PRE-EUROPEAN SETTLEMENT VEGETATION OF KENDALL COUNTY, ILLINOIS

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Summary

We mapped and analyzed the landscape pattern and composition of vegetation described by the U. S. Public Land Survey (PLS) of Kendall County, Illinois, which was conducted between 1821 and 1838. Kendall County was mapped by the PLS as 85 % prairie, 12 % timber, 2 % scattering timber and less than 1 % barrens and brush. Timber was primarily restricted to fire-protected borders of the Fox River and its tributaries, and in isolated groves in the southwestern and southeastern parts of the county. Scattering timber occurred in association with timber along the Fox River, Blackberry Creek and Rock Creek. Based on calculations from bearing tree densities, areas mapped by the PLS as timber were about 60 % savanna, averaged 80 trees/ha, and were dominated by bur, white and black. Areas of scattering timber were about 70 % savanna, averaged less than 40 trees/ha, and were dominated by bur oak. Black oak was an important secondary species in both types. Forest and woodland, represented by > 100 trees/ha and 50-100 trees/ha, respectively, represented about 40 % of the areas mapped as timber and 30 % of the areas mapped as scattering timber. They were also dominated by white oak, but had less abundance of bur oak and greater abundance of the mesophytic species red oak, sugar maple, basswood and ash. The landscape pattern of this vegetation indicates that fire processes played a significant role in shaping the presettlement vegetation pattern of Kendall Co. Fire is therefore critical for restoring and managing woody vegetation to represent presettlement conditions, as well as for maintaining the floristic diversity present at the time of settlement.

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INTRODUCTION

At the time of European settlement (*ca.* 1820), northeastern Illinois was a broad mosaic of prairie and oak (*Quercus*)-dominated savanna, which comprised the northeasterly transition from tallgrass prairie to eastern deciduous forests (Davis 1977, Anderson 1983, Anderson & Bowles 1999). This pattern was climatically induced and controlled by fires set by lightning and by indigenous people, with timber persisting on the lee sides of fire barriers provided by topographic relief or water courses (Gleason 1913, Moran 1978, 1980, Grimm 1983, 1984, Anderson 1991, Leitner *et al.* 1991, Bowles *et al*. 1994, McBride & Bowles 2001). Most of this original vegetation has been lost because of wide-scale fragmentation by agriculture and urbanization, while remnants have deteriorated from fire suppression and overgrazing (Cottam 1949, McCune & Cottam 1985, Anderson 1991, Stearns 1991, Robertson & Schwartz 1994, Schwartz 1997, Bowles & McBride 1998). Consequently, management and restoration of this vegetation represents an important challenge (Apfelbaum & Haney 1991, Leach & Ross 1995, Shore 1997, Bowles & McBride 1998). Conservationists need an understanding of the composition, structure, and dynamic processes of pre-European settlement (traditionally termed "pre-settlement") vegetation so as to better manage and restore its original biodiversity. Ecological models that apply presettlement landscape fire processes to vegetation pattern, composition, and structure will best meet these needs (Leach & Ross 1995). In this report on the presettlement vegetation of Kendall County, we interpret landscape vegetation pattern, structure and composition in relation to landscape features and fire processes and make management and restoration recommendations.

The Public Land Survey

A powerful approach to understanding the landscape pattern and structure of woody vegetation prior to European settlement is analysis of the Government Land Office Public Land Survey (PLS) vegetation notes, maps, and bearing tree data, which were recorded in the early 1800s in Illinois (Hutchison 1988, Ebinger 1997). This survey comprised a square-mile landscape grid upon which the identity, diameter, distance, and direction for one to four bearing trees were recorded at half mile intervals. These data were accompanied by measures of trees intercepted on section lines, section line vegetation summaries, other notes, and township plats distinguishing timber, prairie, and other important landscape features.

Despite evidence for biased or non-random selection of bearing trees (Bourdo 1956, Anderson *in press*), the PLS data represent a large-scale vegetation survey that can be used to reconstruct landscape-scale pre-European vegetation (Brugam & Patterson 1996). These data can allow estimates of forest composition and ranking of species dominance, but the large sampling scale usually prevents accurate and detailed mapping of vegetation types (Manies & Mladenoff 2000). However, site-specific comparisons and precise mapping of vegetation boundaries may be possible (*e.g.* Bowles & McBride 1998). These data also can provide ecological information when landscape features, such as soils, topography, or fire barriers, are used to interpret the distribution pattern of different vegetation types based on their composition and structure (Leitner *et al*. 1991, Anderson & Anderson 1975, Moran 1978, 1980, Rogers & Anderson 1979, Bowles *et al.* 1994, 1999, and Edgin & Ebinger 1997).

A useful landscape fire model that can be tested based on PLS data predicts that fire driven by prevailing

westerly winds would reduce coverage of woody vegetation on the western sides of landscape fire breaks (e.g. Leitner *et al*. 1991). For example, Lake, Cook, DuPage, Will and Kane counties had greater landscape cover of prairie and savanna in areas with little landscape fire protection, and greater tree densities as well as greater abundance of fire-intolerant trees, such as sugar maple, ash and basswood in more fire-protected landscape positions on the eastern sides of watercourses (Kilburn 1959, Moran 1980, Bowles *et al*. 1994, 1999, Bowles & McBride 2001, 2002, 2003, 2004; McBride & Bowles 2001). Modern vegetation studies also support this concept, as maple-dominated forest remnants still occur along the Des Plaines River floodplain (Bowles et al. 2000).

Study area

Kendall County is situated at the southwestern border of the Chicago region. It comprises 9 townships covering 111,91 hectares (27,642 acres). Kendall County uplands occur on the Grand Prairie Section of the Grand Prairie Natural Division of the Chicago Region, while lower areas along the Fox River occur in the Fox River Bluff Section of the Morainal Natural Division (Mierzwa 1984). Although most of the county is drained by the Fox River, the southeastern part of the county drains to the south into Aux Sable Creek, and both flow into the Illinois River. The glacial stratigraphy of Kendall County is primarily Woodfordian-aged glacial drift, including alternating end-moraines, ground moraines and outwash (Figure 1). The southwestern edge of the county lies on the Rockdale moraine, while sections of the Westmont, St. Charles, Norway, Wheaton and West Chicago Moraines border the eastern edge of the county. The southeastern part of the County lies on the northern edge of the bed of glacial Lake Waubonsee, which was deposited as part of the Kankakee Torrent. Most of the lake bed soils are fine-textured, although some linear sand and gravel deposits are present. Sand and gravel also occur as outwash in the northeastern part of the county.

Study objectives

We examined the presettlement woody vegetation pattern and structure in Kendall County based on analysis of PLS maps and data. Our objectives were to: 1) assess how the PLS described and sampled vegetation and relate the results to modern concepts of savanna, woodland, and forest, 2) correlate vegetation pattern and structure with geographic location, landscape features and fire processes, 3) describe presettlement vegetation based on the PLS data, and 4) apply these results toward management and restoration guidelines for native woody-dominated ecosystems.

Based on our previous studies of Chicago region counties, we expected that vegetation in Kendall County was patterned by an interaction between eastward moving prairie fires (driven by westerly winds) and potential landscape firebreaks such as steep topography or water courses. For example, this process would result in greater abundance of timber on the north side of the Fox River, and on the east sides of its tributaries. We also expected fire to affect forest structure and composition. For example, lower tree density (savanna) and dominance by oaks (*Quercus* spp.) would be expected in areas of timber along the south border of the Fox River, while greater tree density and presence of fire sensitive species, such as maple (*Acer*), ash (*Fraxinus*), basswood (*Tilia*) and elm (*Ulmus*) species would be expected in more fire-protected areas north of the river.

HISTORIC METHODS

PLS Vegetation types

The Kendall County Public Land Survey was conducted primarily in 1837-38 by the Deputy surveyors Eli Prescott and James Rees (Table 1). In 1821, George Thomas and Daniel Miller surveyed the areas south of the Indian Boundary, which crossed the southernmost townships of Kendall County (Table 1). Each township was mapped after completion of its survey, showing the distribution of timber, watercourses, and settlement features. The Kendall Co. PLS also described different vegetation types, including *prairie, wet prairie, marsh, slough, swamp, brush, barrens, scattering timber* and *timber*. The PLS indicated distances along section lines for transitions between these vegetation types, which facilitated their mapping. The primary data collected by the PLS were the identity, diameter, distance, and direction for one to four bearing trees, each located in one of the four quadrants at each section corner, as well as for up to two bearing trees located in different quadrants at section quarter-corners and river crossings. Surveyors also recorded the identity and diameter of line trees intercepted by section lines and summarized tree species present along section lines. In Kendall County, the surveyors rarely recorded species presence or absence in undergrowth along section lines. For this reason the data was not considered a representative sample of the abundance or characteristics of woody undergrowth.

Species identification

The surveyors identified about 20 different bearing and line trees by common name, including most of the dominant native tree species. We assume that most witness tree species were correctly identified and placed them in modern species analogs following Swink and Wilhelm (1994). However, identification of oaks, especially members of the black oak group, appears to have been difficult or inconsistent among surveyors (Collins 1997, Clark 2000). References to black oak (*Q. velutina*) in Kendall Co. also may have included scarlet oak or hybrids among scarlet, black and red oak, as pure black oak is frequent only in well drained sand and gravel (Swink and Wilhelm 1994). Surveys south of the Indian Boundary also used the term “B. Oak,” which may have referred to both black oak and bur oak (*Quercus macrocarpa*). The term “maple” was applied to soft maple (*Acer saccharinum*), a floodplain species, while “sugar tree” was applied to *A. saccharum*, a species of mesic forest habitat (Swink and Wilhelm 1994). Ash species (*Fraxinius* sp.) probably included white ash (*Fraxinus americana*), red ash (*F. pennsylvanica*), green ash (*F. pennsylvanica* var. *sub-integerrima*), blue ash (*F. quadrangulata*) or black ash (*F. nigra*). The surveyors also identified 14 species present as woody undergrowth, including many canopy trees. Specific shrub-layer species also included hazel (*Corylus americana*). Other names such as “vines” or “thorn” are vague. Many additional shrub species may have been unknown to the surveyors (Clark 2000).

MODERN METHODS

Mapping and interpretation

The PLS data were taken from microfilmed copies of the original notes, which were transcribed in the

1840's. These data were used to refine the original PLS vegetation plat maps by digitizing vegetation boundaries and bearing tree locations using ARC/INFO Geographical Information System (GIS) software (McBride 2004). GIS was also used to add layers for section lines, bearing trees, section and quarter-corner tree densities, line trees, tree species summaries and woody undergrowth summaries. Features of European settlement, such as fields, were included as separate GIS layers not used in vegetation maps or landscape analysis.

Tree density classes

All recorded bearing tree distances were used to calculate tree density for each section and quarter-corner. This procedure followed the modified point-center-quarter sampling method, where trees/hectare = 10,000 $m^2 \div (\bar{\times} d)^2$, and $\bar{\times} d$ = the mean distance of up to four bearing trees at each corner adjusted for the number of trees sampled (Cottam & Curtis 1956). A 400 trees/ha ceiling for tree densities was used to avoid artificially high values that can result from the point-center-quarter method. Corner and quarter corner bearing tree densities were used to calculate average densities for the PLS vegetation types of timber, scattering timber, prairie and wet prairie, and wetlands. For vegetation that usually did not support bearing trees, such as prairie, these densities represent only corners with trees, and thus local tree densities. According to Clark (2000) selection of the Q1 (nearest) bearing tree was least likely to be biased, and calculation of density using additional bearing trees from the same corner will result in low estimates of stand density. However, use of multiple trees to produce a mean distance may reduce random distance errors produced by using single distances. To further reduce effects of bias on vegetation classification, we placed density calculations into broad classes of *open savanna* (> 0-10 trees/ha), *savanna* (> 10-50 trees/ha), *woodland* (> 50-100 trees/ha) and *forest* (> 100 trees/ha) categories following Bowles *et al*. (1994, 1999). The total and relative (R) density (D) and basal area (BA) and importance value [IV = (RD + RBA)÷2] were calculated for each bearing tree species in all vegetation types and categories. Basal area was calculated in square meters by converting from the original measure of diameter in inches. These data are based on total occurrences within each vegetation type, thus represent an unbalanced sample. As a result, only relative data and importance values can be compared among vegetation types.

Statistical comparisons and analysis

Bearing tree data were used to make comparisons among the vegetation types identified by the PLS (i.e. timber, scattering timber, etc.) and among tree density classes. The structure of PLS vegetation types was compared using the relative abundance of savanna (> 0-10 trees/ha), open savanna (> 10-50 trees/ha), woodland (> 50-100 trees/ha) and forest (> 100 trees/ha) tree density classes within each of these vegetation types. We also examined the relationship between tree density (among the four tree density classes) and abundance of dominant trees (bur oak, white oak and black oak), as well as mesophytic forest trees, which have relatively low importance values. To assess landscape effects on vegetation structure, we compared tree densities and species composition in timber located north and south of the Fox River, as well as in isolated prairie groves in southwest, southeast and northeast Kendall County. We assumed that greater tree densities and abundance of mesophytic species would occur north of the river due to its protection from prairie fires driven by prevailing southwesterly winds.

To determine whether vegetation occurred across an interpretable floristic gradient, we ordinated tree species presence data (n = 13 species) from section line summaries (n = 188 section lines) of timber and scattering timber. These data were ordinated using Non Metric Multi-dimension Scaling on PCORD software with a Sorensen (Bray-Curtis) distance measure (McCune & Mefford 1995). For this analysis, "B oak" and species with fewer than three occurrences were eliminated from the data set. Flexible Beta cluster analysis (β = -0.25) was used to identify species groups using a Sorensen distance metric on PCORD. We then used known ecological adaptations of different species to make inferences about habitat conditions and vegetation types.

RESULTS

Vegetation pattern and structure

About 85 % of the presettlement vegetation cover of Kendall County was grassland, with 13.4 % woody vegetation including about 12 % timber, 2 % scattering timber, and less than 1 % barrens and brush (Table 2). Wetlands and watercourses represented about 1 % of the landscape. Timber was primarily restricted to the Fox River and its northern and southern tributaries, but also occurred in the "Big Grove" in the southwest, in "Wash-kee-shaw's Reservation" in the east, and a linear grove along Aux Sable Creek in the southeast (Figure 2). Scattering timber was infrequent and occurred with timber along the Fox River, Blackberry Creek and Rock Creek. Two small tracts of barrens were mapped along the south edge of timber bordering the south of the Fox River. There was a strong correspondence between areas of timber and areas of forest soils (Figure 2). The greatest difference was a more extensive area of forest soils than timber along the southern border of the Fox River, and along Rob Roy Creek, which was primarily scattering timber.

Landscape vegetation structure based on tree density classes was about 65 % savanna and about 35 % woodland and forest (Figure 3). Based on vegetation described by the PLS, timber was about 55 % savanna and averaged about 80 trees/ha (Figure 3). Scattering timber was almost 70 % savanna and averaged about 35 trees/ha. Prairie had few bearing trees, but when present, 80 % were open savanna, averaging about 10 trees/ha. Barrens and brush were too infrequent to provide meaningful statistics. In the landscape comparison, tree densities were about 140 trees/ha in the Big Grove almost 100 trees/ha in "Wash-kee-shaw's Reservation. Other stands representing timber north and south of the Fox River averaged less than 60 trees/ha (Figure 4).

Woody vegetation composition

Among the PLS vegetation types, species richness was greatest in timber, where 17 species were sampled (Table 3). White oak was dominant over bur oak and black oak, and hickory and red oak were important secondary species. Scattering timber was dominated by bur oak with white oak and black oak as subdominant species. Bur oak was also the predominant species recorded from prairie habitat.

There was little variation in species richness among the tree density classes, with 11 species recorded in open savanna, and 13 species in savanna, woodland and forest (Table 3). However, composition differed across this tree density gradient (Figure 5). Among dominant trees, bur and black oak were most important in open

savanna and declined with increasing tree density, while white oak was most abundant at intermediate densities. Composition of secondary species also shifted across this gradient, with greatest importance of red oak, sugar maple, basswood and ash in forest or woodland conditions (Figure 6). In the landscape comparison, sugar maple and hickory were dominant over white oak in the Big Grove, and sugar maple and red oak were dominant in Wash-kee-shaw's Reservation. (Table 5).

The NMS ordination had less than 5 % randomized runs with stress less than observed stress, and cumulative $r^2 = 0.509$ and 0.737 for the first and second axes, respectively. Black oak, white oak, hickory and bur oak had low first axis scores, red oak, walnut, basswood, ash, elm and sugar maple had intermediate scores, and poplar, sycamore and soft maple had high first axis scores (Figure 6). Flexible Beta cluster analysis had < 15 % chaining, and formed four groups that corresponded closely to the first axis ordination (Figure 6). With 75 % information remaining, it clustered 1) hickory-red oak, 2) ash-basswood-sugar maple, and 3) elm-walnut-soft maple-poplar-sycamore groups. With about 30 % information remaining, it also clustered a white oak-black oak-bur oak group.

DISCUSSION

Landscape vegetation pattern and structure

The structure, composition and pattern of presettlement vegetation in Kendall County has strong similarities but also some differences with other Chicago region counties. The extensive coverage of savanna dominated by bur and white oak reinforces that fire-maintained oak savannas were widespread and typical of the Chicago region vegetation. In addition, the occurrence of timber along corridors associated with the Fox River and its tributaries indicates that these landscape firebreaks were critical in providing the greater degree of fire protection needed for persistence of trees. However, Kendall County also had greater tree densities and greater abundance of mesophytic tree species in two isolated prairie groves than in timber located north of the Fox River. There is no apparent explanation for this anomaly, as these isolated groves were expected to have low tree densities and dominance by oaks based upon conditions in other Chicago region counties.

As in other counties, the relatively high abundance of black oak bearing trees was unexpected, as this species occupies dry habitats and is a rare component of modern Chicago region forests (Bowles et al. 2000). Misidentification of other oak species for black oak is one possible explanation. Nevertheless, excessive drainage on thin layers of till or gravel deposits may have promoted black oak along the Fox River. For example, black oak remains a dominant species in sand savanna habitats in southern Will County and on the Lake Michigan sand plain (Swink & Wilhelm 1994).

The excessively large area of prairie in Kendall, County, exceeding 85 % of the landscape, indicates a trend toward greater cover of prairie in the southern portion of the Chicago region. For example, cover of timber exceeded 40 % in Lake and McHenry counties and 36 % in Kane County but did not exceed 20 % in other counties. This shift toward greater coverage of timber in the northern counties and greater cover of prairie in the souther part of the Chicago region corresponds to northern transitional boundary of the Prairie Peninsula, which crosses northeastern Illinois.

The vegetation pattern in the Chicago region at the time of settlement represents an intermediate stage in a dynamic process of fire-caused conversion from forest to prairie, a process that began 8,000-6,000 years ago during the hottest and driest part of the Holocene in Illinois and continued with Indian-set fires as the Holocene climate began to moderate (Gleason 1922, Transeau 1935, Curtis 1959, Grimm 1984). This vegetation shifted spatially over time in response to changing climatic conditions, favoring either forest during periods of greater rainfall and less frequent fire, or prairie and savanna during periods of less rainfall and more frequent fire. It may have been stabilized by fire, as well as stable climatic conditions, over short time periods, such as at the time of the PLS (Anderson & Bowles 1999). The comparison showing greater coverage of forest soils than extent of timber in Kendall County suggests that an ongoing loss of woody vegetation was occurring at a pace slightly ahead of the conversion of forest soils to prairie soils. Our analysis of the spatial pattern and relationship between prairie, timber and scattering timber in Chicago region presettlement vegetation also indicates that open savanna (<10 trees/ha) as well as scattering timber probably represent an extremely late stage before conversion to prairie. Thus, the areas of scattering timber in Kendall County might eventually have been converted to prairie if fire processes had continued, leaving forest soils as a vestige
of former areas of timber.

Woody vegetation types

Savanna

Open savanna (< 10 trees/ha) dominated by bur oak with secondary abundance of white oak and black oak was the predominant woody vegetation type in Kendall Co. This vegetation appears to correspond most closely to scattering timber described by the Public Land Survey, which was also dominated by bur oak. With increasing tree density, open savanna graded into savanna (10 - < 50 trees/ha) in which white oak replaced bur oak as the dominant species. This shift toward greater tree density, as well as dominance by the less fire resistant white oak, appears to correspond to a decreasing fire effect. This apparently also had an effect on abundance of the mesophytic species sugar maple, basswood and ash, as they were represented in savanna but not in open savanna.

Woodland

Although oak woodland (> 50-100 trees/ha) is often thought of as typifying the Chicago region's presettlement oak timber, this vegetation component has been found to be the most infrequent of presettlement vegetation types based on tree density classes (Bowles *et al.* 1994, 1999, Bowles & McBride 2001, 2002; McBride & Bowles 2001). Indeed, woodland was the rarest wooded landscape component in Kendall Co., although it was only slightly less frequent than forest. This figure also could have been inflated by chance occurrences of sampling points adjacent to trees in savanna, which would result in calculation of higher tree densities by the point-center-quarter method. Our data show no signature tree species for woodland, and its composition appears to have been intermediate between savanna and forest among both dominant oaks and less frequent mesophytic species.

Forest

Forest vegetation was only slightly more abundant than woodland. This figure also could have been inflated by chance occurrences of sampling points adjacent to trees in savanna or woodland, which would result in calculation of higher tree densities by the point-center-quarter method. However, the occurrence in forest of greater abundance of mesophytic species, such as sugar maple, suggests that its greater tree density was an actual landscape feature. Ordination and cluster analysis also suggest that there may have been separate upland and wetland forest groups. A sugar maple-basswood-ash group would have occupied upland habitats along the Fox River and in prairie groves, while the sycamore- poplar-soft maple-walnut-elm group may have been associated with wet-mesic habitats such as the floodplain terraces of the Fox River.

Minor communities

Although Barrrens occupied less than 1 % of the woody vegetation of Kendall County, they have been consistently identified and mapped by the PLS in all Chicago region counties. Barrens vegetation is one of the most ambiguous presettlement vegetation types. The term was originally applied to areas where poor soil limited tree growth, such as "pine barrens." However, in the glaciated region of Illinois it was applied to areas of the forest-prairie border where burning had reduced woody vegetation to post-fire sprouts - a condition though by the surveyors to represent poor soil conditions because of the poor condition of trees. As a result, most barrens mapped by the PLS in the Chicago region had high % cover of woody undergrowth comprising hazel and oak sprouts and low tree density. Woody undergrowth was recorded too infrequently in Kendall County to provide helpful data on the structure of barrens. Likewise, the presence of only four bearing trees, dominated by white and black oak, suggests that there was little difference in canopy trees between barrens and savanna habitats.

MANAGEMENT AND RESTORATION

Issues of scale and accuracy and vegetation change

Although the PLS sampling data provide meaningful information, applying landscape data directly to small-scale restoration and management can be problematic without an appropriate transfer of scale (Manies & Mladenoff 2000). For example, the landscape-scale PLS sample coverage would provide few sample points that might directly apply at a small scale to existing sites (Bowles & McBride 1998). Further, the point-center-quarter sampling method is vulnerable to non-random vegetation patterns and to sampling error, and may provide erroneous information with small sample sizes. A single random sample occurring within a small group of trees in open savanna could result in an estimate of forest tree density, leading to a conclusion that the site was forest.

Management to restore presettlement or "natural" vegetation conditions also must take into account the dynamic nature of vegetation and the strong possibility that many, if not most, Holocene fires were Indian set. If presettlement vegetation pattern and structure changed very little during periods of stable climatic conditions, then conditions present in the early 1800's probably would have persisted after the 19th century, especially if the presettlement fire regime had been stable. Therefore, the structure and composition of this vegetation would represent a framework for setting restoration management goals and objectives, and for understanding the landscape

processes needed to reach these goals.

Restoring fire processes, species composition and structure

The structure and composition of woody vegetation in Kendall County indicate that restoration goals should include oak dominance in most woody vegetation types. The landscape pattern of this vegetation also indicates that fire processes played a significant role in shaping the presettlement vegetation pattern of Kendall Co. Fire is therefore critical for restoring and managing woody vegetation to represent presettlement conditions, as well as for maintaining the floristic diversity present at the time of settlement. The dominance of oaks throughout all woody vegetation types also indicates that fire affected the entire continuum of woody vegetation. Replacement in tree fall gaps, probably also occurred at higher tree densities in forests.

The Kendall County data also indicate that assumptions about former levels of abundance of woodland need to be re-evaluated. Woodland is often considered to have been the predominant woody vegetation type of the Chicago region and is an important focus of restoration activities (Chicago Biodiversity Council 1999). However, results from Kendall Co., as well as from other counties (e.g. McBride and Bowles 2001), indicate that woodland occupied less than 20% of the landscape, and that forest vegetation was more abundant. Many existing woody vegetation remnants that are considered representative of woodland (e.g. Bowles & McBride 1996) may have been formerly more open savanna communities (Bowles et al. 1998). As a result, management to restore woodland structure may not replicate the conditions present prior to settlement. In turn, some modern forest remnants may have been originally more open and similar to woodland. Restructuring these remnants to a former more open woodland structure will require the use of fire as well as supplemental mechanical canopy thinning. However, based on tree density classes, forest vegetation was also present in fire-protected habitat, and little information is available about the fine-scale structure and composition of these forests. Because of the limited information about presettlement woodland and forest, applied research will be required to learn how to maintain biological diversity when these habitats are managed to replicate presettlement conditions (Bowles et al. 1998).

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Table 1. Year of survey and species translations for bearing trees identified by Deputy Surveyors for the Public Land Survey of Lake County, Illinois.

Common Name	Scientific Name	1821 Daniel Miller	1821 George Thomas	1837-1839 Eli Prescott	1838 James Rees
Ash	*Fraxinus sp.*	Ash		Ash	Ash
Basswood	*Tilia americana*	Lynn		Lynn	Lynn
B oak	*Quercus sp.*	B oak	B oak		
Bur oak	*Quercus macrocarpa*			Bur oak	Bur oak
Black oak	*Quercus velutina*			Black oak	Black oak
Cherry	*Prunus serotina*				Cherry
Elm	*Ulmus sp.*			Elm	Elm
Hickory	*Carya ovata*	Hickory		Hickory	Hickory
Ironwood	*Ostrya virginiana*			Ironwood	
Maple	*Acer saccharinum*			Maple	
Red oak	*Quercus rubra*			Red oak	Red oak
Sugar maple	*Acer saccharum*	Sugartree	Sugartree	Sugartree	
Sycamore	*Platanus occidentalis*			Sycamore	Sycamore
Walnut	*Juglans nigra*	Walnut	Walnut	Walnut	Black walnut
Butternut	*Juglans cinerea*			White walnut	
White oak	*Quercus alba*	White oak	White oak	White oak	White oak

Table 2. Coverage of pre-European settlement landscape features of Kendall Co., Illinois.

Vegetation type	Community	Square meters	Hectares	Percent
Woody		**111911669.17**	**11191.17**	**13.40**
	Timber	97171930.99	9717.19	11.64
	Scattering timber	14160744.30	1416.07	1.70
	Barrens	527174.14	52.72	0.06
	Brush	51819.73	5.18	0.01
Grassland		**713701881.07**	**71370.19**	**85.47**
	Prairie	701583558.65	70158.36	84.02
	Wet prairie	12118322.42	1211.83	1.45
Wetlands		**4720743.50**	**472.07**	**0.57**
	Marsh	1876952.53	187.70	0.22
	slough	1300345.48	130.03	0.16
	Swamp	1543445.49	154.34	0.18
Aquatic		**4612904.59**		**0.55**
	River	4477859.19	447.79	0.54
	Lake	135045.41	13.50	0.02
Unsurveyed		**102492.67**	**10.25**	**0.01**
Total		**835049691.00**	**83043.68**	**100.00**

Table 3. Abundance, basal area and importance values of bearing tree species by tree density classes in Kendall County, Illinois.

Open Savanna	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**
Bur oak	59	8.88	43.07	42.34	42.70
White oak	37	5.83	27.01	27.80	27.41
Black oak	17	3.22	12.41	15.34	13.87
Hickory	12	1.08	8.76	5.16	6.96
Red oak	3	0.91	2.19	4.34	3.26
Elm	4	0.47	2.92	2.26	2.59
Black walnut	1	0.20	0.73	0.97	0.85
Sycamore	1	0.16	0.73	0.78	0.76
B oak	1	0.11	0.73	0.54	0.64
Ash	1	0.07	0.73	0.35	0.54
Cherry	1	0.02	0.73	0.12	0.42
	137	20.97	100.00	100.00	100.00
Savanna	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**
White oak	61	9.68	38.61	47.07	42.84
Bur oak	45	4.29	28.48	20.85	24.67
Black oak	20	2.21	12.66	10.76	11.71
Hickory	11	0.82	6.96	3.97	5.47
Sugartree	6	0.97	3.80	4.73	4.26
Red oak	3	0.82	1.90	4.00	2.95
Basswood	3	0.48	1.90	2.35	2.12
Ash	2	0.58	1.27	2.84	2.05
Walnut	2	0.29	1.27	1.43	1.35
Elm	2	0.19	1.27	0.91	1.09
Maple	1	0.16	0.63	0.80	0.72
B oak	1	0.04	0.63	0.20	0.42
White walnut	1	0.02	0.63	0.09	0.36
	158	20.57	100.00	100.00	100.00
Woodland	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**
White oak	30	5.55	33.71	45.89	39.80
Bur oak	15	1.62	16.85	13.37	15.11
Basswood	8	1.17	8.99	9.66	9.32
Sugartree	6	0.64	6.74	5.27	6.01
Black oak	6	0.56	6.74	4.65	5.70
Hickory	6	0.48	6.74	3.93	5.34
Ash	5	0.53	5.62	4.38	5.00
Red oak	4	0.59	4.49	4.91	4.70
Elm	4	0.58	4.49	4.80	4.65
Maple	2	0.16	2.25	1.28	1.77
B oak	1	0.16	1.12	1.36	1.24
Ironwood	1	0.04	1.12	0.34	0.73
Black walnut	1	0.02	1.12	0.15	0.64
	89	12.09	100.00	100.00	100.00
Forest	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**
White oak	20	3.54	22.47	28.76	25.62
Red oak	9	2.31	10.11	18.75	14.43
Sugartree	14	1.15	15.73	9.31	12.52
Bur oak	9	1.21	10.11	9.80	9.95
Hickory	10	0.69	11.24	5.58	8.41
Basswood	5	1.08	5.62	8.80	7.21
Ash	6	0.74	6.74	6.03	6.38
Black oak	6	0.66	6.74	5.32	6.03
Elm	5	0.32	5.62	2.63	4.12
Walnut	1	0.29	1.12	2.37	1.75
Ironwood	2	0.08	2.25	0.67	1.46
Sycamore	1	0.13	1.12	1.05	1.09
Maple	1	0.11	1.12	0.93	1.02
	89	12.33	100.00	100.00	100.00

Table 4. Abundance, basal area and importance values of bearing tree species by Public Land Survey Vegetation types in Kendall County, Illinois.

Prairie	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**
Bur oak	15.00	2.68	35.71	37.33	36.52
Black oak	9.00	1.82	21.43	25.35	23.39
White oak	10.00	1.32	23.81	18.36	21.08
Red oak	2.00	0.86	4.76	11.97	8.37
Hickory	5.00	0.34	11.90	4.72	8.31
Maple	1.00	0.16	2.38	2.29	2.33
	42.00	7.18	100.00	100.01	100.01

Wet prairie	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**
White oak	1.00	0.76	100.00	250.00	175.00
Bur oak	1.00	0.61	100.00	200.00	150.00
Ash	1.00	0.30	100.00	100.00	100.00
	3.00	1.68	300.00	550.00	425.00

Timber	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**
White oak	123.00	20.57	34.55	40.94	37.74
Bur oak	75.00	9.33	21.07	18.56	19.82
Black oak	29.00	4.02	8.15	8.00	8.07
Hickory	32.00	2.64	8.99	5.26	7.12
Sugar maple	26.00	2.76	7.30	5.49	6.40
Red oak	16.00	3.73	4.49	7.42	5.96
Basswood	15.00	2.63	4.21	5.24	4.73
Elm	14.00	1.40	3.93	2.79	3.36
Ash	11.00	1.63	3.09	3.24	3.16
Walnut	3.00	0.59	0.84	1.17	1.00
B oak	3.00	0.32	0.84	0.64	0.74
Black walnut	2.00	0.22	0.56	0.44	0.50
Maple	2.00	0.16	0.56	0.31	0.44
Ironwood	2.00	0.08	0.56	0.17	0.36
Sycamore	1.00	0.13	0.28	0.26	0.27
Cherry	1.00	0.02	0.28	0.05	0.17
White walnut	1.00	0.02	0.28	0.04	0.16
	356.00	50.24	100.00	100.00	100.00

Scattering timber	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**
Bur oak	36.00	3.64	55.38	36.40	45.89
White oak	12.00	1.95	18.46	19.52	18.99
Black oak	8.00	1.98	12.31	19.79	16.05
Ash	2.00	0.76	3.08	7.61	5.34
Elm	1.00	0.46	1.54	4.57	3.05
Maple	1.00	0.38	1.54	3.81	2.67
Lynn	1.00	0.36	1.54	3.55	2.55
Hickory	2.00	0.08	3.08	0.83	1.95
Ironwood	1.00	0.23	1.54	2.28	1.91
Sycamore	1.00	0.16	1.54	1.64	1.59
	65.00	10.01	100.00	100.00	100.00

Barrens	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**
White oak	2.00	0.31	33.33	57.03	45.18
Black oak	2.00	0.13	33.33	24.33	28.83
Bur oak	1.00	0.05	16.67	9.32	12.99
Red oak	1.00	0.05	16.67	9.32	12.99
	6.00	0.54	100.00	100.00	100.00

Swamp	**Abundance**	**Basal Area**	**Rel.abund.**	**Rel.BA**	**IV**

Black oak	1.00	0.51	100.00	100.00	100.00	

Table 5. Landscape differences in relative abundance of tree species located north and south of the Fox River, in the Big Grove, the Wash-kee-shaw, Reservation, and in southeast Kendall County, Illinois.

Species	N of river	S of river	Big Grove	Reservation	SE
White oak	33.58	56.52	16.67	21.21	36.36
Bur oak	40.30	--	11.11	--	4.55
Sugar maple	--	17.39	22.22	15.15	4.55
Hickory	8.21	--	22.22	12.12	9.09
Basswood	0.75	3.26	8.33	3.03	18.18
Red oak	0.75	17.39	2.78	27.27	--
Black oak	11.94	--	5.56	9.09	--
Ash	0.75	--	2.78	9.09	13.64
B oak	--	--	--	--	9.09
Elm	2.99	--	5.56	--	--
Walnut	0.75	--	--	--	4.55
Soft maple	--	3.26	--	--	--
Ironwood	--	--	2.78	3.03	--
Butternut	--	1.09	--	--	--
Sycamore	--	1.09	--	--	--

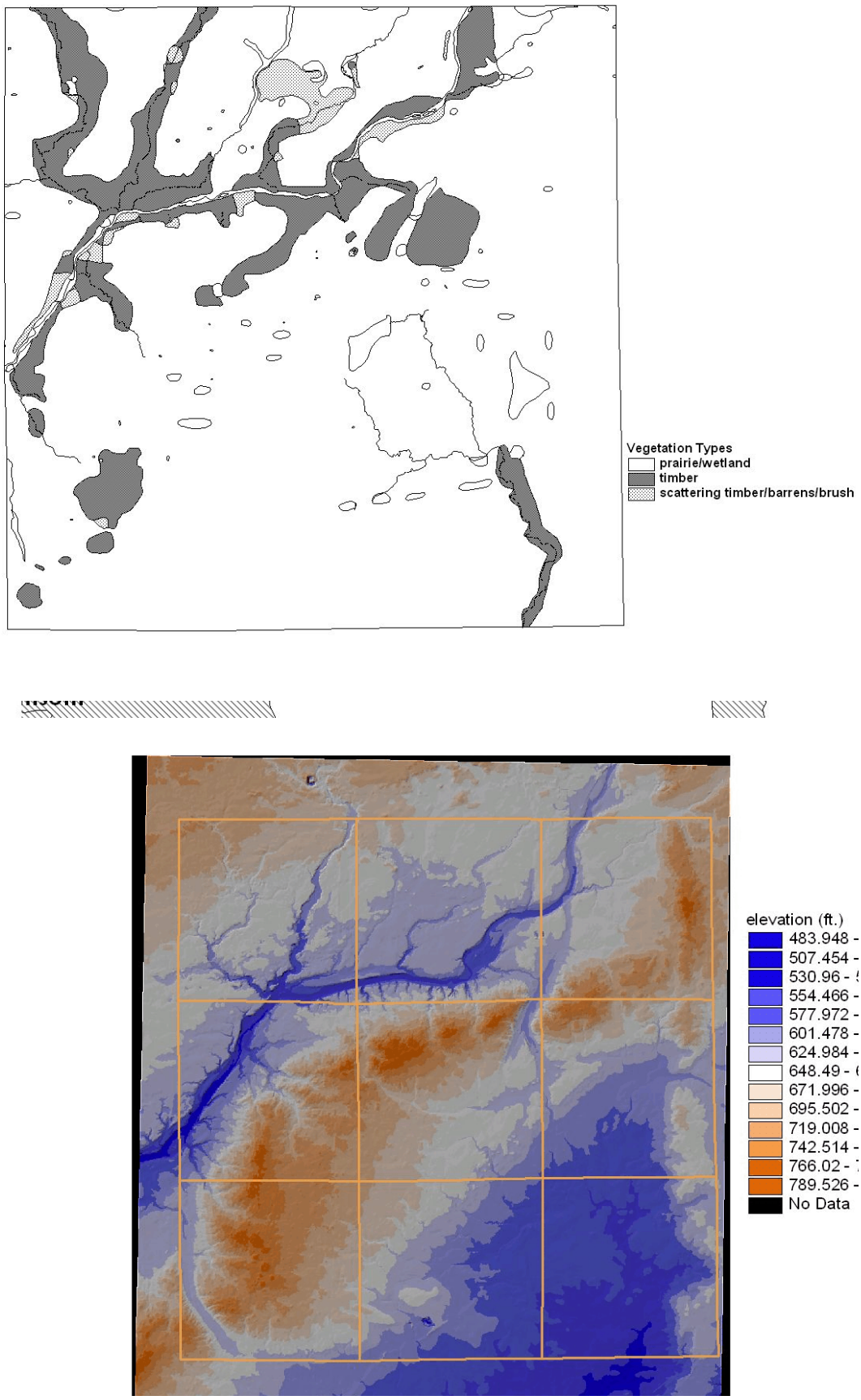
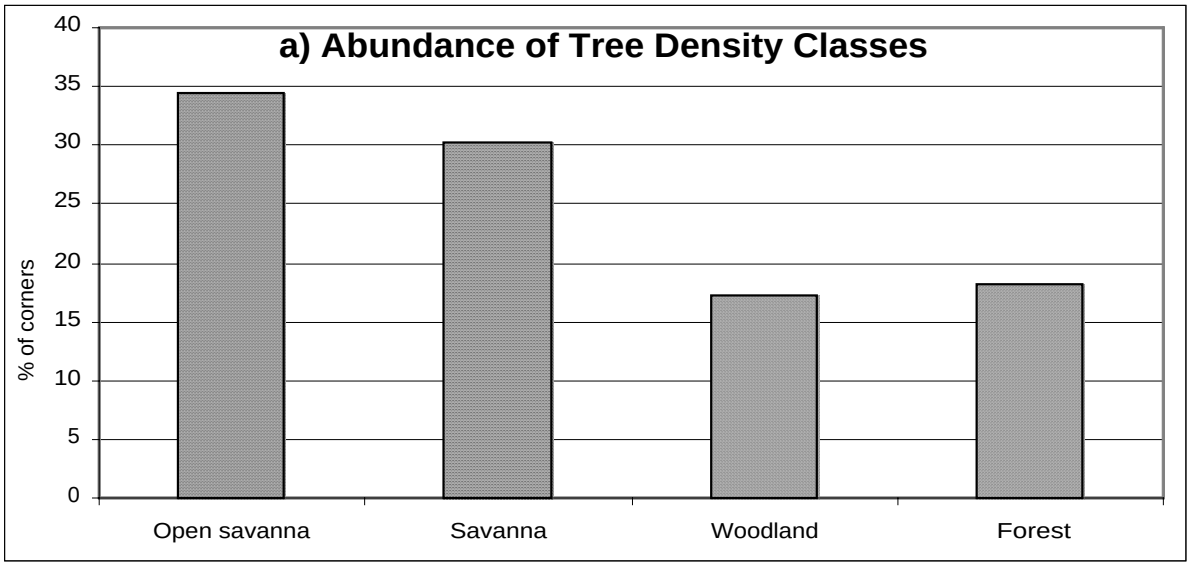


Figure 1. Upper: glacial moraines of Kendall County, Illinois. Lower: digital elevation model of Kendall County, Illinois.



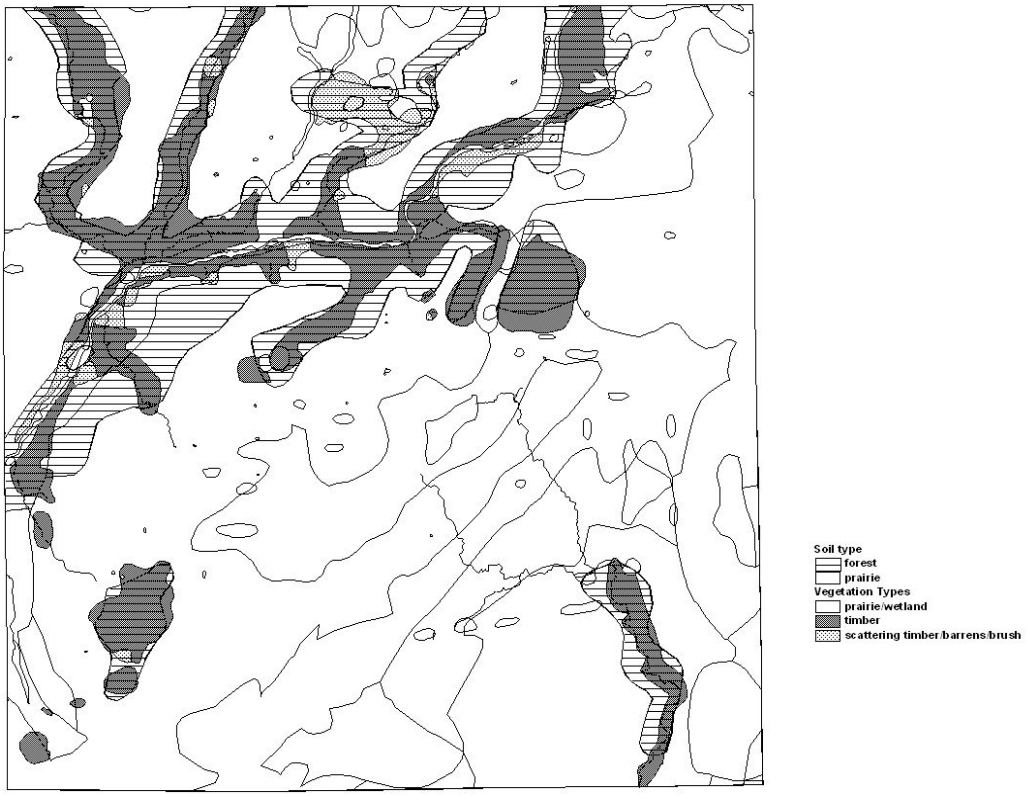
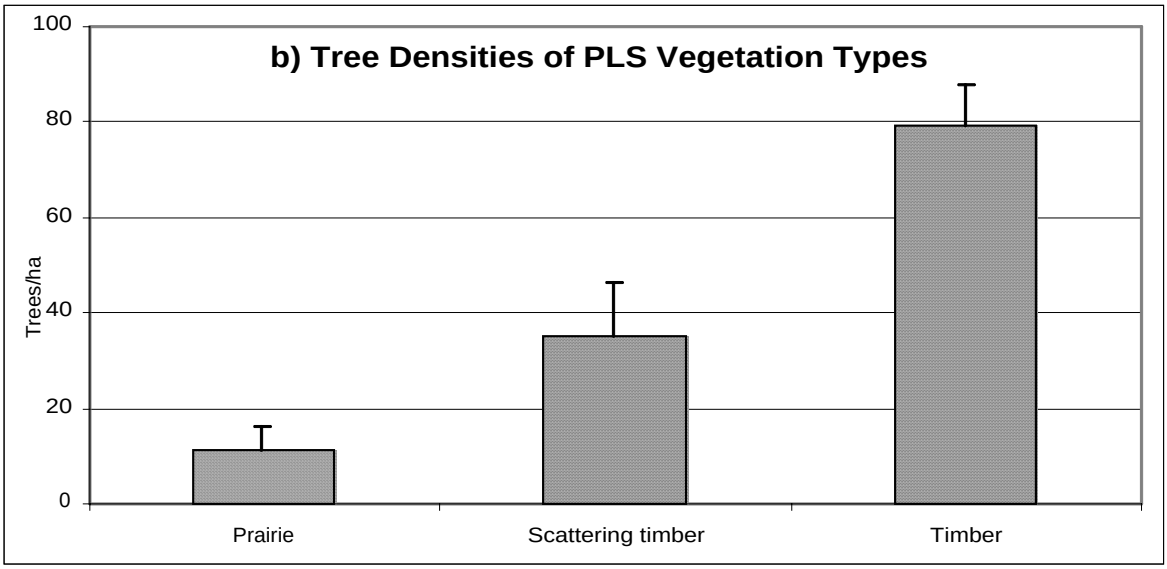


Figure 2. Upper: Pre-European settlement vegetation pattern of Kendall County, Illinois.
Lower: correspondence between presettlement vegetation and forest or prairie soils in Kendall County, Illinois.



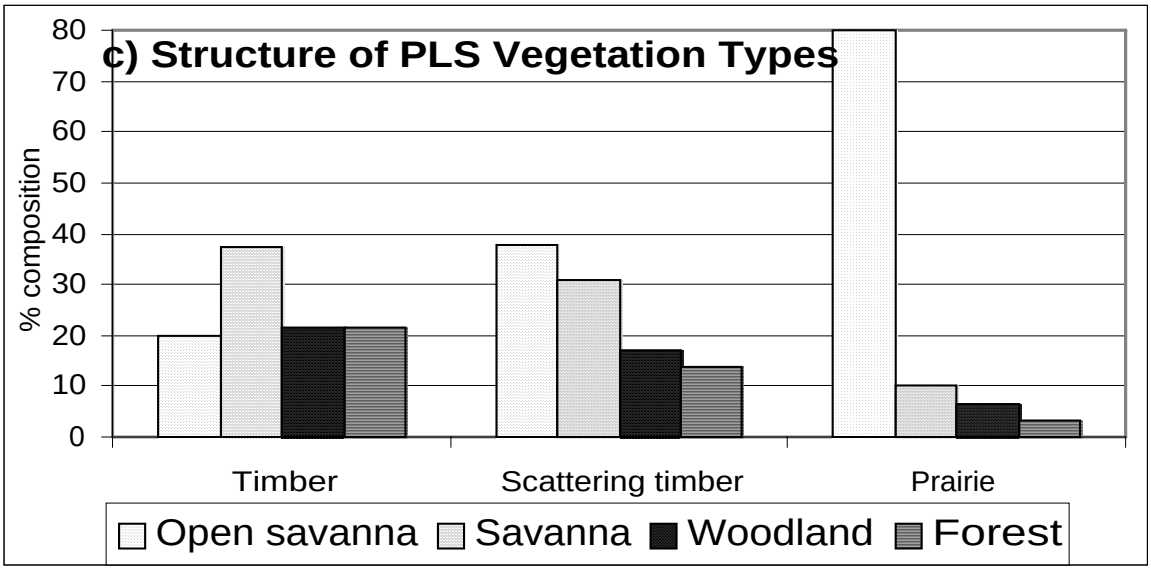


Figure 3. Landscape vegetation structure in Kendall Co., Ill., based on a) percentage of bearing tree corners in tree density classes, b) tree density of PLS vegetatin types, and c) relative abundance of tree density classes within PLS vegetation classes.

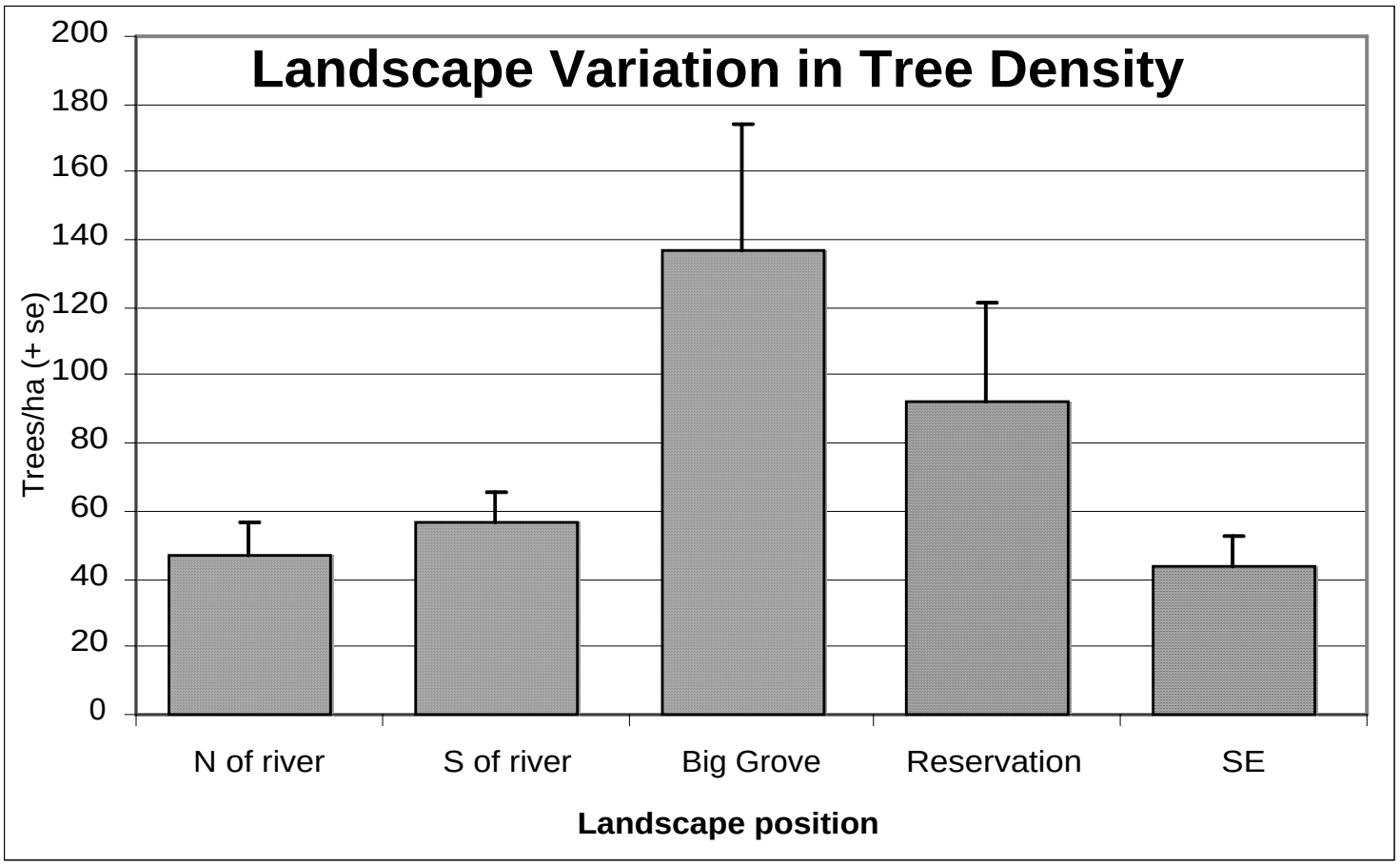
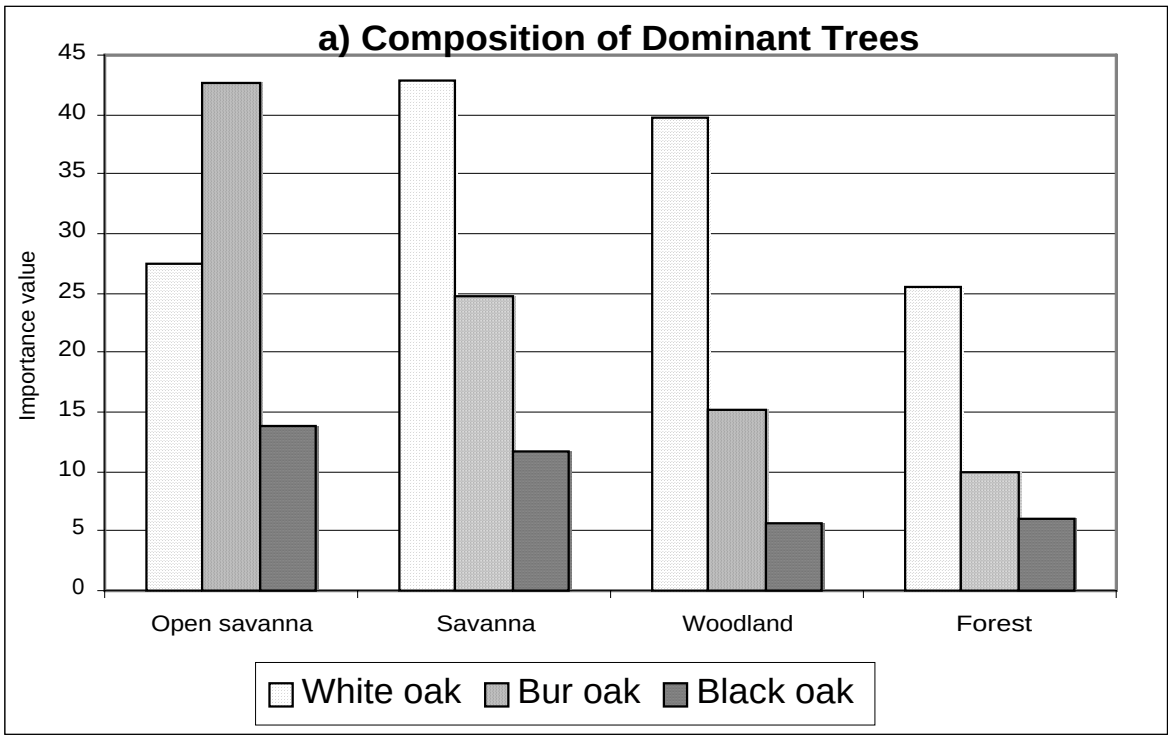


Figure 4. Landscape differences in densities of tree species located north and south of the Fox River, in the Big Grove, the Wash-kee-shaw Reservation, and in southeast Kendall County, Illinois.



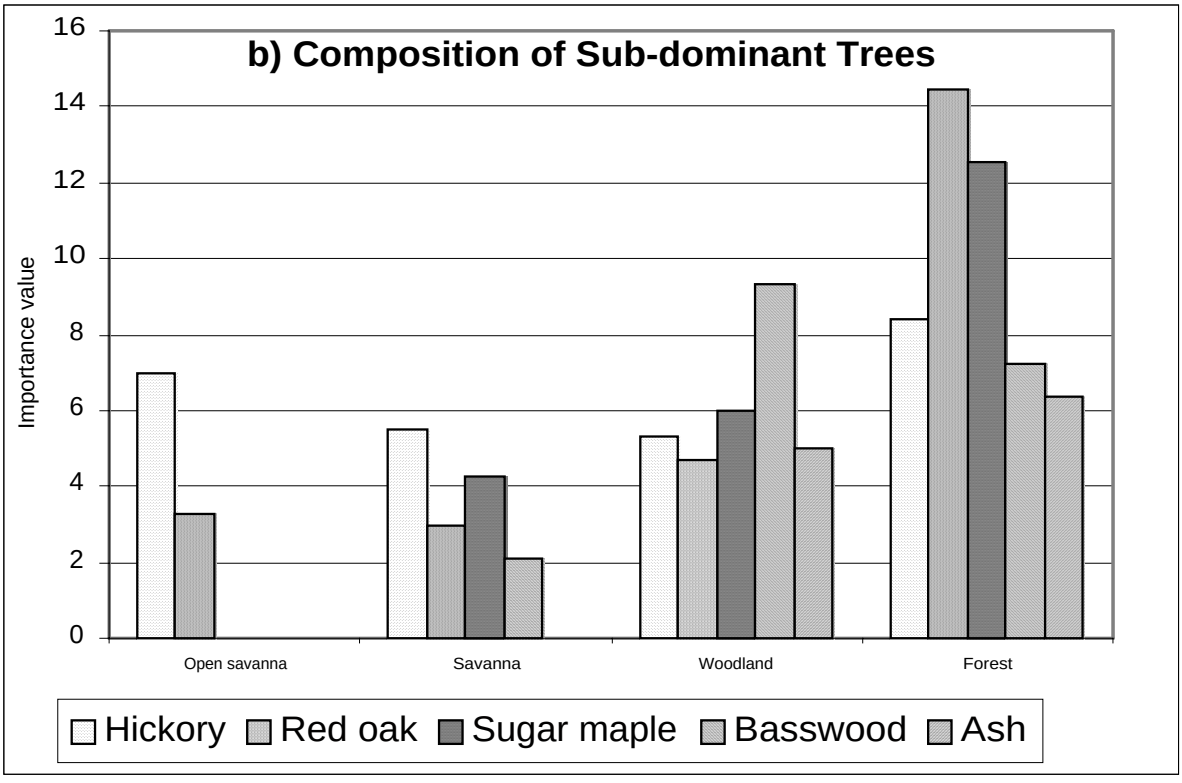


Figure 5. Relationship between tree density and importance of 1) dominant tree species, and b) sub-dominant tree species in the presettlement vegetation of Kendall County, Illinois.

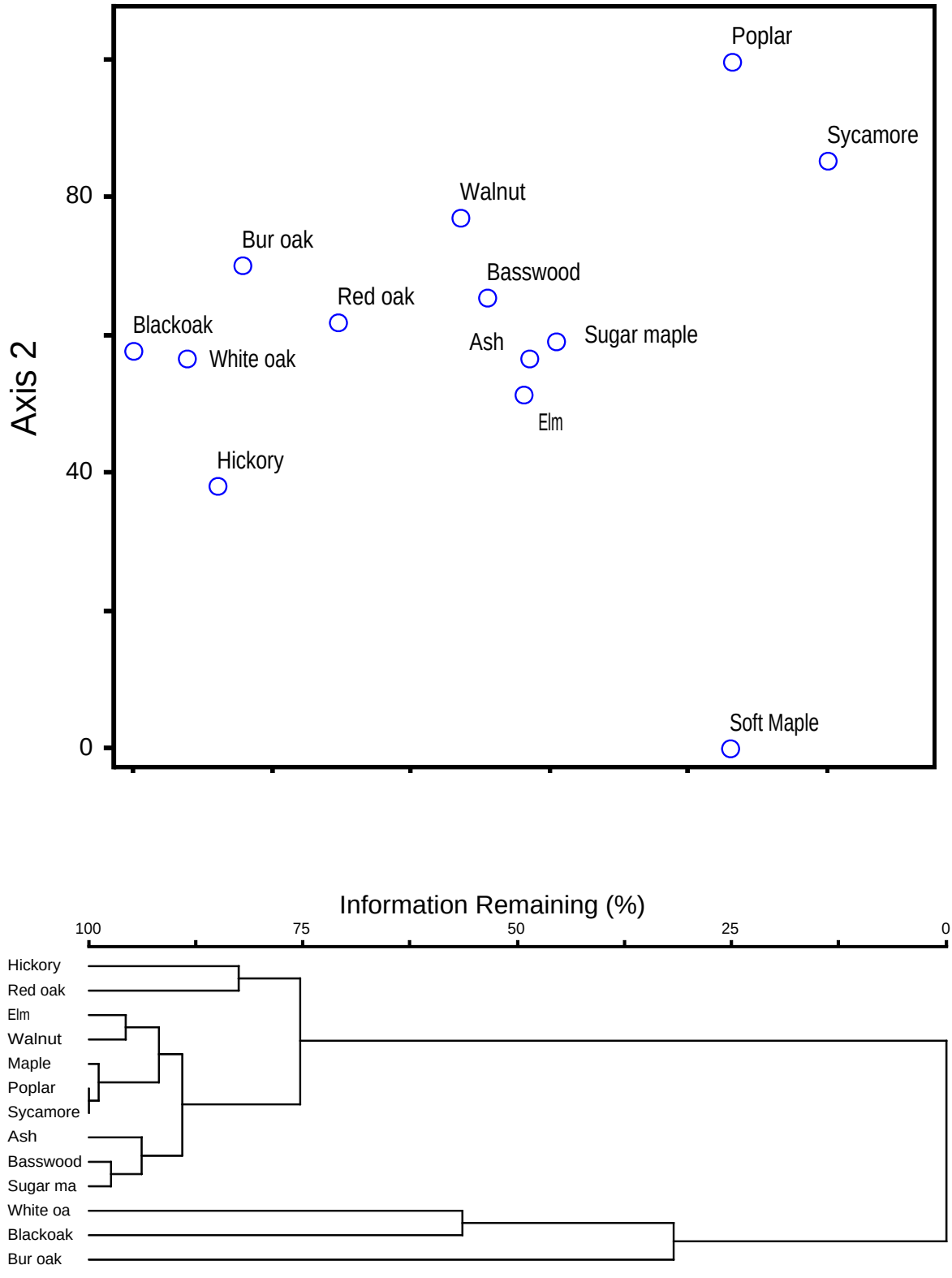


Figure 6. Non Metric Multidimensional Scaling ordination (upper) and Flexible Beta cluster analysis of section line summary vegetation data from the Public Land Survey of Kendall County, Illinois.