxinus pennsylvanica</i>	0.9 $\pm$ 0.5	1.2 $\pm$ 0.8	+	30 $\pm$ 15	14 $\pm$ 8	-
U		<0.1 $\pm$ <0.1	-	-	3 $\pm$ 3	-	-
O	<i>Juglans nigra</i>	0.1 $\pm$ 0.1	-	-	3 $\pm$ 3	-	-
O	<i>Juniperus virginiana</i>	0.4 $\pm$ 0.2	0.1 $\pm$ 0.1	-	13 $\pm$ 8	7 $\pm$ 7	-
U		0.3 $\pm$ 0.2	-	-	13 $\pm$ 8	-	-
			<0.1 $\pm$ <0				
U	<i>Ligustrum vulgare</i>	0.2 $\pm$ 0.2	.1	-	17 $\pm$ 17	4 $\pm$ 4	-
O	<i>Liquidambar styraciflua</i>	1.1 $\pm$ 0.7	0.9 $\pm$ 0.7	-	20 $\pm$ 14	14 $\pm$ 11	-
U		0.4 $\pm$ 0.3	-	-	13 $\pm$ 8	-	-
O	<i>Liriodendron tulipifera</i>	6.2 $\pm$ 2.9	7.6 $\pm$ 4.4	+	30 $\pm$ 12	21 $\pm$ 13	-
			<0.1 $\pm$ <0				
U		0.3 $\pm$ 0.2	.1	-	10 $\pm$ 5	4 $\pm$ 4	-
O	<i>Morus rubra</i>	-	0.2 $\pm$ 0.2	+	-	11 $\pm$ 11	+
			<0.1 $\pm$ <0				
U		-	.1	-	-	4 $\pm$ 4	+
O	<i>Nyssa sylvatica</i>	0.2 $\pm$ 0.1	0.1 $\pm$ 0.1	-	7 $\pm$ 5	4 $\pm$ 4	-
			<0.1 $\pm$ <0				
U		0.2 $\pm$ 0.2	.1	-	7 $\pm$ 5	4 $\pm$ 4	-
U	<i>Ostrya virginiana</i>	0.1 $\pm$ 0.1	-	-	3 $\pm$ 3	-	-
O	<i>Pinus strobus</i>	1 $\pm$ 1	4.3 $\pm$ 4.3	+	7 $\pm$ 7	7 $\pm$ 7	=
U		0.1 $\pm$ 0.1	-	-	7 $\pm$ 5	-	-

Table 6. Continued

Strata Species		Basal area (m ² /Ha:dm ² /Ha)		Change	Density (#/Ha)		
		1985	1997		1985	1997	Change
O	<i>Prunus serotina</i>	1.2±0.8	1.4±0.9 <0.1±<0	+	20±17	18±14	-
U	<i>Quercus alba</i>	<0.1±<0.1	.1	=	3±3	4±4	+
O	<i>Quercus rubra</i>	0.6±0.6	1.2±1.2	+	10±7	11±8	+
O	<i>Robinia pseudo-acacia</i>	0.7±0.4	-	-	17±9	-	-
O	<i>Sassafras albidum</i>	0.7±0.6	0.7±0.7	=	23±18	18±14	-
U		0.7±0.4	-	-	30±17	-	-
O	<i>Ulmus alata</i>	0.1±0.1	-	-	3±3	-	-
U		0.4±0.4	-	-	7±7	-	-
U	<i>Ulmus americana</i>	-	0.5±0.5	+	-	11±11	+
O	<i>Ulmus rubra</i>	0.1±0.1	0.3±0.2	+	3±3	7±5	+
U		0.1±0.1	0.1±0.1	=	7±7	4±4	-
U	<i>Viburnum prunifolium</i>	<0.1±<0.1	<0.1±<0.1	=	3±3	4±4	+
	Overstory Total	25.7±2.9	35.5±4.9	+	417±35	375±37	-
	Understory Total	1.1±0.3	1±0.2	-	423±98	336±81	-

Table 7. Summary of changes in basal area and density by overstory (O) and understory (U) for the lowland successional forest at LIBO. Basal area for the understory is expressed as dm²/ha.

Strata Species		Basal area (m ² /Ha:dm ² /Ha)			Density (#/Ha)		
		1985	1997	Change	1985	1997	Change
O	<i>Acer rubrum</i>	3.8±2.2	11.9±5.9	+	125±50	229±74	+
U		11.1±4.5	8.8±3.2	-	450±198	343±132	-
O	<i>Acer saccharum</i>	0.2±0.2	0.6±0.6	+	13±8	14±14	+
U		0.5±0.4	0.7±0.7	+	38±31	14±14	-
U	<i>Carya alba</i>	-	0.3±0.3	+	-	7±7	+
O	<i>Cercis canadensis</i>	-	0.3±0.3	+	-	21±21	+
U		0.6±0.4	0.1±0.1	-	31±21	14±14	-
O	<i>Cornus florida</i>	0.1±0.1	0.8±0.6	+	6±6	21±10	+
U		5.5±2.5	7±5	+	219±103	250±180	+
O	<i>Diospyros virginiana</i>	0.6±0.6	1.1±1.1	+	31±31	43±43	+
U		-	0.2±0.2	+	-	7±7	+
O	<i>Fraxinus americana</i>	-	2±2	+	-	14±14	+
O	<i>Fraxinus pennsylvanica</i>	2.1±1.2	2±1.5	-	56±37	36±28	-
U		0.8±0.4	0.2±0.2	-	44±15	14±9	-
O	<i>Juglans cinerea</i>	0.1±0.1	-	-	6±6	-	-
O	<i>Juglans nigra</i>	-	0.5±0.5	+	-	14±14	+
U	<i>Juniperus virginiana</i>	0.9±0.5	0.7±0.5	-	31±16	14±9	-
O	<i>Liquidambar styraciflua</i>	4.7±3.4	6.8±4.3	+	131±74	121±60	-
U		5.2±2.6	1.8±1.2	-	150±82	50±36	-
O	<i>Liriodendron tulipifera</i>	0.4±0.4	0.9±0.6	+	13±13	36±24	+
U		0.2±0.2	0.1±0.1	-	6±6	7±7	+
U	<i>Morus alba</i>	0.3±0.3	-	-	6±6	-	-
O	<i>Nyssa sylvatica</i>	0.2±0.2	0.4±0.4	+	13±8	7±7	-
U		0.7±0.5	0.5±0.5	-	19±13	7±7	-
O	<i>Platanus occidentalis</i>	0.7±0.7	3±2	+	13±13	21±15	+
U		0.3±0.2	-	-	13±8	-	-
O	<i>Prunus serotina</i>	1±0.6	1.1±0.8	+	31±21	29±21	-
U		0.2±0.2	0.1±0.1	-	6±6	14±9	+
U	<i>Rhus copallina</i>	0.6±0.4	-	-	25±13	-	-
U	<i>Rhus hirta</i>	0.1±0.1	-	-	19±19	-	-
O	<i>Robinia pseudo-acacia</i>	0.9±0.9	0.2±0.2	-	25±25	14±14	-
U		0.3±0.3	-	-	13±13	-	-
O	<i>Sassafras albidum</i>	0.1±0.1	-	-	6±6	-	-
U		2.6±2.1	0.2±0.2	-	106±92	7±7	-
O	<i>Ulmus alata</i>	-	0.1±0.1	+	-	7±7	+
U		1±0.8	-	-	19±13	-	-
O	<i>Ulmus americana</i>	-	0.2±0.2	+	-	14±14	+
U		-	0.5±0.5	+	-	7±7	+

Table 7. Continued

Strata Species		Basal area (m ² /Ha:dm ² /Ha)			Density (#/Ha)		
		1985	1997	Change	1985	1997	Change
O	<i>Ulmus rubra</i>	0.9±0.5	1±0.5	+	38±16	29±15	-
			0.7±0.				
U		1.7±0.9	5	-	56±32	29±21	-
U	<i>Vitis riparia</i>	0.3±0.3	-	-	13±13	-	-
	Overstory Total	15.7±3.7	32.8±7	+	506±85	671±73	+
	Understory Total	3.3±0.3	2.2±0.4	-	1206±124	757±128	-

Table 8. Summary of changes in basal area and density of overstory (O) and understory (U) stems for the mesic hardwood forest at LIBO. All values are mean $\pm$ standard errors. Basal area for the understory is expressed as dm²/ha.

Strata Species		Basal area (m ² /Ha:dm ² /Ha)			Density (Ha)		
		1985 ~ $\pm$ SE	1997 ~ $\pm$ SE	Change	1985 ~ $\pm$ SE	1997 ~ $\pm$ SE	Change
U	<i>Carya cordiformis</i>	0.3 $\pm$ 0.3	0.4 $\pm$ 0.4	+	50 $\pm$ 50	50 $\pm$ 50	=
O	<i>Carya glabra</i>	1.4 $\pm$ 1	1.7 $\pm$ 0.5	+	100 $\pm$ 50	75 $\pm$ 25	-
U		0.5 $\pm$ 0.5	0.2 $\pm$ 0.2	-	25 $\pm$ 25	25 $\pm$ 25	=
O	<i>Carya ovalis</i>	6.3 $\pm$ 6.3	14.6 $\pm$ 10.9	+	100 $\pm$ 100	200 $\pm$ 50	+
U		-	1.1 $\pm$ 1.1	+	-	25 $\pm$ 25	+
U	<i>Cercis canadensis</i>	-	2.3 $\pm$ 1.5	+	-	200 $\pm$ 100	+
U	<i>Cornus florida</i>	7.3 $\pm$ 6.1	11.5 $\pm$ 5	+	400 $\pm$ 300	475 $\pm$ 175	+
O	<i>Diospyros virginiana</i>	0.6 $\pm$ 0.6	-	-	25 $\pm$ 25	-	-
U		0.9 $\pm$ 0.9	-	-	25 $\pm$ 25	-	-
O	<i>Fraxinus americana</i>	-	4 $\pm$ 4	+	-	25 $\pm$ 25	+
O	<i>Fraxinus pennsylvanica</i>	10.6 $\pm$ 9.9	5.8 $\pm$ 5.8	-	125 $\pm$ 75	25 $\pm$ 25	-
U		0.3 $\pm$ 0.3	-	-	25 $\pm$ 25	-	-
U	<i>Juglans nigra</i>	1.4 $\pm$ 1.4	-	-	25 $\pm$ 25	-	-
U	<i>Liquidambar styraciflua</i>	0.1 $\pm$ 0.1	-	-	25 $\pm$ 25	-	-
O	<i>Prunus serotina</i>	1.1 $\pm$ 1.1	1.2 $\pm$ 1.2	+	25 $\pm$ 25	25 $\pm$ 25	=
U	<i>Quercus alba</i>	-	0.1 $\pm$ 0.1	+	-	25 $\pm$ 25	+
O	<i>Quercus imbricaria</i>	4.6 $\pm$ 4.6	6.2 $\pm$ 6.2	+	25 $\pm$ 25	25 $\pm$ 25	=
U	<i>Quercus rubra</i>	-	1.7 $\pm$ 1.7	+	-	25 $\pm$ 25	+
O	<i>Ulmus rubra</i>	1.6 $\pm$ 1.6	1.4 $\pm$ 1.4	-	50 $\pm$ 50	25 $\pm$ 25	-
U		2.5 $\pm$ 2.5	2.5 $\pm$ 2.5	=	100 $\pm$ 100	75 $\pm$ 75	-
U	<i>Vitis riparia</i>	0.9 $\pm$ 0.9	-	-	25 $\pm$ 25	-	-
Overstory Total		26.1 $\pm$ 7.2	34.9 $\pm$ 11.4	+	450 $\pm$ 0	400 $\pm$ 50	-
Understory Total		1.4 $\pm$ 0.1	2 $\pm$ 0.2	-	600 $\pm$ 100	825 $\pm$ 25	+

Table 9. Summary of changes in basal area and density of overstory (O) and understory (U) stems at razed homesites at LIBO. All values are mean $\pm$ standard errors. Basal area for the understory is expressed as dm²/ha.

Strata	Species	Basal area (m ² /Ha:dm ² /Ha)			Density (#/Ha)		
		1985	1997	Change	1985	1997	Change
O	<i>Acer negundo</i>	-	0.7 $\pm$ 0.4	+	-	30 $\pm$ 20	+
U		1.3 $\pm$ 1.2	0.5 $\pm$ 0.3	-	80 $\pm$ 68	40 $\pm$ 29	-
O	<i>Acer rubrum</i>	1.6 $\pm$ 1.6	3.6 $\pm$ 2.5	+	20 $\pm$ 20	110 $\pm$ 58	+
U		0.2 $\pm$ 0.2	11 $\pm$ 7.2	+	30 $\pm$ 20	550 $\pm$ 301	+
U	<i>Inus incana</i>	0.1 $\pm$ 0.1	-	-	10 $\pm$ 10	-	-
U	<i>Cornus florida</i>	0.1 $\pm$ 0.1	0.3 $\pm$ 0.2	+	10 $\pm$ 10	30 $\pm$ 20	+
O	<i>Fraxinus americana</i>	-	0.7 $\pm$ 0.6	+	-	40 $\pm$ 29	+
U		0.4 $\pm$ 0.4	1.9 $\pm$ 1.3	+	20 $\pm$ 20	80 $\pm$ 49	+
O	<i>Fraxinus pennsylvanica</i>	-	0.1 $\pm$ 0.1	+	-	10 $\pm$ 10	+
U		0.2 $\pm$ 0.2	1 $\pm$ 1	+	30 $\pm$ 30	70 $\pm$ 70	+
O	<i>Juglans nigra</i>	-	0.1 $\pm$ 0.1	+	-	10 $\pm$ 10	+
U		0.1 $\pm$ 0.1	0.3 $\pm$ 0.3	+	10 $\pm$ 10	10 $\pm$ 10	=
O	<i>Juniperus virginiana</i>	-	0.1 $\pm$ 0.1	+	-	10 $\pm$ 10	+
U		-	0.2 $\pm$ 0.2	+	-	10 $\pm$ 10	+
O	<i>Liquidambar styraciflua</i>	-	2.4 $\pm$ 2.1	+	-	130 $\pm$ 107	+
U		0.6 $\pm$ 0.6	1.3 $\pm$ 1	+	50 $\pm$ 50	50 $\pm$ 32	=
O	<i>Liriodendron tulipifera</i>	-	1.7 $\pm$ 1.4	+	-	90 $\pm$ 78	+
U		-	3.4 $\pm$ 3.4	+	-	90 $\pm$ 90	+
U	<i>Prunus serotina</i>	-	0.4 $\pm$ 0.4	+	-	10 $\pm$ 10	+
O	<i>Prunus virginiana</i>	-	0.1 $\pm$ 0.1	+	-	10 $\pm$ 10	+
U		1.5 $\pm$ 1.5	1.4 $\pm$ 1.4	-	120 $\pm$ 120	30 $\pm$ 30	-
U	<i>Rhus copallina</i>	0.4 $\pm$ 0.4	0.3 $\pm$ 0.3	-	40 $\pm$ 40	10 $\pm$ 10	-
O	<i>Robinia pseudo-acacia</i>	-	0.1 $\pm$ 0.1	+	-	10 $\pm$ 10	+
U		-	1.4 $\pm$ 1.4	+	-	20 $\pm$ 20	+
U	<i>Ulmus alata</i>	-	0.2 $\pm$ 0.2	+	-	10 $\pm$ 10	+
O	<i>Ulmus rubra</i>	0.2 $\pm$ 0.1	1.1 $\pm$ 0.9	+	20 $\pm$ 12	30 $\pm$ 20	+
U		1.3 $\pm$ 1.3	3.5 $\pm$ 2.2	+	90 $\pm$ 90	90 $\pm$ 66	=
	Overstory Total	1.8 $\pm$ 1.6	10.8 $\pm$ 2	+	40 $\pm$ 19	480 $\pm$ 90	+
	Understory Total	0.6 $\pm$ 0.5	2.7 $\pm$ 0.7	+	400 $\pm$ 254	1010 $\pm$ 293	+

Table 10. Summary of changes in basal area and density of overstory (O) and understory (U) stems for the old field at LIBO. All values are mean $\pm$ standard errors. Basal area for the understory is expressed as dm²/ha.

Strata Species		Basal area (m ² /Ha:dm ² /Ha)			Density (#/Ha)		
		1985	1997	Change	1985	1997	Change
U	<i>Acer rubrum</i>	-	3.3 $\pm$ 3	+	-	317 $\pm$ 268	+
U	<i>Carya alba</i>	-	0.2 $\pm$ 0.2	+	-	17 $\pm$ 17	+
U	<i>Cornus florida</i>	-	5.2 $\pm$ 2.2	+	-	317 $\pm$ 93	+
U	<i>Diospyros virginiana</i>	-	0.9 $\pm$ 0.9	+	-	83 $\pm$ 83	+
O	<i>Juniperus virginiana</i>	-	0.2 $\pm$ 0.2	+	-	17 $\pm$ 17	+
U		-	3.4 $\pm$ 2.1	+	-	83 $\pm$ 44	+
O	<i>Liquidambar styraciflua</i>	-	0.7 $\pm$ 0.5	+	-	33 $\pm$ 17	+
U		0.2 $\pm$ 0.2	3.5 $\pm$ 2.1	+	17 $\pm$ 17	183 $\pm$ 73	+
U	<i>Parthenocissus quinquefolium</i>	-	0.1 $\pm$ 0.1	+	-	17 $\pm$ 17	+
U	<i>Prunus serotina</i>	-	0.6 $\pm$ 0.6	+	-	50 $\pm$ 50	+
U	<i>Quercus alba</i>	-	1.2 $\pm$ 0.7	+	-	50 $\pm$ 29	+
U	<i>Rhus copallina</i>	-	2.1 $\pm$ 2	+	-	150 $\pm$ 126	+
U	<i>Sassafras albidum</i>	-	0.3 $\pm$ 0.3	+	-	17 $\pm$ 17	+
U	<i>Ulmus rubra</i>	-	0.2 $\pm$ 0.2	+	-	17 $\pm$ 17	+
Overstory Total		0 $\pm$ 0	0.9 $\pm$ 0.4	+	0 $\pm$ 0	50 $\pm$ 0	+
Understory Total		0 $\pm$ 0	2.1 $\pm$ 1.4	+	17 $\pm$ 17	1283 $\pm$ 710	+

Table 11. Changes in shrub density of upland hardwood forest by year at LIBO. All values are mean $\pm$ standard errors.

Species	Density (#/Ha)		
	1985	1997	Change
<i>Acer negundo</i>	11 $\pm$ 11	-	-
<i>Acer saccharum</i>	222 $\pm$ 78	6789 $\pm$ 2252	+
<i>Amelanchier spp.</i>	22 $\pm$ 22	-	-
<i>Carpinus caroliniana</i>	-	22 $\pm$ 22	+
<i>Carya cordiformis</i>	11 $\pm$ 11	22 $\pm$ 22	+
<i>Carya glabra</i>	-	22 $\pm$ 22	+
<i>Carya spp.</i>	-	33 $\pm$ 24	+
<i>Cercis canadensis</i>	267 $\pm$ 111	633 $\pm$ 232	+
<i>Cornus florida</i>	156 $\pm$ 58	467 $\pm$ 183	+
<i>Diospyros virginiana</i>	11 $\pm$ 11	-	-
<i>Fraxinus americana</i>	-	22 $\pm$ 22	+
<i>Fraxinus pennsylvanica</i>	67 $\pm$ 29	2456 $\pm$ 738	+
<i>Ligustrum vulgare</i>	11 $\pm$ 11	11 $\pm$ 11	=
<i>Lindera benzoin</i>	189 $\pm$ 165	1044 $\pm$ 909	+
<i>Liriodendron tulipifera</i>	-	11 $\pm$ 11	+
<i>Parthenocissus quinquefolia</i>	-	22 $\pm$ 22	+
<i>Philadelphus coronarius</i>	278 $\pm$ 158	-	-
<i>Prunus serotina</i>	111 $\pm$ 81	11 $\pm$ 11	-
<i>Quercus alba</i>	-	33 $\pm$ 24	+
<i>Quercus muehlenbergii</i>	11 $\pm$ 11	-	-
<i>Quercus prinus</i>	-	11 $\pm$ 11	+
<i>Quercus velutina</i>	-	22 $\pm$ 15	+
<i>Sassafras albidum</i>	33 $\pm$ 24	567 $\pm$ 312	+
<i>Toxicodendron radicans ssp. radicans</i>	-	11 $\pm$ 11	+
<i>Ulmus alata</i>	56 $\pm$ 44	-	-
<i>Ulmus rubra</i>	-	56 $\pm$ 24	+
<i>Ulmus americana</i>	-	11 $\pm$ 11	+
<i>Viburnum lentago</i>	-	44 $\pm$ 44	+
Total	1456	12322	+

Table 12. Changes in shrub density by species for upland successional forest from 1985 to 1997. All values are mean $\pm$ standard errors.

Species	Density (#/Ha)		
	1985	1997	Change
<i>Acer saccharum</i>	33 $\pm$ 33	2550 $\pm$ 250	+
<i>Carya glabra</i>	100 $\pm$ 100	-	+
<i>Cornus florida</i>	800 $\pm$ 0	350 $\pm$ 350	-
<i>Diospyros virginiana</i>	67 $\pm$ 67	-	-
<i>Fraxinus americana</i>	-	150 $\pm$ 150	+
<i>Fraxinus pennsylvanica</i>	267 $\pm$ 67	200 $\pm$ 200	-
<i>Hypericum spp.</i>	33 $\pm$ 33	-	-
<i>Ligustrum vulgare</i>	67 $\pm$ 67	-	-
<i>Lindera benzoin</i>	-	100 $\pm$ 100	+
<i>Liquidambar styraciflua</i>	-	200 $\pm$ 200	+
<i>Prunus serotina</i>	33 $\pm$ 33	-	-
<i>Sassafras albidum</i>	-	300 $\pm$ 200	+
<i>Viburnum prunifolium</i>	67 $\pm$ 33	-	-
Total	1467	3850	+

Table 13. Changes in shrub density in mixed maple/tulip tree forest from 1985 to 1977. All values are mean $\pm$ standard errors.

Species	Density (#/Ha)		Change
	1985	1997	
<i>Acer rubrum</i>	8 $\pm$ 8	193 $\pm$ 114	+
<i>Acer saccharum</i>	285 $\pm$ 133	8092 $\pm$ 2987	+
<i>Carpinus caroliniana</i>	15 $\pm$ 15	43 $\pm$ 43	+
<i>Carya cordiformis</i>	-	14 $\pm$ 14	+
<i>Carya glabra</i>	-	21 $\pm$ 21	+
<i>Carya spp.</i>	-	7 $\pm$ 7	+
<i>Cercis canadensis</i>	-	36 $\pm$ 20	+
<i>Cornus florida</i>	300 $\pm$ 79	214 $\pm$ 100	-
<i>Fraxinus americana</i>	-	7 $\pm$ 7	+
<i>Fraxinus pennsylvanica</i>	154 $\pm$ 75	836 $\pm$ 228	+
<i>Juniperus virginiana</i>	23 $\pm$ 17	7 $\pm$ 7	-
<i>Ligustrum obtusifolium</i>	8 $\pm$ 8	-	-
<i>Ligustrum vulgare</i>	338 $\pm$ 330	943 $\pm$ 935	+
<i>Lindera benzoin</i>	269 $\pm$ 261	1650 $\pm$ 1078	+
<i>Liquidambar styraciflua</i>	38 $\pm$ 18	-	-
<i>Liriodendron tulipifera</i>	77 $\pm$ 54	21 $\pm$ 15	-
<i>Lonicera morrowii</i>	-	7 $\pm$ 7	+
<i>Morus rubra</i>	8 $\pm$ 8	-	-
<i>Nyssa sylvatica</i>	-	114 $\pm$ 74	+
<i>Prunus serotina</i>	38 $\pm$ 31	257 $\pm$ 127	+
<i>Quercus rubra</i>	8 $\pm$ 8	14 $\pm$ 10	+
<i>Robinia pseudo-acacia</i>	-	7 $\pm$ 7	+
<i>Rosa multiflora</i>	-	7 $\pm$ 7	+
<i>Sassafras albidum</i>	23 $\pm$ 12	779 $\pm$ 360	+
<i>Staphylea trifoliata</i>	23 $\pm$ 23	357 $\pm$ 357	+
<i>Tilia americana</i>	8 $\pm$ 8	-	-
<i>Ulmus alata</i>	-	14 $\pm$ 14	+
<i>Ulmus americana</i>	-	7 $\pm$ 7	+
<i>Ulmus rubra</i>	8 $\pm$ 8	36 $\pm$ 29	+
<i>Viburnum dentatum</i>	-	364 $\pm$ 327	+
<i>Viburnum lentago</i>	-	207 $\pm$ 177	+
<i>Viburnum prunifolium</i>	162 $\pm$ 64	-	-
Total	1793	14255	+

Table 14. Changes in shrub density of lowland successional forest by year at LIBO. All values are mean $\pm$ standard errors.

Species	Density (#/Ha)		Change
	1985	1997	
<i>Acer negundo</i>	-	50 $\pm$ 50	+
<i>Acer rubrum</i>	444 $\pm$ 174	1313 $\pm$ 1022	+
<i>Acer saccharum</i>	-	1525 $\pm$ 1525	+
<i>Carya alba</i>	-	13 $\pm$ 13	+
<i>Carya glabra</i>	-	38 $\pm$ 38	+
<i>Cercis canadensis</i>	33 $\pm$ 24	113 $\pm$ 113	+
<i>Cornus florida</i>	100 $\pm$ 71	438 $\pm$ 257	+
<i>Corylus americana</i>	33 $\pm$ 33	-	-
<i>Diospyros virginiana</i>	-	38 $\pm$ 38	+
<i>Fraxinus americana</i>	-	350 $\pm$ 256	+
<i>Fraxinus pennsylvanica</i>	133 $\pm$ 71	275 $\pm$ 221	+
<i>Lindera benzoin</i>	-	75 $\pm$ 62	+
<i>Liquidambar styraciflua</i>	122 $\pm$ 60	25 $\pm$ 16	-
<i>Liriodendron tulipifera</i>	11 $\pm$ 11	113 $\pm$ 55	+
<i>Nyssa sylvatica</i>	-	13 $\pm$ 13	+
<i>Prunus serotina</i>	44 $\pm$ 34	25 $\pm$ 25	-
<i>Quercus alba</i>	-	13 $\pm$ 13	+
<i>Quercus muehlenbergii</i>	-	25 $\pm$ 16	+
<i>Quercus rubra</i>	11 $\pm$ 11	-	-
<i>Quercus velutina</i>	-	63 $\pm$ 63	+
<i>Rosa multiflora</i>	-	63 $\pm$ 50	+
<i>Rubus spp.</i>	-	175 $\pm$ 175	+
<i>Salix alba</i>	-	50 $\pm$ 50	+
<i>Sassafras albidum</i>	11 $\pm$ 11	150 $\pm$ 76	+
<i>Toxicodendron radicans ssp. radicans</i>	-	13 $\pm$ 13	+
<i>Ulmus alata</i>	11 $\pm$ 11	38 $\pm$ 38	+
<i>Ulmus americana</i>	-	38 $\pm$ 38	+
<i>Ulmus rubra</i>	22 $\pm$ 15	188 $\pm$ 126	+
<i>Viburnum dentatum</i>	11 $\pm$ 11	-	-
Total	986	5220	+

Table 15. Changes in shrub density at razed homesites by year at LIBO. All values are mean $\pm$ standard errors.

Species	Density (#/Ha)		
	1985	1997	Change
<i>Acer negundo</i>	-	120 $\pm$ 49	+
<i>Acer rubrum</i>	660 $\pm$ 322	640 $\pm$ 280	-
<i>Acer saccharum</i>	-	80 $\pm$ 80	+
<i>Carya glabra</i>	-	20 $\pm$ 20	+
<i>Cornus florida</i>	20 $\pm$ 20	20 $\pm$ 20	=
<i>Diospyros virginiana</i>	-	20 $\pm$ 20	+
<i>Fraxinus americana</i>	-	600 $\pm$ 302	+
<i>Fraxinus pennsylvanica</i>	80 $\pm$ 80	500 $\pm$ 475	+
<i>Liquidambar styraciflua</i>	80 $\pm$ 80	80 $\pm$ 49	=
<i>Liriodendron tulipifera</i>	-	80 $\pm$ 80	+
<i>Prunus serotina</i>	80 $\pm$ 80	-	-
<i>Prunus virginiana</i>	-	20 $\pm$ 20	+
<i>Quercus rubra</i>	-	20 $\pm$ 20	+
<i>Rhus copallina</i>	120 $\pm$ 73	-	-
<i>Robinia pseudo-acacia</i>	340 $\pm$ 223	-	-
<i>Rosa multiflora</i>	60 $\pm$ 40	-	-
<i>Sassafras albidum</i>	260 $\pm$ 260	-	-
<i>Ulmus alata</i>	-	80 $\pm$ 80	+
<i>Ulmus rubra</i>	80 $\pm$ 58	380 $\pm$ 307	+
Total	1780	2660	+

Table 16. Changes in shrub density in old fields by year.
All values are mean $\pm$ standard errors.

Species	Density (#/Ha)		Change
	1985	1997	
<i>Acer rubrum</i>	1067 $\pm$ 371	12333 $\pm$ 2849	+
<i>Carya alba</i>	-	33 $\pm$ 33	+
<i>Carya glabra</i>	-	200 $\pm$ 200	+
<i>Cornus florida</i>	200 $\pm$ 58	467 $\pm$ 371	+
<i>Diospyros virginiana</i>	-	333 $\pm$ 333	+
<i>Fraxinus americana</i>	167 $\pm$ 67	167 $\pm$ 88	=
<i>Juniperus virginiana</i>	67 $\pm$ 67	100 $\pm$ 100	+
<i>Liquidambar styraciflua</i>	67 $\pm$ 33	533 $\pm$ 393	+
<i>Liriodendron tulipifera</i>	-	100 $\pm$ 100	+
<i>Platanus occidentalis</i>	-	33 $\pm$ 33	+
<i>Prunus serotina</i>	-	300 $\pm$ 208	+
<i>Quercus alba</i>	-	33 $\pm$ 33	+
<i>Quercus velutina</i>	-	33 $\pm$ 33	+
<i>Rhus copallina</i>	-	400 $\pm$ 252	+
<i>Rosa multiflora</i>	-	33 $\pm$ 33	+
<i>Sassafras albidum</i>	-	67 $\pm$ 67	+
<i>Ulmus rubra</i>	-	1000 $\pm$ 764	+
Total	1568	16165	+

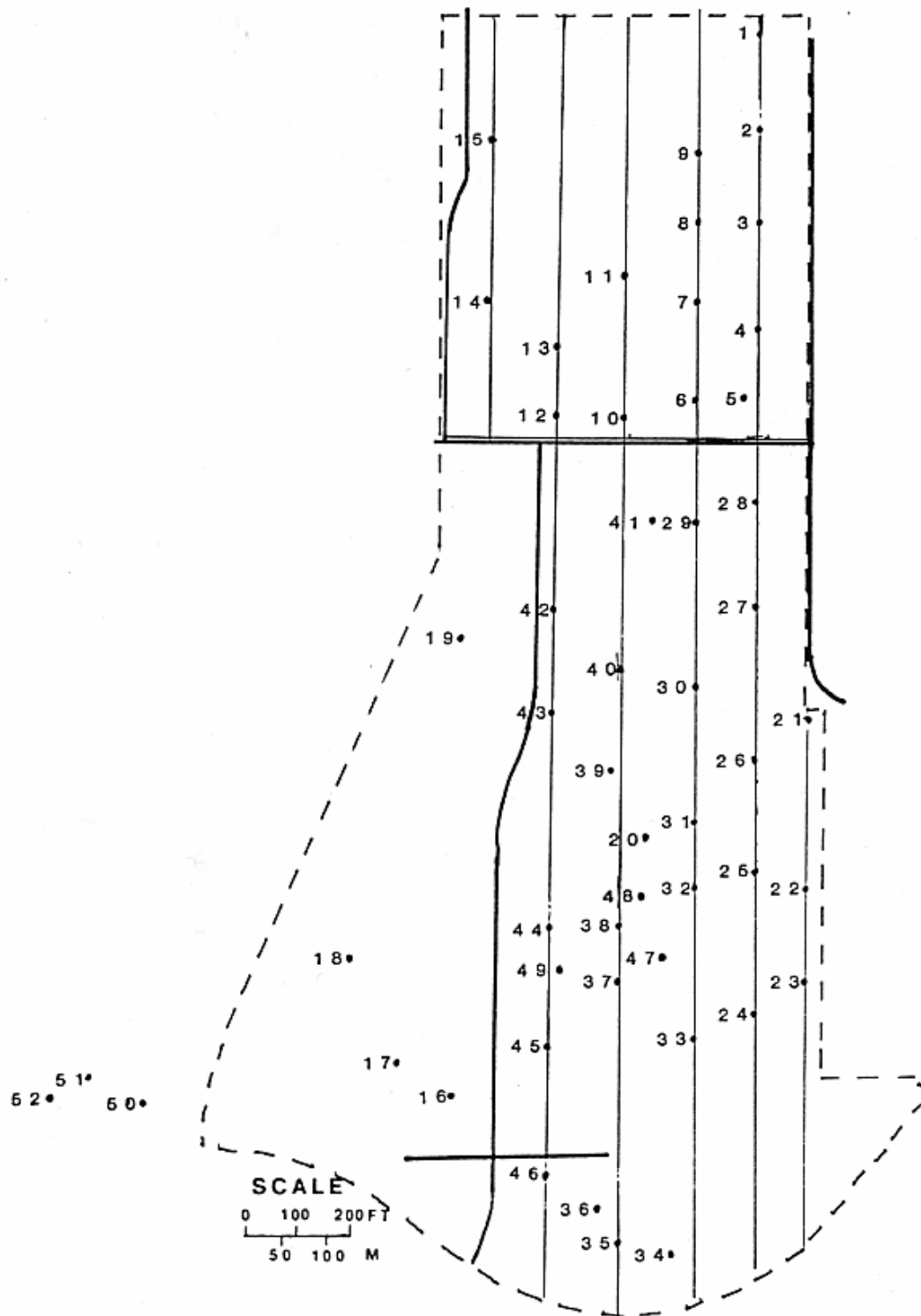


Figure 1. Vegetation plot transects and sampling points at Lincoln Boyhood National Memorial and Lincoln State Park.



LEGEND

-  Upland Hardwood Forest
-  Mesic Mixed Hardwood Forest
-  Bottomland Hardwood Forest
-  Successional Hardwood Forest
-  Mixed Maple/Tuliptree Forest
-  Fescue Pasture
-  Old Homesite
-  Old Field
-  Upland Old Field

- ① Lincoln Memorial Building
- ② Nancy Hanks Cemetery
- ③ Allee
- ④ Living Historical Farm
- ⑤ Maintenance Area
- ⑥ Reservation of Use Area

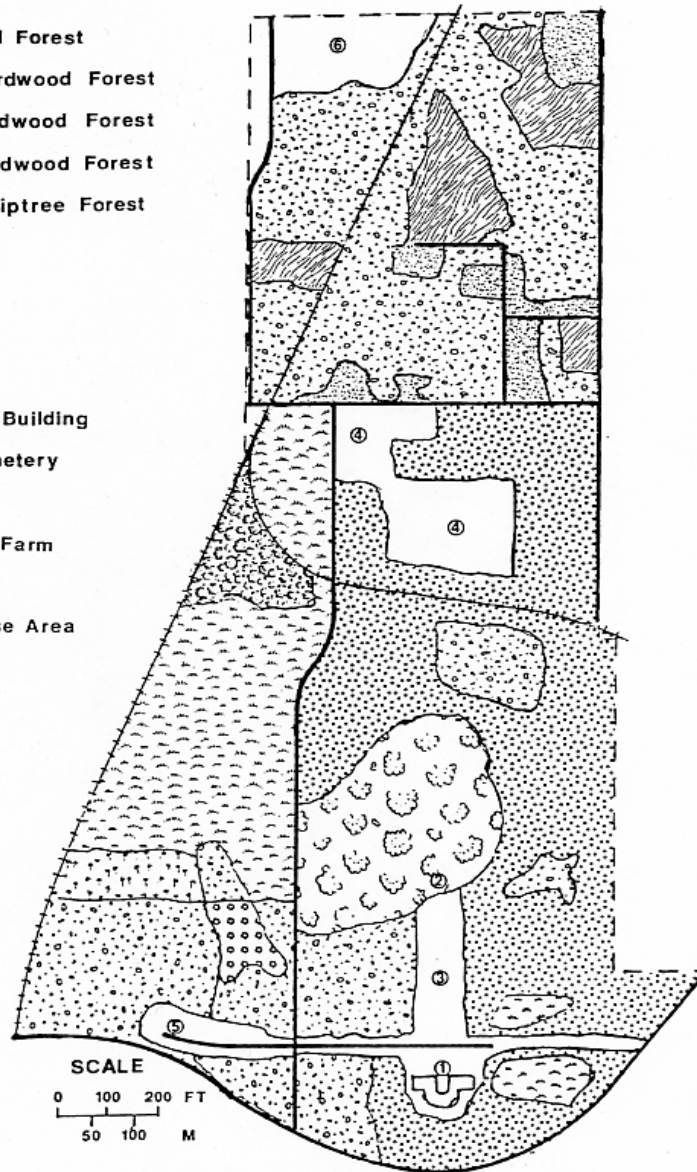


Figure 3. Vegetation map of Lincoln Boyhood National Memorial based on vegetation sampled in 1985.

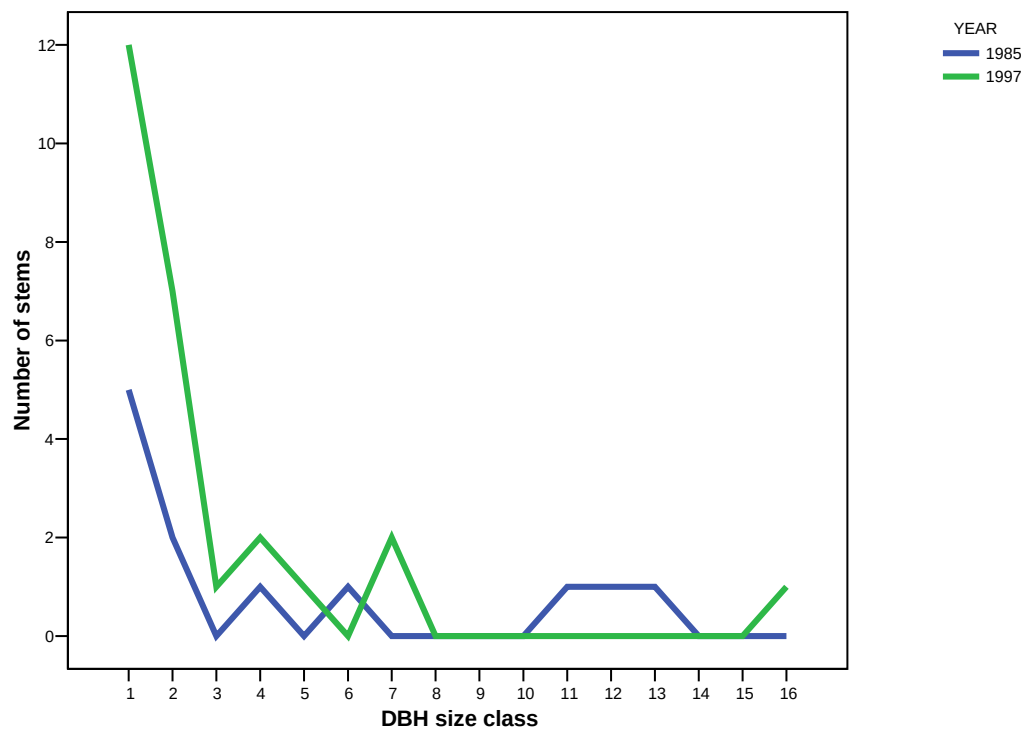


Figure 4. Size class distribution of sugar maple (*Acer saccharum*) in the upland hardwood forest at Lincoln Boyhood National Memorial from 1985 and 1997. Size classes are 2.5 cm intervals with class 1 being from 2.5 to < 5 cm.

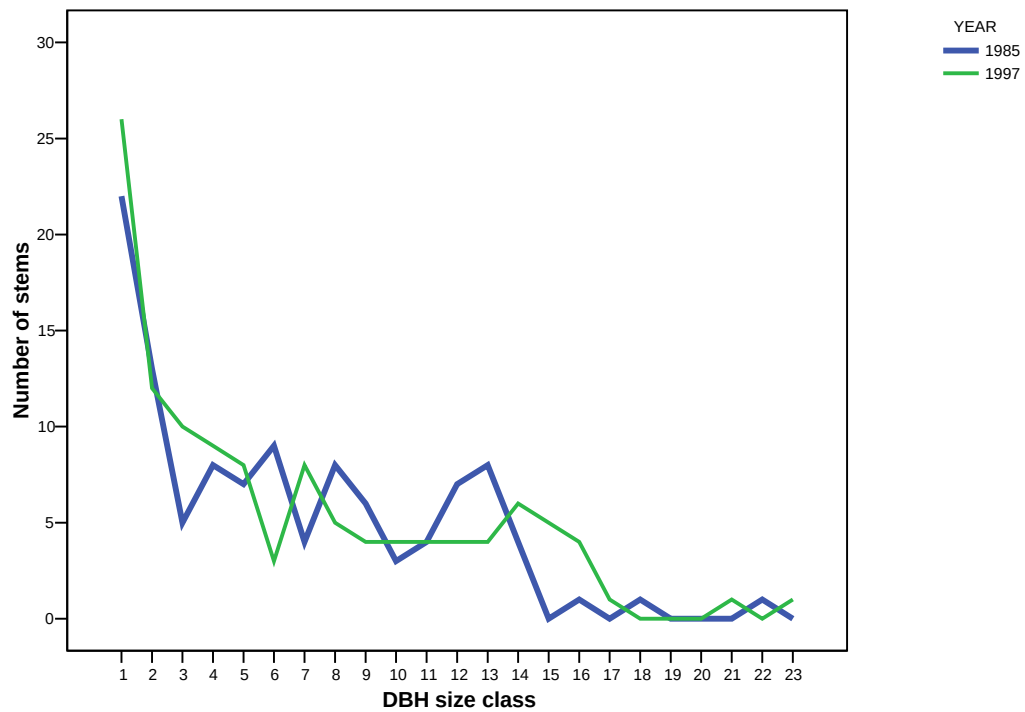


Figure 5. Size class distribution of sugar maple (*Acer saccharum*) at Lincoln Boyhood National Memorial from 1985 and 1997. Size classes are 2.5 cm intervals with class 1 being from 2.5 to < 5 cm.

Appendix 1. Table structure of the components of vegetation relational database. Each field is defined and relationships between tables are indicated.

Tbl_locationID

ID - unique index for each location

GPS_Plot# - unique index for each location GPSed

Date - date that data were collected

Time – the time when position was taken

#Positions – number of points taken by GPS to calculate a particular position

LocationID – park code, project and GPS plot# combined to give a unique identification

Parkcode – four-letter code given to identify a particular park (LIBO = Lincoln Boyhood)

Project - Type of project data collected for (vegetation study, fire monitoring)

StartUTMX – Universal Transverse Mercator Map (UTM) Projection coordinate axis running from the system origin to the Greenwich Meridian

StartUTMY - UTM Map Projection coordinate axis running from the system origin through the 90-degree east longitude meridian

UTMZone – UTM zone, in this case 16 N

Datum – NAD-83, North American Datum of 1983

Datatype – type of GPS data taken (point, lines, polygons)

EstHError – estimated horizontal error

Accnotes – Type of GPS unit used (Geoexplorer3, GRS)

Horz Prec – the horizontal precision of the GPS coordinates

Vert Prec – vertical precision of the GPS coordinates

GPSElevation – Height above sea level taken from point where GPS was recording data

Antennaheight – Height of pole from ground to where GPS was recording data

Elevation – Height above sea level taken from the ground

Aspect –direction facing the slope on a hill

Slope –inclination or the degree of slant on a hill

Topop – takes values of ‘D’, ‘F’, ‘S’ or ‘T’.

Topoid – takes integer values of 1,2 or 3.

Tbl_EventID

ID - unique index for each date

Date – date that data was collected, e.g. 5/21/79.

Year – year in four characters

Additional tables include tlu_Park, tbl_Project, and tbl_Topography,

TblPark

Parkname – full name of the park

Parkcode – four letter NPS code for the park.

Utmzone – UTM zone where the park is found. This is used to ensure correct GPS data.

Tbl_Project

ProjectID – unique index for each type of project

Projecnam – projects entered are either ‘vegetation’ or ‘fire effects’. Others can be added later.

Tbl Topography

Topography – topographic position of the plot

Topoid - unique index for each type of topography

The core of the vegetation related data is in the following tables.

Tlu Plants

ID - unique index for each plant species

Commonname - common name of plant given by Integrated Taxonomic Information System (ITIS) data access

Genus – Local genus name used by researchers

Species – Local species name used by researchers

Variety – variety of plant in name if plant has one

Authority – person or authority that gave plant the plant its scientific name

ITISnumber – unique index given by the ITIS data access

Namecode – Eight-letter code given to plants, is based upon using the first four letters of the Genus and the first four letters of the species

Name – complete scientific name of a plant

ITISGenus – Genus of plant as accepted by ITIS data access

ITISSpecies – species of plant as accepted by ITIS data access

ITISAuthority - person or authority that gave plant the plant its scientific name used by ITIS data access

Synonym (1-26) – scientific names that have been used in the past and are not accepted by the ITIS

Familynname – name of scientific family that the plant is associated (linked to Tlu_PlantFamily)

Lifeform – form that characterizes the kind of plant at maturity (Annual, Biennial, Monocarpic Perennial, Perennial)

Growthform – broad categories resulting from variation in the morphology of plants (Tree, Shrub, Forb, Graminoid, Fern, Fern Ally, Vine)

Tlu Herbaceous

ID - unique index for each plant species

LocationID- type of sampling plot and identification number used by researchers

Date – date the data was collected

Quadrat – specified subplot (1 of 10) in sampling plot

Species – Genus-species of plant given in eight-letter code based upon using the first four letters of the Genus and the first four letters of the species

Value – value given if plant is present or absent; 1 = present 0 = absent, or other value types designated by the ‘Type’ field.

Type – describes the type of data collected by the researchers. The data types are: 1) Presence/Absence 2) Density 3) Cover.

Tlu_Shrubs

ID - unique index for each plant species

LocationID- type of sampling plot and identification number used by researchers

Date – date the data was collected

Year – year in four characters

ITISNumber – linked to the ITIS number found in the plant table, an eight-letter code given to plants that is based upon using the first four letters of the Genus and the first four letters of the species

Density – stems that are > 1 m tall and < 2.5 cm dbh, in a sampling plot (5.64 m radius) are counted by species

Tlu_Trees

The Tree data are entered on a stem basis; therefore each line is a tree or a stem of a tree. The stem variable allows the later aggregation of the stems per tree into a total basal area and number of stems per tree. A second aggregation will allow the summary of the plot data by species to generate one line per species present at each plot. This format allows the creation of a file with three fields: 1) plotcode, 2) species code, and 3) value that can then be imported into PCORD from a txt file. The value can be any response variable, basal area, cover, density etc.

ID – unique index for each plot

PlotID – park code, project and plot# combined to give a unique identification

Year - year in four characters

Tree – number assigner to each tree within sampling plot

Stemnumber – Sequential number assigned to each stem (trunks) of each tree

ITISnumber – linked to the ITIS number found in the plant table, an eight-letter code given to plants that is based upon using the first four letters of the Genus and the first four letters of the species

A/D – Alive or Dead status of a stem: A = tree stem is alive, D = tree stem is dead
(Linked to Tlu_Status)

DBH – diameter of tree measured at breast height (1.4m)

Livesprout – number of live tree sprouts from a tree

Deadsprout – number of dead tree sprouts from a tree

BasalareaHa – total area of stem at breast height calculated from dbh (this variable is found in the query table)

Approximate Age – minimum age of tree because center was rotten or increment bore did not reach tree center.

Tree Age – age of tree

Notes – notes usually about species name changes

Tlu_Quadrat

This table assigns unique subquadrat numbers

ProjectID – unique index for each quadrat

Quadrat – specified area in the sampling plot

Azimuth – horizontal direction clockwise from the north point through 360°

Radius – radial distance from plot center where quadrat is located

Tlu_Datatype

The data type is selected from three available categories that describe the type of data collected by the researchers. Others can be created as needed. The data types are:

- 1) Presence/Absence – only the presence or absence of a species is noted.
- 2) Density – each stem which meet a specific criteria in a sampling plot is counted by species
- 3) Cover – an estimate on the percentage of the area taken up by a specific category (vegetation, bare ground, leaf litter, individual plant species, etc.)
- 4) Tree layer – layer where unknown specimen was collected
- 5) Shrub layer - layer where unknown specimen was collected
- 6) Herbaceous layer - layer where unknown specimen was collected

Tlu_Status

Status – alive and dead categories

ID – unique index for each status category: 1 = a live plant, 2 = a dead plant

Tlu_Growthform

Growthform – Morphological growth form categories for plants (Tree, Shrub, Forb, Graminoid, Fern, Fern Ally, Vine)

Tlu_LifeForm

Lifeform – plant life span categories: Annual, Biennial, Monocarpic Perennial, and Perennial)

Tlu_PlantFamily

Family – name of scientific family

Famcom - common name of plant family given by ITIS data access

Altfamily – Alternate or scientific family names that have been used in the past and are no longer accepted

Tlu_CanopyCover

ID – unique key variable for table

PlotID – locationID (linked with Tbl_LocationID)

Date – Date sample was taken (linked with Tbl_EventID)

CanopyNorth – densitometer sky counts from plot center facing north

CanopyEast - densitometer sky counts from plot center facing east

CanopyWest - densitometer sky counts from plot center facing west

Canopy South – densitometer sky counts from plot center facing south

Tlu_Soils

Soil parameters are measured on a weight basis.

ID – locationID (linked from Tbl_LocationID)

Habitat – habitat type in 1985 where soil sample was taken

Elevation – elevation in feet of location, estimated from park topographic maps

% Organic – percent organic matter in soil

Pppm – phosphorous concentration in ppm.

Kppm – potassium concentration in ppm
 Mg – magnesium concentration in ppm
 Ca – calcium concentration in ppm
 pH – soil pH
 T – cation exchange capacity,
 %bs K – percent base saturation of potassium
 %bs Mg – percent base saturation of magnesium
 %bs Ca – percent base saturation of calcium
 %bs H – percent base saturation of hydrogen
 %tkN – percent total Kjeldahl nitrogen
 Laboratory – laboratory where samples were analyzed

Tlu_Unknowns: this table has no entries at present, but will be used for further sampling
 ID – unique id for each unknown, assigned by program
 Date – date unknown was collected
 PlotID – plot locationID (linked to Tlb_LocationID)
 Subplot – subplot number if appropriate (linked to Tlu_Quadrat)
 VegetationLayer – layer of vegetation where sample is taken (linked to Tlu_Datatype)_
 UnknownNumber – unique unknown number, usually a combination of year and unique number for that sample
 Notes – any notes describing the unknown, e.g. ‘Carex sp.’, ‘opposite leaf – hairy stem’
 ITISnum – species that it is determined to be (linked to Tlu_Plants)
 Verifier – name of individual that verified the determination
 DateVerified – date the specimen was verified

The following query tables are created as well.

HerbSubPlotSummary

PlotID - plot locationID (linked to Tlb_LocationID)
 Date – date plot was sampled
 Species - linked to the ITIS number found in the plant table, an eight-letter code given to plants that is based upon using the first four letters of the Genus and the first four letters of the species
 CountofValue – frequency (N=10) of subplots containing the species

Tlu_TreeBasalHa

ID – unique index for each plot
 PlotID – park code, project and plot# combined to give a unique identification
 Year - year in four characters
 Tree – number assigner to each tree within sampling plot
 Stemnumber – Sequential number assigned to each stem (trunks) of each tree
 ITISnumber – linked to the ITIS number found in the plant table, an eight-letter code given to plants that is based upon using the first four letters of the Genus and the first four letters of the species
 A/D – Alive or Dead status of a stem: A = tree stem is alive, D = tree stem is dead
 (Linked to Tlu_Status)

DBH – diameter of tree measured at breast height (1.4m)

Livesprout – number of live tree sprouts from a tree

Deadsprout – number of dead tree sprouts from a tree

BasalareaHa – total area of stem at breast height calculated from dbh (this variable is found in the query table)

Approximate Age – minimum age of tree because center was rotten or increment bore did not reach tree center.

Tree Age – age of tree

Notes – notes usually about species name changes