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USING GENERAL LAND OFFICE SURVEY NOTES TO DEFINE REFERENCE ECOSYSTEMS FOR BALL STATE UNIVERSITY'S GINN WOODS, DELAWARE COUNTY, INDIANA

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ABSTRACT. Nineteenth century land surveyors listed the species and size of witness trees. From this information we have first-person accounts for the timber comprising Indiana's presettlement forests. The goal of this investigation was to use historic General Land Office (GLO) survey notes to establish reference ecosystems for Ginn Woods, a Ball State University Field Station property. For the region surrounding Ginn Woods, witness tree species and sizes were charted on a mile section grid and a presettlement map of plant associations was created. Results show that Ginn Woods was historically part of a larger Beech-Maple community geographically isolated between the Mississinewa River and Pipe Creek floodplain ecosystems. Species associated with the Oak-Hickory community were located near Ginn Woods, but these species were not historically recorded in what became the Ginn Woods site. GLO data also identified the presence of prairies, swamps, and springs in or around the Ginn Woods property. GLO results were compared to more recent examinations of the composition of Ginn Woods, and Geographic Information Systems (GIS) land use data were incorporated to illustrate the dramatic loss of historic forest and wetland complexes to modern agriculture.

Keywords: Reference ecosystems, presettlement landscapes, Ginn Woods, ecological restoration, landscape management

INTRODUCTION

Reference ecosystems are historic ecosystems that existed prior to European settlement, and have since been altered by human activities such as urbanization and agriculture (Egan & Howell 2001). Indiana landscapes have multiple reference ecosystems, for instance glacial, inter-glacial, pre, and post settlement. Typically, however, the community type and composition of presettlement landscapes is used as a benchmark or goal for restoration projects (Egan & Howell 2001; Barr et al. 2002). GLO survey notes produced for east-central Indiana in the early decades of the nineteenth century offer a glimpse of the Hoosier presettlement landscape. An awareness of historic reference ecosystems, along with observed changes over time (clearing of vegetation, species loss, invasive species, woodland pasturing of livestock, hydrological alterations, etc.), inform restoration and management decisions in the 21st Century.

General Land Office survey.—The General Land Office (GLO) was an agency created by the US Government in 1812 to quickly and efficiently divide and sell publically owned land. The government sought to extend its influence, and secure its control, over recently acquired public lands from European and Native American competition (i.e., lands acquired in the 1783 Treaty of Paris and the 1803 Louisiana Purchase)(White 1991).

The GLO adopted the Rectangular Land System where surveyors divide the landscape into townships made up of thirty-six, square-mile (1.6 km), 640 acre (259 ha) sections demarcated by mile-long north-south and east-west lines. To delineate these lines in forested areas surveyors placed a wood post at the corner of each section, and the half-mile point between each section corner. The surveyor used an ax to "blaze" (chop out a flat surface in the tree's trunk) two nearby trees as more permanent markers of the wood post. Since blazed trees identified legally surveyed locations, they became known as "witness trees" and later "bearing trees" (BLM 1980).

For each mile-long section line the surveyor was directed to record specific information about the landscape: the species of the witness trees and undergrowth typically found along the section line, and the potential of the land for agriculture. For each witness tree the surveyors were instructed to record its "kind and diameter," and to use

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compass bearings to locate it in the landscape. Witness trees at township and section corners were "not less than five inches in diameter" in size (12.7 cm). This size was later changed to "not less than two and a half inches in diameter" (6.35 cm). The beech tree (*Fagus grandifolia*) is the only species specifically mentioned in the guidance to surveyors, who were permitted to scar the tree's smooth bark rather than cutting through the thick bark typically required of other timber species. Vegetation for a section line was to be summarized by accounting for the "several kinds of timber and undergrowth in the order in which they predominate." Finally, topography, or "Land Surface" was described either as "level, broken, or hilly—1st, 2d, or 3d rate on each mile—1st rate to indicate extra quality, 2d rate good average, and 3d rate inferior quality" (Hawes 1868; GLO 1871). Surveyor's notes were used by prospective buyers to judge a property's value for farming or industry. Since the surveyors were required to list the tree's species, we have first-person accounts for the timber comprising Indiana's historic presettlement forests.

GLO data are used in a variety of research in both the sciences and humanities. Several articles and texts are effective in describing the agency's history (Bourdo 1956; Rohrbough 1968), and nineteenth century guidelines for GLO surveyors are available online from the Bureau of Land Management's web site (Hawes 1868; GLO 1871; BLM 2017).

Using GLO data for reconstructing nineteenth century forest composition is limited by potential surveyor bias of species, size, and witness tree location (Bourdo 1956; Manies & Mladenoff 2000; Schulte & Mladenoff 2001; Fralish & McArdle 2009; Hanberry et al. 2012). Bourdo explains how some surveys used fraudulent data or contained errors that were never corrected. More importantly, he suggests that the guidelines directing surveyors to choose witness trees of "the soundest and most thrifty in appearance" led to a bias in species selection in that tree species were not randomly selected and not a purely objective sample of the presettlement forest (Bourdo 1956:760). However, given that many of the witness tree sizes in the area surrounding what is now Ginn Woods are small (Table 3), Bourdo's claim appears to be overstated. Schulte & Mladenoff (2001) stated that surveyors were paid by the mile, and likely selected witness trees that were easiest to locate. Therefore, the patterns of species in the landscape "tempered surveyor choice through reduced availability of tree species and sizes in the environment surrounding the [section] corner (Schulte & Mladenoff 2001:7)." Manies & Mladenoff (2000) concluded that GLO data somewhat underestimates species diversity and size, but GLO reconstructions are still representative of the landscape for large-scale studies.

Since GLO data is, in essence, a "snapshot in time", it is most often used to define reference ecosystems for modern day ecological restorations and management decisions. While there is a multitude of published research describing the use of GLO data to inform restoration and management decisions, those that directly influence this project are highlighted here. Indiana presettlement landscape maps built on GLO data, and illustrating major vegetative communities, have been assembled by Gordon (1936), Potzger et al. (1956), Crankshaw & Lindsey (1965), and Jackson (1997). Barr et al. (2002) used Geographic Information Systems (GIS) software and GLO data to map presettlement vegetative communities to guide ecological restoration decisions in Marion County, Indiana. Barr et al., with modification (see Methods), could act as a model for GLO studies in Indiana.

Ginn Woods and the GLO study site.—Ginn Woods is a 65.2 ha (161 ac), Ball State University owned and managed property containing one of the largest stands of old-growth forest remaining in Indiana (Badger et al. 1998; Ginn Woods 2017). In *Natural Areas of Indiana and their Preservation* Alton Lindsey et al. (1969) described the woods as "largely flat, and in some places the soil is imperfectly drained so that water is ponded at least in early spring." The survey valued the property for its large and intact size, and the potential use as an educational facility (Lindsey et al. 1969:312). Studies of Ginn Woods have looked at flora and vegetation (Schoultz 1997; Ruch et al. 1998), its old-growth structure and composition (Badger et al. 1998), the influence of soils on vegetation (McClain 1985), and the distribution of specific species (Crankshaw & Cartwright 1978). While this on-going body of research examines the property from within, this study's use of GLO survey notes attempts to recreate the historic vegetative context of Ginn Woods within the presettlement landscape.

The GLO study site encompasses the two square mile sections in which Ginn Woods is

Table 1.—Location of Ginn Woods study site. The Ginn Woods study site consists of thirty township sections located in Blackford, Delaware, and Grant counties.

Township/range	County	Township name	Township sections	Number of sections
T22N, R9E, 2nd Meridian	Grant	Jefferson	1–2	2
	Delaware	Washington	11–14, 23–26, 35–36	10
T22N, R10E, 2nd Meridian	Blackford	Licking	4–6	3
	Delaware	Union	7–9, 16–21, 28–33	15

located (Section 18 and 19 of Union Township, Delaware County), and the two tiers of townships encircling the site (Fig. 1). Therefore, the study area contains 30 mile-square (640 acre, 258.9 ha) sections totaling 19,200 acres (7,769.9 ha). Two sections are in Blackford County, three in Grant County, and twenty-five in Delaware County (Table 1).

METHODS

From the GLO notes, the quantity of each tree species, percent of total trees, and average diameter for each tree species were recorded. Tree species were assigned a forest association using Whitaker & Amlaner (2012:327–336) (Table 2 & 3), a reference specific to Indiana In a similar study from Marion County, Barr et al. (2002) used a less precise, geographically broad guide (Kricher & Morrison 1988) for assigning witness tree species to specific communities. Several witness trees recorded in the GLO notes were listed with only their genus (e.g., elm, hickory, ash), but not their species. Since they could not be assigned a community association, they were listed as non-indicators. For instance, if the surveyor simply listed "ash," he could have meant a green ash associated with a Floodplain Forest, or a white ash associated with a Beech-Maple forest. Another set of non-indicators were species with multiple associations (i.e., black cherry).

Tree species from GLO survey notes were mapped on a one-mile section grid using GIS sofware (ESRI 2017). Species associated with the Beech-Maple community are represented on the map with a solid circle (•), species associated with the Oak-Hickory community are represented with a plus (+), generalist species are represented with solid square (■), and non-indicator species are represented with a circle (○). To simplify the illustration, the two Floodplain Forest species (one willow and one sycamore) were not mapped. Landforms identified in the survey (swamp, spring, prairie) were mapped (Fig. 2.).

A pressttlement map was created using the GLO data (Fig. 3.). Trees with an Oak-Hickory association were rare in the study area, and the community was mapped around the cluster of

Table 2.—Assumed Forest Association for Ginn Woods Species. Species were recorded in the 1820 General Land Office surveyor notes. Assumed forest association from Table P-5 Whitaker & Amlaner (2012:327–336). Hickory, ash, and elm are considered non-indicators because only their genus was listed.

Assumed Forest Association for GinnWoods Species	
Beech-Maple	
Fagus grandifolia	Beech
Ulmus rubra	Red elm
Oak-Hickory	
Celtis occidentalis	Hackberry
Cornus florida	Dogwood
Liquidambar styraciflua	Sweetgum*
Ostrya virginiana	Ironwood
Quercus macrocarpa	Bur oak
Quercus velutina	Black oak
Beech-Maple and Oak-Hickory (Generalist Species)	
Acer negundo	Box elder
Acer saccharum	Sugar maple
Aesculus glabra	Ohio buckeye
Carpinus caroliniana	Hornbeam
Fraxinus americana	White ash
Fraxinus quadrangulata	Blue ash
Juglans nigra	Black walnut
Morus rubra	Red mulberry
Populus grandidentata	Aspen
Quercus alba	White oak
Quercus rubra	Red oak
Floodplain	
Platanus occidentalis	Sycamore
Salix spp.	Willow
Non-indicator	
Carya spp.	Hickory
Fraxinus spp.	Ash
Prunus serotina	Cherry
Ulmus spp.	Elm

* Sweetgum is not common to Delaware County (Deam 1953), and is likely Black gum (*Nyssa sylvatica*) which is an Oak-Hickory association.

Table 3.—Results of General Land Office survey notes for the Ginn Woods study area: scientific name, witness tree common name, number surveyed, species percentage of total trees surveyed, average DBH, and assigned forest association (Beech-Maple, Oak-Hickory, Floodplain, or Non-indicator). Witness trees recorded with only their genus (e.g., elm, hickory, ash), but not their species, are listed as non-indicators.

Inferred scientific name	Witness tree recorded name	Number surveyed	Percent of total trees	Average DBH (in)	Assumed forest association
Acer negundo	Box elder	1	0.3	6	Beech-Maple, Oak-Hickory
Acer saccharum	Sugar maple	24	7.6	16	Beech-Maple, Oak-Hickory
Aesculus glabra	Ohio buckeye	13	4.1	10	Beech-Maple, Oak-Hickory
Carpinus caroliniana	Hornbeam	1	0.3	5	Beech-Maple, Oak-Hickory
Carya	Hickory	19	6	14	Non-indicator
Celtis occidentalis	Hackberry	1	0.3	26	Oak-Hickory
Cornus florida	Dogwood	4	1.2	6	Oak-Hickory
Fagus grandifolia	Beech	138	44	16	Beech-Maple
Fraxinus americana	White ash	11	3.5	15	Beech-Maple, Oak-Hickory
Fraxinus	Ash	15	4.7	12	Non-indicator
Fraxinus quadrangulata	Blue ash	16	5	9	Beech-Maple, Oak-Hickory
Juglans nigra	Black walnut	2	0.6	13	Beech-Maple, Oak-Hickory
Liquidambar styraciflua	Sweetgum*	4	1.2	24	Oak-Hickory
Morus rubra	Red mulberry	2	0.6	10	Beech-Maple, Oak-Hickory
Ostrya virginiana	Ironwood	15	4.7	6	Oak-Hickory
Platanus occidentalis	Sycamore	1	0.3	24	Floodplain
Populus grandidentata	Aspen	1	0.3	12	Beech-Maple, Oak-Hickory
Prunus serotina	Cherry	2	0.6	18	Non-indicator
Quercus alba	White oak	15	4.7	24	Beech-Maple, Oak-Hickory
Quercus macrocarpa	Bur oak	4	1.3	20	Oak-Hickory
Quercus rubra	Red oak	5	1.6	18	Beech-Maple, Oak-Hickory
Quercus velutina	Black oak	5	1.6	33	Oak-Hickory
Ulmus rubra	Red elm	1	0.3	22	Beech-Maple
Ulmus	Elm	15	4.7	13	Non-indicator
Salix	Willow	1	0.3	4	Floodplain
	Total	316			

* Sweetgum is not common to Delaware County (Deam 1953), and is likely Black gum (*Nyssa sylvatica*) which is an Oak-Hickory association.

associated witness trees in the central portions, and on the western edge, of the project site. Section lines with more than one species from the Oak-Hickory association were identified, then GIS was used to create a half-mile buffer around each witness tree to estimate an area of potential environmental conditions supporting Oak-Hickory association species (Tulowiecki & Larsen 2015). Since few Floodplain Forest species were identified (2% of species), this community was defined using the floodplain soils identified in county soil surveys (USDA1985, 2004). Wetlands were mapped using the Historic Wetlands GIS shapefile from the Indiana Map website (2017).

To estimate change in the study area over time, the GLO presettlement map was compared to current land uses using Gap Analysis Project data (GAP), and gains or losses in vegetative communities were reported (Tables 4 & 5). GAP data is land cover information mapped by the United States Geological Survey and used for conservation planning. It is used in the Ginn Woods study to estimate land cover change over time.

RESULTS

Representing 25 different species, 316 witness trees were identified in the study area (Table 2 & 3). Of the trees 44% (139) are representative of a Beech-Maple community, 10% (33) represent an Oak-Hickory community, and 1% (2) represent a Floodplain Forest community. Generalist species common to multiple associations accounted for 29% (91) of the total. Sixteen percent (51) of the trees were non-indicators for a specific community, or the GLO notes recorded the genus but not the specific species.

The presettlement map created using GLO witness trees, in conjunction with soil and wetland

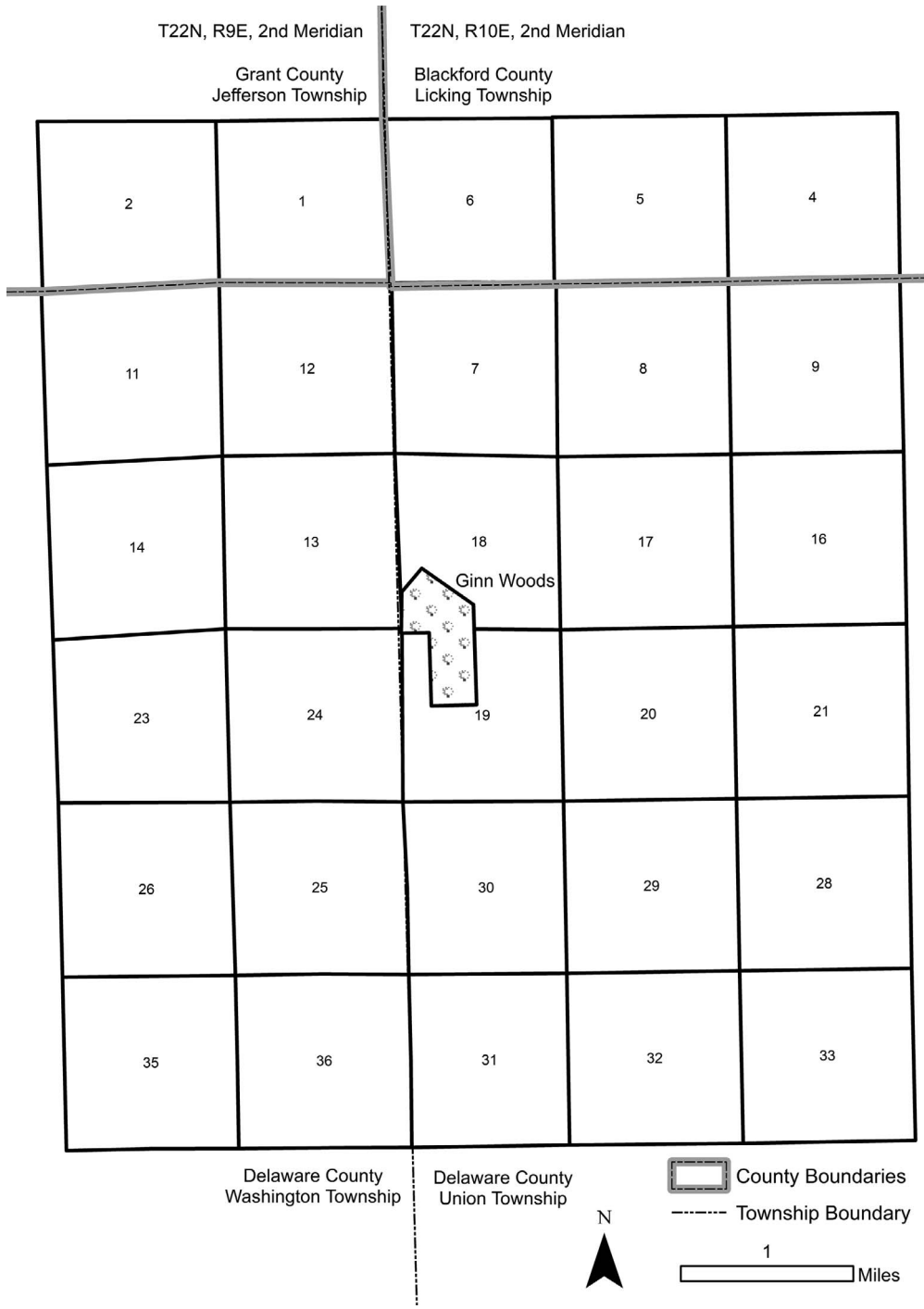

Figure 1.—Ginn Woods and accompanying GLO study area. The study area encompasses thirty square miles of Delaware, Grant, and Blackford Counties. Ginn Woods straddles the line between Sections 18 and 19 in Union Township, Delaware County.

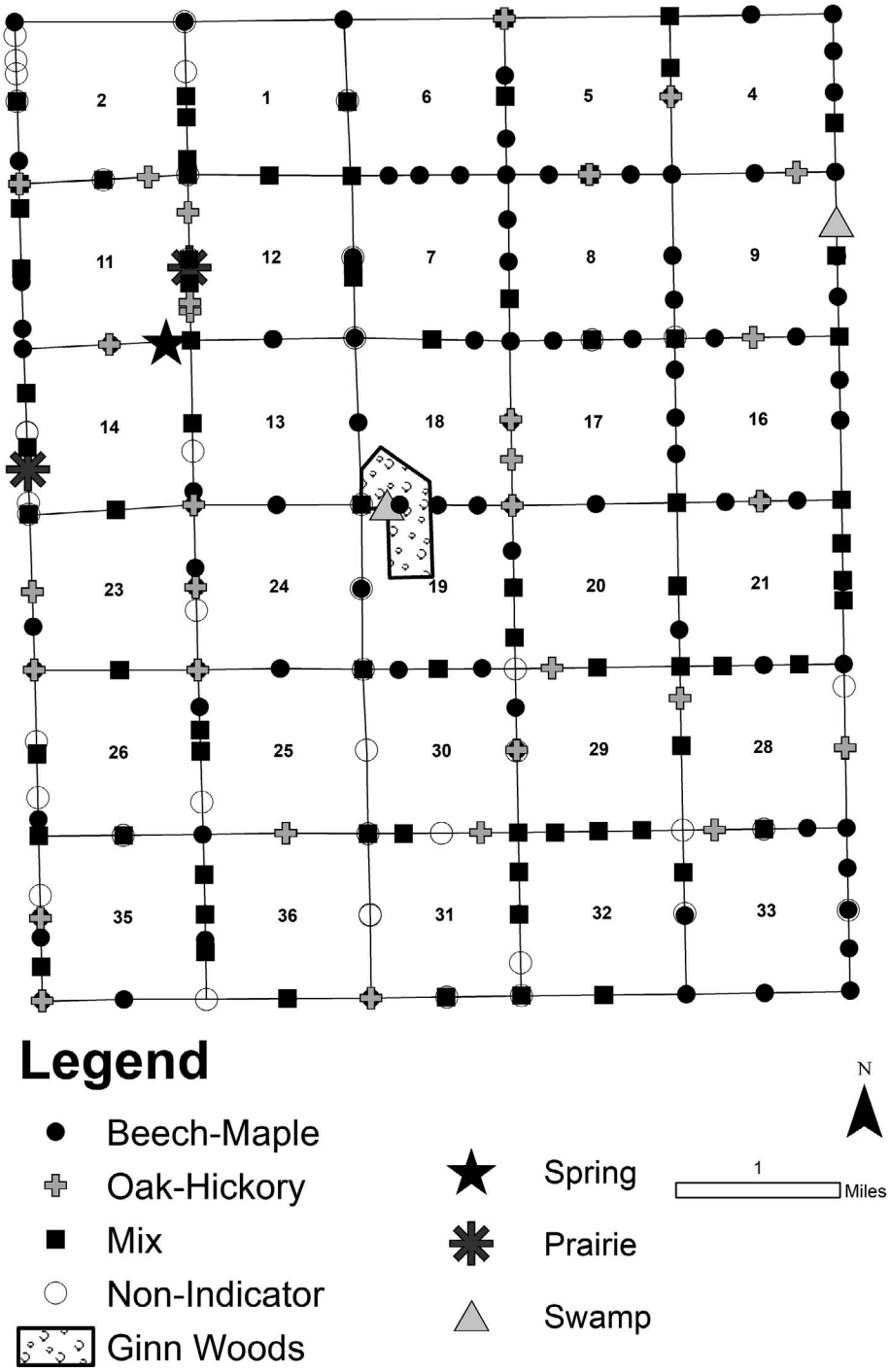

Figure 2.—Study Area Witness Tree Locations. Witness tree locations and species associations charted onto the square-mile section grid. The illustration includes the surveyor's locations for prairies, swamps, and springs.

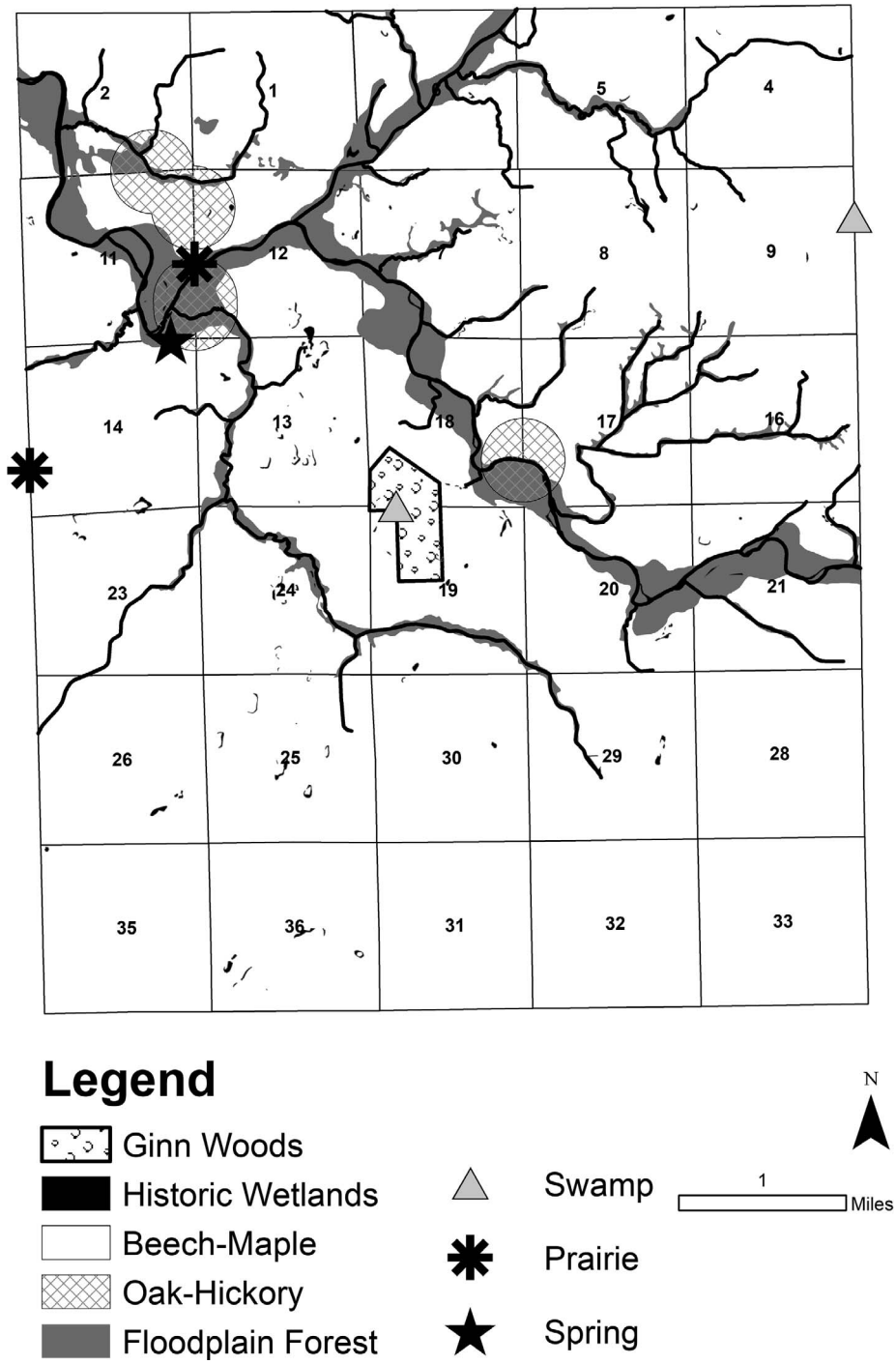

Figure 3.—Presettlement Map for Township Sections surrounding Ginn Woods. The map was assembled using methods from Barr et al. (2002) and represents the study site's historic 1820 forest associations and landscape features.

Table 4.—Cumulative totals of Historic Land Associations for the Ginn Woods study area for acreage and percent of total acres (See Fig. 3).

Historic Land Associations	Historic acreage	Percent of total acres
Beech-Maple	13,392	69
Oak-Hickory	4,223	22
Floodplain	1,597	8.5
Wetlands	88	0.5
Total	19,200	100

data, illustrates that the Beech-Maple community accounts for 69% of the study area, followed by Oak-Hickory at 22%. The hydrological system-related associations of Floodplain (8.5%) and Wetland (0.5%) account for about 9% of the study area (Table 4).

A comparison of presettlement GLO and GAP data illustrates changes to the study site over time (Tables 4 & 5). The historic forest/wetland/floodplain landscape composition documented by GLO surveyors is now dominated by agriculture (78%). The presettlement forest, identified as "deciduous" in the GAP data, has shrunk to only 13% of the study site. Wetland and floodplain communities that represented about 9% of the presettlement landscape have contracted to only 2%.

DISCUSSION

The Ginn Woods study site is located at the southern end of the Bluffton Till Plain, and is characterized by poorly drained clayey till. A common characteristic of the soils are small depressions that facilitate ponding. Red maple, bur oak, swamp white oak, American elm, and green ash are timber species characteristic of poorly drained areas. Beech, sugar maple, tulip poplar, and white ash are timber species typical of the plain's better drained but moist soils (Homoya et al. 1995). Braun (1950) reported that the Beech-Maple region of the US is "so uniform throughout its extent" that vegetative changes are unrecognizable (1950:309). Till plain forests are characterized by "low relief where minor differences in elevation (a foot or two), resulting in differences in soil moisture and aeration, determine the soil type" (1950:316). Oak-Hickory association species are typically found in gravel or sandy areas too dry for Beech-Maple species. Therefore, vegetative changes are based on local edaphic and topographic changes.

The level plain of the study site is divided by the Mississinewa River valley that runs southeast to northwest approximately thirty feet (10 m) below the adjacent uplands. The river channel is characterized by a level flood plain containing mounds of soil deposits from seasonal flooding. Additional topographic changes in the study area are created by small stream tributaries to the river.

The sections were surveyed by John McDonald in 1819 and 1820, and digital copies of the notes were viewed at the Ball State University Applied Anthropology Laboratories. Along with the identification of witness trees, McDonald identified several distinct landscape features. In two locations he recorded "prairie" in the notes; the first as part of the Mississinewa River floodplain, and a second on the uplands of Section 14. From notes describing a wet "prairie" in the township just west of the study site, and his inability to set a post or blaze a tree, we know that the surveyor used the term to describe a treeless landscape. Conversley, the term "swamp" was used to describe a forested wetland in the uplands of Section 9, and in what would become Ginn Woods in Sections 18 and 19. A "spring" was also identified in the Mississinewa River floodplain between Sections 11 and 14, although there is no

Table 5.—Cumulative totals of current land associations for the Ginn Woods study area for acreage and percent of total acres.

Current GAP land use categories	Current acreage (from GAP data)	Percent of total	Percent loss from historic woodlands and wetlands
Agriculture	14, 974	78.0	
Deciduous Forest	2,489	13.0	(85.7)
Evergreen Forest	34	0.2	
Other Vegetation	262	1.3	
Development	1,070	5.6	
Wetlands	371	1.9	(78.4)
Total	19,200		

indication in the notes that it supported a significant vegetative community.

Ginn Woods is located on a flat upland site between the Mississinewa River and Pipe Creek. It straddles the east-west survey line between Sections 18 and 19. Four of the six witness trees in the property are beech, and the other two are white ash and white oak. The notes also identify a swamp fifteen chains (990 ft, 302 m) from the west boundary of the Ginn Woods property, and demonstrates the presence of ponding within the woods. Spicebush (*Lindera benzoin*; denoted by the surveyor as spicewood) and prickly ash (*Zanthoxylum americanum*) are listed as understory species.

Mapped witness trees from GLO survey notes illustrate that, historically, Ginn Woods and its surrounding landscape represented an upland, mostly level Beech-Maple forest association dotted with small ponded wetlands. More than 50% of the trees in the GLO sample were either beech or sugar maple. American beech (*Fagus grandifolia*) accounted for 138 trees and 44% of the total trees in the study area. Sugar maple (*Acer saccharum*) was the next most populous tree at 24 and counted for 7.6% of witiness trees. The section of landscape containing Ginn Woods was mostly isolated between the floodplain communities asociated with the Mississenawa River and Pipe Creek.

The GLO notes identified treeless prairies in both floodplain and upland settings. The surveyor used the term "swamp" twice, indicating locations of forested wetlands in contrast to open wet meadows. One of the swamp areas is part of Ginn Woods. A review of aerial photography shows how ditches drain the farm fields surrounding the current forest, a practice common in northern Delaware County.

GLO notes indicate the presence of trees representating the Oak-Hickory association in the sections west of Ginn Woods (Sections 11–14, 23–26, and 35), and east (Sections 17–20). Till plain soil characteristics, hydrology, and topography are consistent throughout the upland area on the south side of the Mississenawa, and no patterns of soil types driving a change in species composition, as described by Crankshaw & Lindsey (1965) and Braun (1950), were discernable. Absent of these patterns, a designation of Beech-Maple-Oak mix might better represent these woodlands. Kricher & Morrison (1988) describe how Oak-Hickory forests "intermingle with virtually all other forest types" on moist sites, and are typically characterised by "both" oak and hickory species. The GLO data tend to support this characterization. Twenty-nine oaks, and nineteen hickories were recorded as witness trees (15% of all trees). Twenty-eight share a point with a witness tree having a Beech-Maple association, or are within a quarter mile of a witness tree with a Beech-Maple association.

GLO notes provide a sample of trees species and sizes that can be compared to the current species composition of Ginn Woods. Badger et al. (1998) defined the structure and composition for the woods, and described it as a Maple-Beech-Basswood old-growth forest. The study identified twenty-eight species within Ginn Woods. Nine are not listed as witness trees in the GLO study (i.e., red maple, silver maple, black ash, green ash, Kentucky coffeetree, tulip poplar, cottonwood, chinquapin oak, and basswood). The GLO study identified twenty-five species, five of which are not found in Ginn Woods (i.e., dogwood, black gum, ironwood, aspen, and willow). The composition of the study area is also significantly different than that of the property. Badger et al. found a dominance of sugar maple (36%) over beech (8%) when the three areas of Ginn Woods were averaged. Conversely, the GLO study identified a composition of beech (44%) over sugar maple (8%). Therefore, the current composition of Ginn Woods is significantly different from the presumed composition recorded in the GLO data. There are several potential explanations for this difference, such as change in species composition over time, the local environmental conditions creating Ginn Woods is distinct from the study area as a whole, surveyor bias, or the GLO data is too coarse to define composition at the Ginn Woods scale.

While wet prairies were not identified in the area that became Ginn Woods, the GLO notes do indicate that it was common to find these wetland openings in the study area's forest canopy. The notes identify Ginn Woods as "swamp." Unfortunately, they do not identify the wetland species for comparison to present conditions. Regardless, GLO notes identify this body of water as historic, and management and future land purchases should focus on preserving the offsite hydrologic systems supporting the woods.

A comparison of the historic GLO and contemporary GAP landscapes illustrates the dramatic change from presettlement forest to agriculture (Table 5). The presettlement forest, identified as "deciduous" in the GAP data, has

shrunk to only 13% of the study site—a loss of more than 85% of the historic woodland landcover. The GAP data does not provide a measurement of the ecological quality of the current forest cover, but these woodlands are mainly restricted to fencerows, ravines, floodplain, and the occasional 2nd growth, degraded woodlot. Equally dramatic is the loss of approximately 78% of the site's wetlands. While not yet studied, agricultural practices have likely caused changes to the landscape affecting Ginn Woods, including hydrological changes, the introduction of exotic species, and the use of pesticides, herbicides, and fertilizers that drift or flow into the woods.

Finally, GLO and GAP data indicate, to a degree, how species makeup has changed in the study area. For instance, GAP data indicates the presence of 34 acres of non-native "evergreen forests" at four Christmas tree farms. Species have surely disappeared as well. Ash of various species (possibly black, blue, white, and green) account for 13% of the GLO witness trees, and elm another 5% (with American elm likely represented). However, due to the emerald ash borer and Dutch elm disease infestations, these species have declined, and it is unclear what species will fill the void. Fortunately, in the light of all these changes, Ginn Woods remains a rare and protected example of Indiana's presettlement forests.

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