PRE-EUROPEAN SETTLEMENT VEGETATION OF MCHENRY COUNTY, ILLINOIS

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2005

Summary

We mapped and analyzed the landscape pattern and composition of vegetation described by the U. S. Public Land Survey (PLS) of McHenry County, Illinois, which was conducted between 1833 and 1838. McHenry County was mapped by the PLS as 50 % prairie, 44 % timber, 3 % scattering timber and less than 1 % barrens. Timber was predominantly savanna, averaging about 45 trees/ha, while scattering timber averaged less than 40 trees/ha. Both types of vegetation were dominated by bur oak, with white and black oak as secondary species, and about 70 % cover of woody undergrowth dominated by American hazelnut. Forest and woodland, represented by > 100 trees/ha and 50-100 trees/ha, respectively, were far less common than savanna, representing < 30 % of the areas mapped as timber. Both were also dominated by bur, black and white oaks. However, bur oak, the most fire tolerant oak, was less important in forest than in savanna, while white oak was more abundant in forest than in savanna. In addition, more mesophytic and fire intolerant forest trees including red oak, hickory, Scarlet or Hill's oak, basswood, ash and ironwood had greater importance in forest and woodland than in savanna. This composition and structure of woody vegetation suggests that fire played a strong role in patterning the vegetation of McHenry County. The lack of extensive forest conditions indicates that landscape firebreaks had a minor impact on vegetation pattern. The structure and composition of woody vegetation in McHenry County indicate that restoration goals should include fire management for oak dominance in most woody vegetation types, with woody vegetation dominated by hazel as an important understory component.

Acknowledgments

We thank the Forest Preserve District of McHenry County, Chicago Wilderness, USDA Forest Service, US Fish & Wildlife Service, and Illinois Conservation Foundation for funding this project. We also thank Ed Collins, George Ware and Michael Jones for their valuable comments and discussion. Figure 1 is reproduced with permission of the Ecological Society of America.

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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 such as topographic relief and water courses (Gleason 1913, Moran 1978, 1980, Grimm 1983, 1984, Anderson 1991, Leitner *et al.* 1991, Bowles *et al*. 1994). 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 processes to vegetation pattern, composition, and structure will best meet these needs (Leach & Ross 1995). In this report on the presettlement vegetation of McHenry 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), 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). In Illinois, Cook, DuPage, Will

and Kane counties had greater landscape cover of prairie and savanna occurred in areas with little landscape fire protection, while higher tree densities and greater abundance of fire-intolerant trees, as well as presence of woody undergrowth, occurred in more fire-protected landscape positions (Kilburn 1959, Moran 1980, Bowles *et al.* 1994, 1999, Bowles & McBride 2001, 2002, 2003; McBride & Bowles 2001). The Fox River in Kane County had a strong firebreak effect, with higher tree densities and greater abundance of sugar maple along its eastern flank (Bowles & McBride 2003). Although the Fox River drains eastern McHenry County, it is unknown whether this same landscape effect occurs there.

Study area

McHenry County lies along the northwestern border of the Chicago region and the northeastern border of the Prairie Peninsula (Figure 1). It comprises 16 full and 4 partial townships covering 158,204 hectares (390,764 acres). The glacial stratigraphy of McHenry County is primarily Woodfordian-aged glacial drift, including end-moraines, ground moraines and outwash (Figure 2). The western quarter of the county lies on the Altonian substage of Wisconsinan glaciation, which includes a much older glacial drift plain. Glacial lakes also occur in the eastern portion of the county. Relief ranges from about 170 meters above sea level along the Fox River to 350 meters on the Fox Lake Moraine in the north western part of the county. The Fox Lake, Park Ridge, Huntley and Cary moraines form a drainage divide, with Nippersink, Boone and Spring creeks flowing east into the Fox River, and Picasaw, Rush and Coon creeks draining west into the Kishwaukee River (Figure 2). McHenry Co. comprises two sections of the Morainal Natural Division of the Chicago Region, which correspond to glacial drift of different ages (Mierzwa 1984). The Winnebago Drift Section occurs on Altonian drift, while the Kettle Moraine Section occurs on Woodfordian drift and outwash. Although both sections are thought to have formerly supported prairie and savanna, the Kettle Moraine Section has more rugged topography and also supported extensive wetland vegetation.

Study objectives

We examined the presettlement woody vegetation pattern and structure in McHenry 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 McHenry 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. This process would result in persistence of timber on the leeward sides of waterways, ravines or bluffs, or in areas of rugged topography (Anderson 1991, Ebinger 1997). We also expected fire to affect forest structure and composition. For example, low tree density (savanna) and dominance by oaks (*Quercus* spp.) would be expected in areas receiving only moderate fire protection. 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. We also expected to find greater linear cover of woody undergrowth and greater richness of undergrowth species, associated with greater fire protection and higher tree densities.

HISTORIC METHODS

PLS Vegetation types

The McHenry County Public Land Survey was conducted primarily in 1837-38 by the Deputy surveyors James Thompson, James Gallway, and Ignatious Sprigg, with the state line surveyed in 1833 by Lucius Lyons (Table 1). Each township was mapped after completion of its survey, showing the distribution of timber, watercourses, and settlement features. The McHenry Co. PLS also described different vegetation types, including *prairie, wet prairie, brushy 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. Surveyors also recorded the identity and diameter of line trees intercepted by section lines and summarized tree species present along section lines. They also often recorded the species present in undergrowth along each section lines, and the distances along section lines with and without undergrowth.

Species identification

The surveyors identified about 21 different tree species as either bearing trees or 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 (1984). However, identification of oaks, especially members of the black oak group, appears to have been difficult or inconsistent among surveyors (Collins 1997, Clark 2000, Table 1). Scarlet oak (*Quercus coccinea*), also known as Hill's oak or jack oak (*Q. ellipsoidalis*), was not identified by the PLS for McHenry Co., although it was apparently frequent in the Chicago region (Trelease 1919, Waterman 1920). References to pin oak by the McHenry Co. PLS may have been *Q. coccinea* as its northern form is also known as northern pin oak (Kilburn 1959). Numerous references to black oak (*Q. velutina*) in McHenry Co. also may have been scarlet oak or hybrids among scarlet, black and red oak, as pure black oak is infrequent in McHenry Co. (Swink and Wilhelm 1994). 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 22 species present as woody undergrowth, including many canopy trees. Some of the shrubs, such as hazel (*Corylus americana*), redroot (*Ceanothus americana*), sumac (*Rhus* sp.) spice (*Lindera benzoin*) and

dogwood (*Cornus* sp) could be assigned to species or genera, other names such as "vines" or "briars" are vague. Many additional shrub species may have been unknown to the surveyors (Clark 2000).

MODERN METHODS

Mapping and interpretation

The PLS data were transcribed and analyzed from microfilm of copies transcribed from the original notes in the mid-1800s. 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 (http://esri.com). 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 and roads, 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. To reduce effects of potential bias on vegetation classification, we placed density calculations into 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 as $BA = \pi * r^2$, where r = the tree radius converted 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, comparing species abundance among vegetation types usually requires relative data and importance values.

Statistical comparisons

Bearing tree data were used to make multiple comparisons between the vegetation types identified by the PLS and classes identified by tree density. 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 the PLS

vegetation types. We contrasted the relative abundance of tree density classes among different landscape units to determine whether their tracts of timber differed in structure. This contrast compared timbered areas east of the Fox River and north of Nippersink Creek with those located in central and western parts of the County. If watercourses have a strong effect on landscape fire, we would expect greater abundance of forest and woodland tree density classes on their lee sides than on their windward sides in the central part of the county. If the older Altonian drift and outwash plain in the western part of the county is more fire-prone because it has comparatively low relief and no large watercourses, it should support greater abundance of open savanna.

We also made a similar but more detailed comparison of mean tree density across different morainal areas of McHenry Co. (see Figure 2). We then tested for a physiographic effect on vegetation pattern described by the PLS by comparing the abundance of prairie, timber, scattering timber and barrens on outwash and drift plains vs moraines. For this comparison, we assumed that fires would be more frequent and intense on level topography, selecting for greater abundance of prairie on plains and more timber on moraines. We tested 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 using mesophytic forest trees, which have relatively low importance values. We expected that bur oak would be more important in open savanna than white and black oak because it has more fire-resistant bark. We expected that fire intolerant and shade tolerant mesophytic trees, such as maple, ash, basswood and elm, would be more important at higher tree densities, which are usually associated with more fire-protected habitats that are also often more mesic.

Section line summary data were used to calculate the extent and composition of woody undergrowth. The linear extent of section lines for which woody undergrowth was recorded was summed for each PLS vegetation type and expressed as a percentage of the total length of all section lines in which woody undergrowth was recorded as either present or absent. This statistic was also calculated for each species, and converted to relative abundance among all species recorded.

We used species tree presence data from 583 section line summaries to help define vegetation types. These data were ordinated using Non Metric Multi-dimension Scaling PCORD software (McCune & Mefford 1995). For this analysis, all species with fewer than five occurrences were eliminated from the data set. Ward's cluster analysis was used to identify species groups using a Relative Euclidean distance metric on PCORD. We then used known ecological adaptations of different species to make inferences about presettlement habitat conditions and vegetation types.

RESULTS

Vegetation pattern and structure

About 50 % of the presettlement vegetation cover of McHenry County was grassland, more than a third of which was wet prairie (Table 2, Figure 3). About 47 % of the landscape was woody vegetation. Most of this was described as timber, with about 3 % scattering timber and less than 1 % barrens and brush. Wetland vegetation and aquatic systems accounted for about 3 % cover, most of which was identified as swamps or lakes and ponds. Linear cover of woody undergrowth measured on section lines

was extensive in McHenry County (Figure 3), exceeding 70 % in timber and scattering timber and reaching 100 % in barrens. There was a moderate longitudinal landscape effect on composition and structure of timbered, with the proportion of open savanna (> 0-10 trees/ha) increasing from 25-35 % along the Fox and Nippersink water courses to 55 % in the west, and savanna (> 10-50 trees/ha) increasing from < 30 % in the west to ~ 50 % along the Fox and Nippersink (Figure 4). However, there was much less difference in the distribution of woodland and forest. Tree density also varied across the county, averaging from about 29 to 97 trees/ha, but with high variance:mean ratios and low predictability (Table 3). As expected, the lowest density occurred on Altonian drift and outwash in the western part of McHenry County. However, highest density occurred in Pleasant Grove, a small prairie grove on the Barlina Moraine in the west central region. In the east, density reached a high of 65 trees/ha north of the Nippersink Creek, but was less than 40 trees/ha east of the Fox River. However, these areas did not differ structurally by their tree density classes ($X^2 = 3.335$, $P = 0.344$). Prairie, scattering timber and barrens were most strongly associated with outwash and drift plain habitats, while timber tended to be more evenly distributed with respect to stratigraphy (Figure 5).

Landscape vegetation structure based on tree density classes was about 75% open savanna and savanna combined, and about 12 % woodland and about 13 % forest (Figure 6). Based on vegetation described by the PLS, over 93 % of the bearing tree corners were described as occurring in timber, with 6 % in scattering timber and less than 1 % in barrens and brush. Timber averaged about 45 trees/ha and was 34 % open savanna and 40 % savanna, while scattering timber averaged about 39 trees/ha and was 66 % open savanna and only 20 % savanna (Figure 6). Tree size was larger ($F = 7.46$, $P = 0.0006$) in timber, which averaged 41.06 cm (± 0.35 se) dbh, than in barrens and scattering timber, which averaged 38.37 cm (± 2.29 se) and 37.37 cm (± 0.92 se), respectively. Prairie and wetland habitats with bearing trees also averaged about 20 or less trees/ha and were over 80 % open savanna (Figure 7). Barrens averaged over 80 trees/ha and was about 80 % open savanna, with < 10 % representation of savanna, woodland and forest.

Woody vegetation composition

Among the PLS vegetation types, bur oak was the most important tree species, with white and black oak as the most important secondary species (Table 4). Bur oak was also significantly smaller ($F = 28.67$, $P < 0.0001$), averaging 38.66 (± 0.61 se) dbh, while white oak and black oak averaged 43.64 (± 0.66 se) and 43.41 (± 0.79 se), respectively. White oak was slightly more important than black oak in timber and scattering timber but was absent from barrens. Timber had 22 species recorded as woody undergrowth, including eight shrub species, as well as vines and briers. Hazel (*Corylus americana*) was the dominant undergrowth species in timber, exceeding 40 % linear cover and 48 % relative cover (Table 5). Oak and black oak were important secondary species in timber, with 19 % and 12 % linear cover respectively. Oaks were more important than hazel and other shrubs in scattering timber, and no shrub species were recorded in woody undergrowth for barrens. Among all tree density classes, bur oak was the most important tree species, with white and black oak as the most important secondary species and red oak the fourth most important species (Table 6). Species composition changed across the gradient

represented by tree density classes (Figure 7). Among the dominant tree species, bur and white oak had contrasting distributions, with greater abundance of bur oak in open savanna and greater abundance of white oak in forest. Among less important species, almost all had greater importance in forest conditions. The single anomaly was sugar maple, which was recorded only in savanna.

The NMS ordination and Ward's cluster analysis of section line summaries showed a strong separation between different species assemblages (Figure 8). On the first ordination axis, ash-elm-oak and basswood-sugar maple-walnut groups had high axis scores, while a bur oak-white oak-black oak group had a low axis score. The remaining species formed an intermediate group in which red oak had a low second axis score, while others corresponded to high second axis scores.

DISCUSSION

Factors shaping landscape vegetation pattern and structure

The structure, composition and pattern of presettlement vegetation in McHenry County has strong similarities and differences with other Chicago region counties. The extensive coverage of savanna dominated by bur oak, white and black oak, with > 50 % coverage of section lines by woody undergrowth of hazel corresponds to appears representative of much of the Chicago region. However, the large area of timber in McHenry, County, exceeding 40% of the landscape, indicates a trend toward greater cover of timber and less prairie in the northern portion of the Chicago region, as cover of timber reached 36 % in Kane County and did not exceed 20 % elsewhere. This shift toward greater coverage of timber apparently represents the transition toward forest that occurs at the northeastern border of the Prairie Peninsula. However, despite the greater cover of timber in McHenry County, this area lacked a significant concentration of forest tree densities in areas that could conceptually provide a greater degree of fire protection, such as east of the Fox River or north of Nippersink Creek. These characteristics suggest that moderate-intensity fire regimes tended to be uniform across the county, except in the more level area of Altonian drift in the extreme west. This landscape effect probably resulted from a lack of extreme fire protection from only moderate morainal topograhy, low stream valley walls, and an extremely high water table that provided habitat for graminoid wetland vegetation in the eastern part of the county. Nevertheless, small areas of more mesophytic forest appear to have persisted in fire-protected microhabitats on north slopes of moraines and along streams. This is indicated by the presence of scattered tree corners that have forest tree densities, as well as the greater concentration of mesophytic trees at these corners.

Extensive coverage of savanna and lack of extensive forest indicate an intermediate stage in the fire-caused process of 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). Our analysis of other

Chicago region presettlement vegetation also indicates that open savanna (<10 trees/ha) as well as presence of scattering timber probably represent an extremely late stage in conversion to prairie. A secondary pathway also appears to involve continued decline of tree density but maintenance of woody undergrowth as barrens, followed by conversion to brush prairie. The extensive cover of woody undergrowth in McHenry County suggests that continued loss of tree density could lead to a shift toward greater cover of barrens and brush prairie.

Woody vegetation types

Savanna

Savanna vegetation was widespread and dominated by bur oak in McHenry Co., with only white and black oak of secondary importance. However, the minor shift in compositional structure across the open savanna-savanna gradient suggests a weak decreasing fire-effect gradient, with bur oak three times as important as white and black oak in open savanna (> 0-10 trees/ha), but only twice as important as these secondary species in savanna (>10-50 trees/ha). This gradient is also indicated by the greater importance of mesophyitc forest species in savanna than in open savanna. The more than 70 % linear cover of woody undergowth throughout McHenry County indicates that savanna structure in this area was multi-layered, with less open grassland and greater occurrences of hazel and oak fire-sprouts. The presence of black and white oak in these habitats also suggests that much of the savanna west of the Fox River was well drained. However, if some black oak bearing trees were actually Hill's oak, or hybrids with Hill's oak, they may have occupied the more mesic conditions preferred by Hill's oak. The minor representation of red oak, with lower importance of elm, hickory, ash, sugar maple and basswood indicates that more diverse savanna vegetation developed in mesic or wet mesic habitat conditions, probably in more fire-protected habitats along the west valley of the Fox River or in more rugged kettle-moraine topography.

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 McHenry Co., represented by about 15 % of the bearing tree corners. Woodland probably occurred along stream drainages or lakes, in the interior of tracts of timber, presumably in more fire-protected mesic situations than savanna. This vegetation was co-dominated by bur, black and white oak, with minor occurrences of other species, primarily red oak, hickory, basswood and ash. Woody understory vegetation may have been similar to savanna, with about 70% linear cover and dominance by hazel and oak.

Forest

Forest habitat was rare in McHenry County, and only slightly more frequent than woodland.

Although this vegetation was dominated by bur oak, black oak and white oak, greater abundance of red oak, hickory, Hill's oak, basswood, ash and ironwood indicates that forest tree densities were linked with greater species richness, including some mesophytic species. The ordination and cluster analysis suggest that two forest species groups were present. Oak, elm and ash probably represent a wet mesic forest type that could have developed in lowland sites, while the basswood, walnut, sugar maple group would represent an upland mesic to wet-mesic group. Forest conditions apparently occurred on fire-protected north slopes or kettle holes in the interior of timber tracts, and along fire-protected borders of streams.

MANAGEMENT AND RESTORATION

Issues of scale, 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. The linear measure of woody undergrowth also represents a large-scale sample that does not directly translate to more precise small-scale measures of woody undergrowth.

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 McHenry County indicate that restoration goals should include oak dominance in most woody vegetation types, with woody vegetation dominated by hazel as an important understory component. The landscape pattern of this vegetation also indicates that fire processes played a significant role in shaping the presettlement vegetation pattern of McHenry 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 suggests that fire affected the entire continuum of woody vegetation.

The McHenry 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 McHenry Co., as well as from DuPage and Will Counties (McBride and Bowles 2001), indicate that woodland occupied less than 20% of the landscape, and that forest vegetation was considerably 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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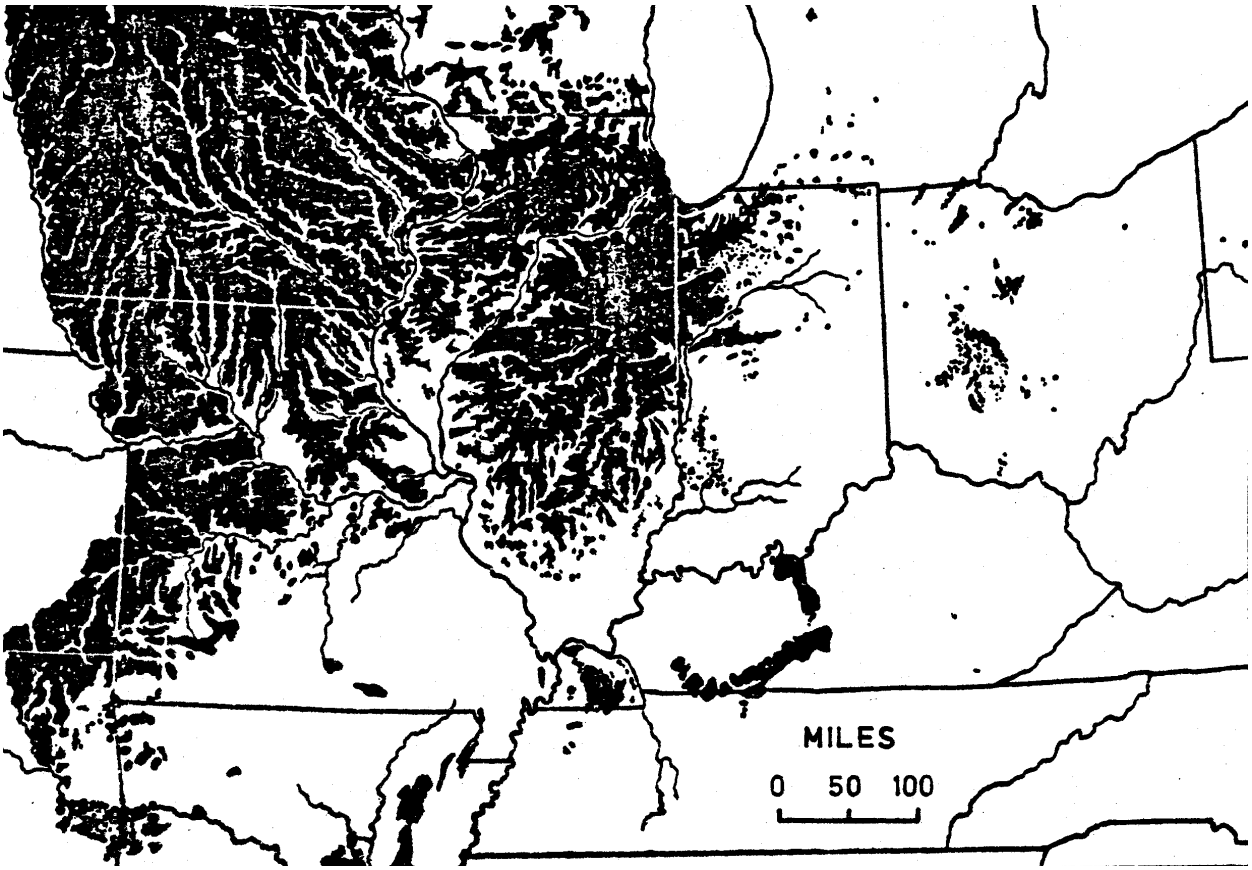


Figure 1. Extension of tallgrass prairie (in black) eastward as the “Prairie Peninsula.” Mapped by E. N. Transeau (1935).

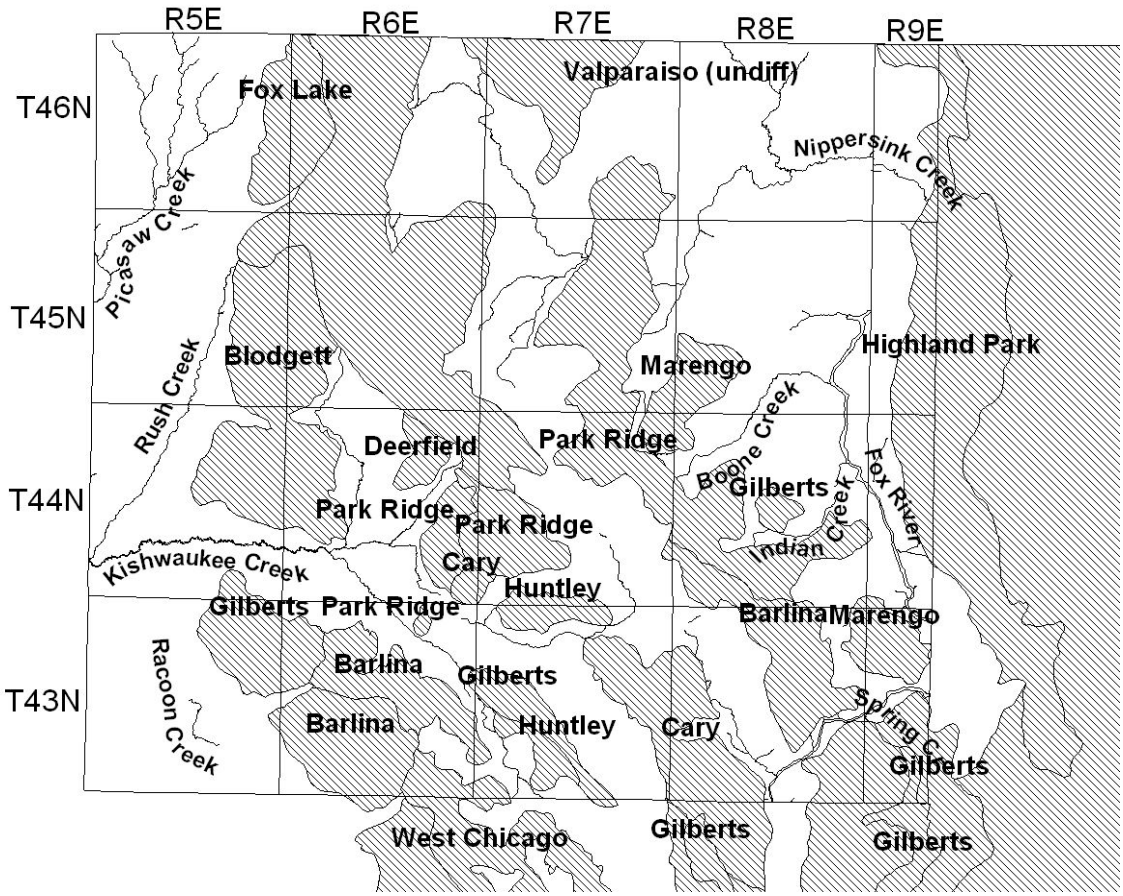


Figure 2. Glacial moraines, rivers and streams of McHenry County, Illinois.

Figure 3. Landscape distribution of prairie (unshaded), timber, scattering timber and barrens (shaded), and linear pattern of woody undergrowth in McHenry County in about 1837 as determined by the Public Land Survey. Absence of lines in shaded areas indicates that undergrowth was not recorded in these areas.

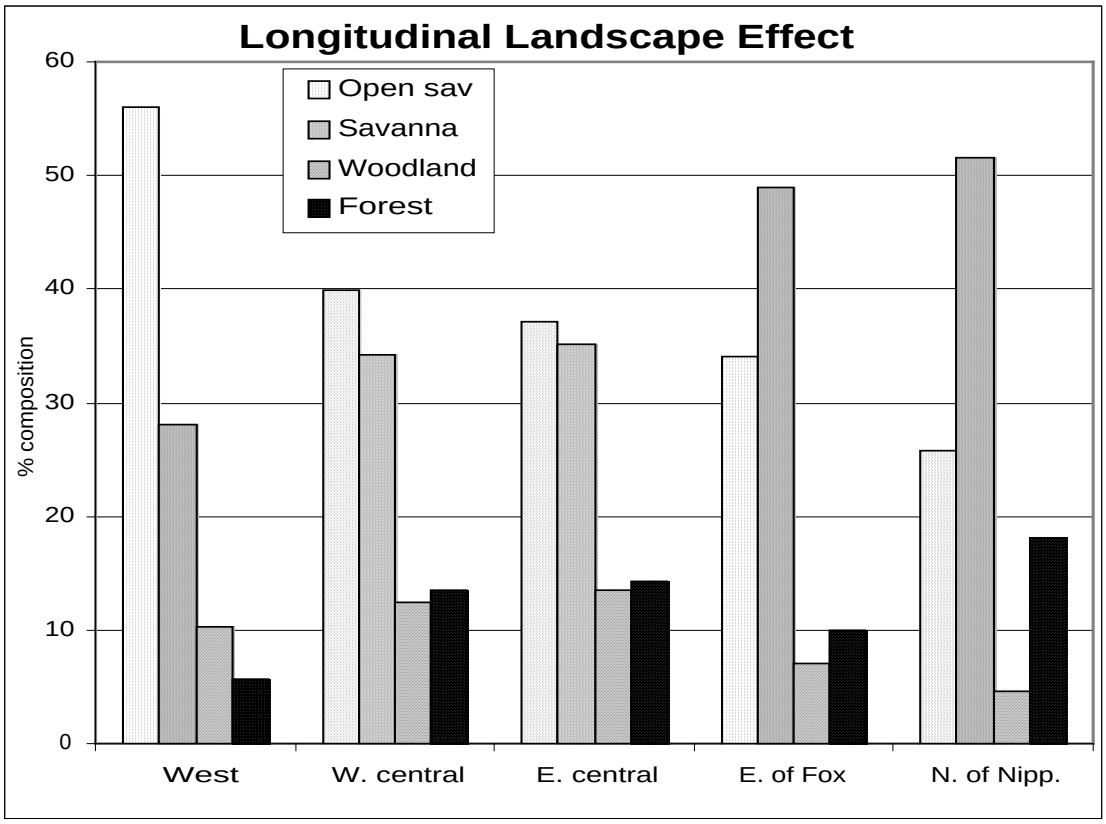


Figure 4. Comparison of longitudinal landscape effects of the Fox River and Nippersink Creek on structure of timber in comparison to central and western McHenry Co. X2 = 19.533, P = 0.023.

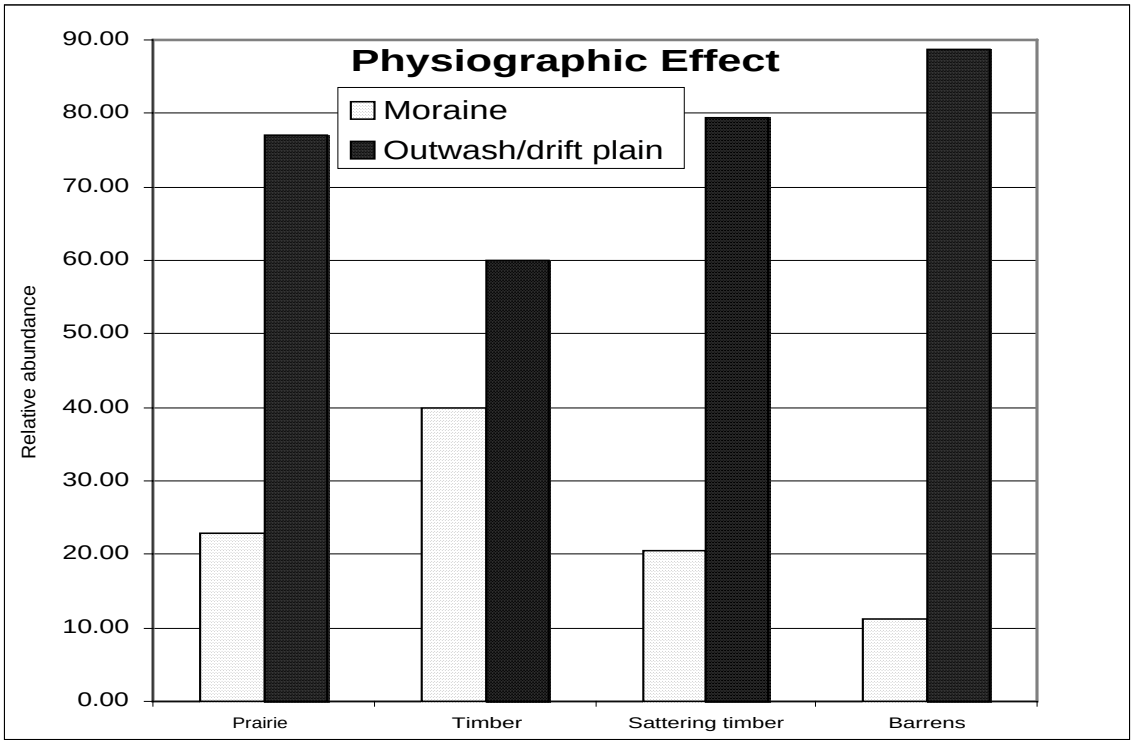


Figure 5. Distribution of prairie, timber, scattering timber and barrens with respect to glacial stratigraphy in McHenry County.

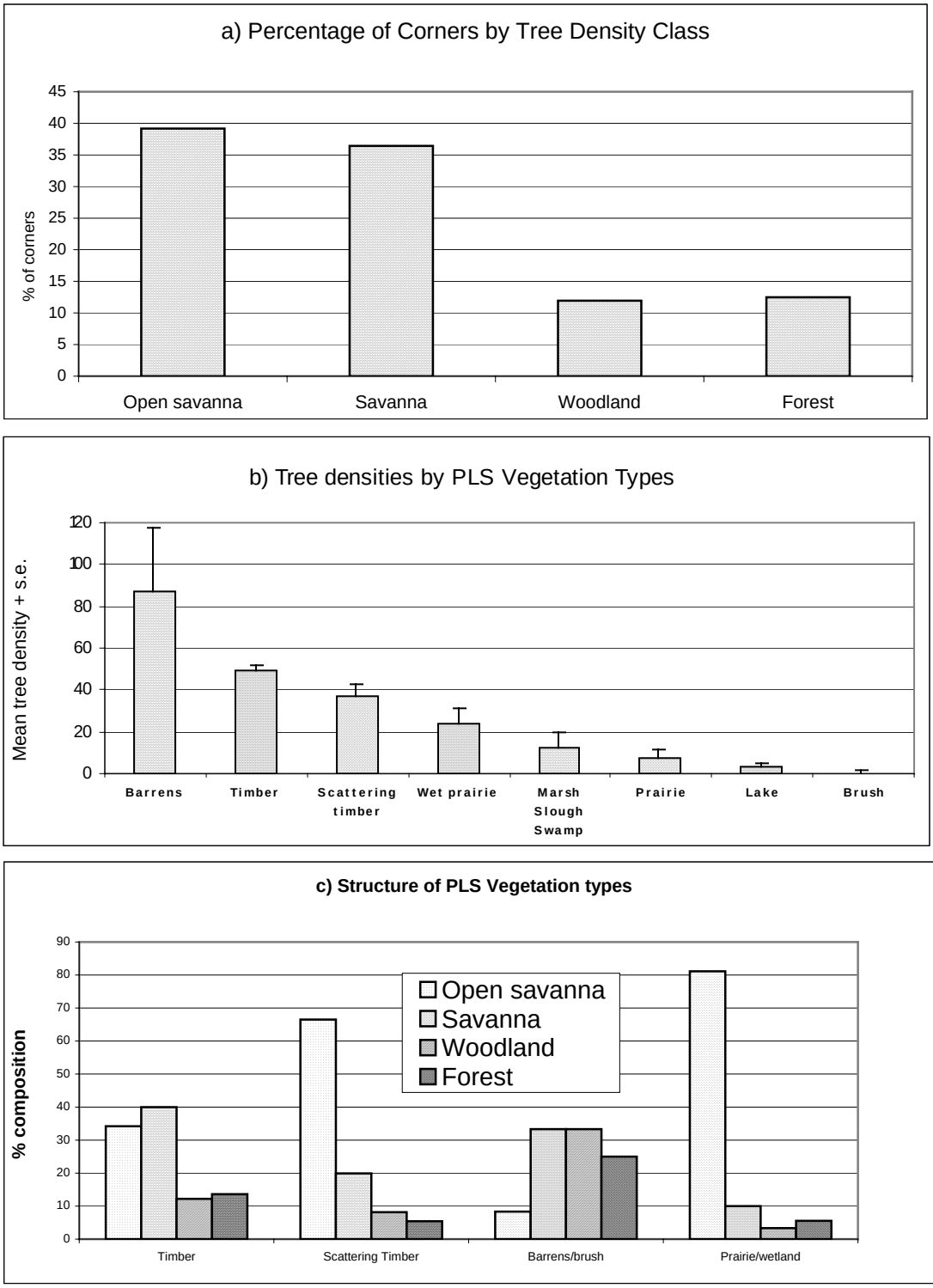
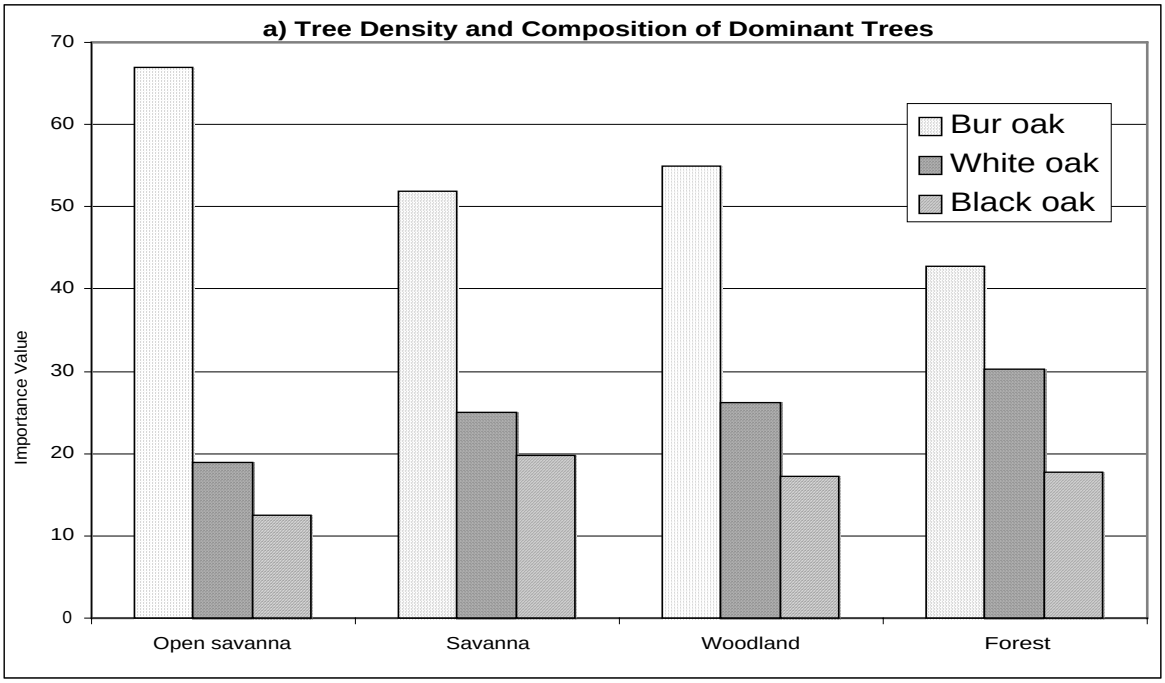


Figure 6. Landscape vegetation structure in McHenry Co., Ill., based on a) percentage of tree corners in tree density classes, b) tree density of PLS vegetation types, and c) relative abundance of tree density classes within PLS vegetation types.



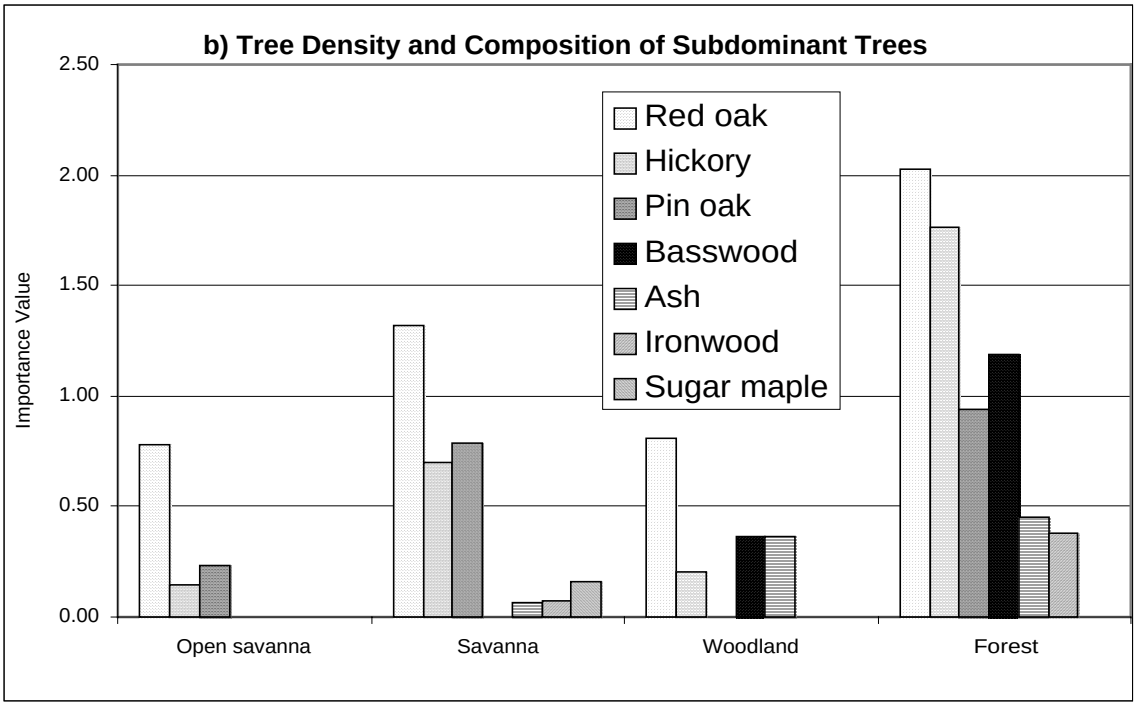


Figure 7. Relationship between tree density and importance values of a) dominant tree species and b) subdominant tree species by tree density classes.

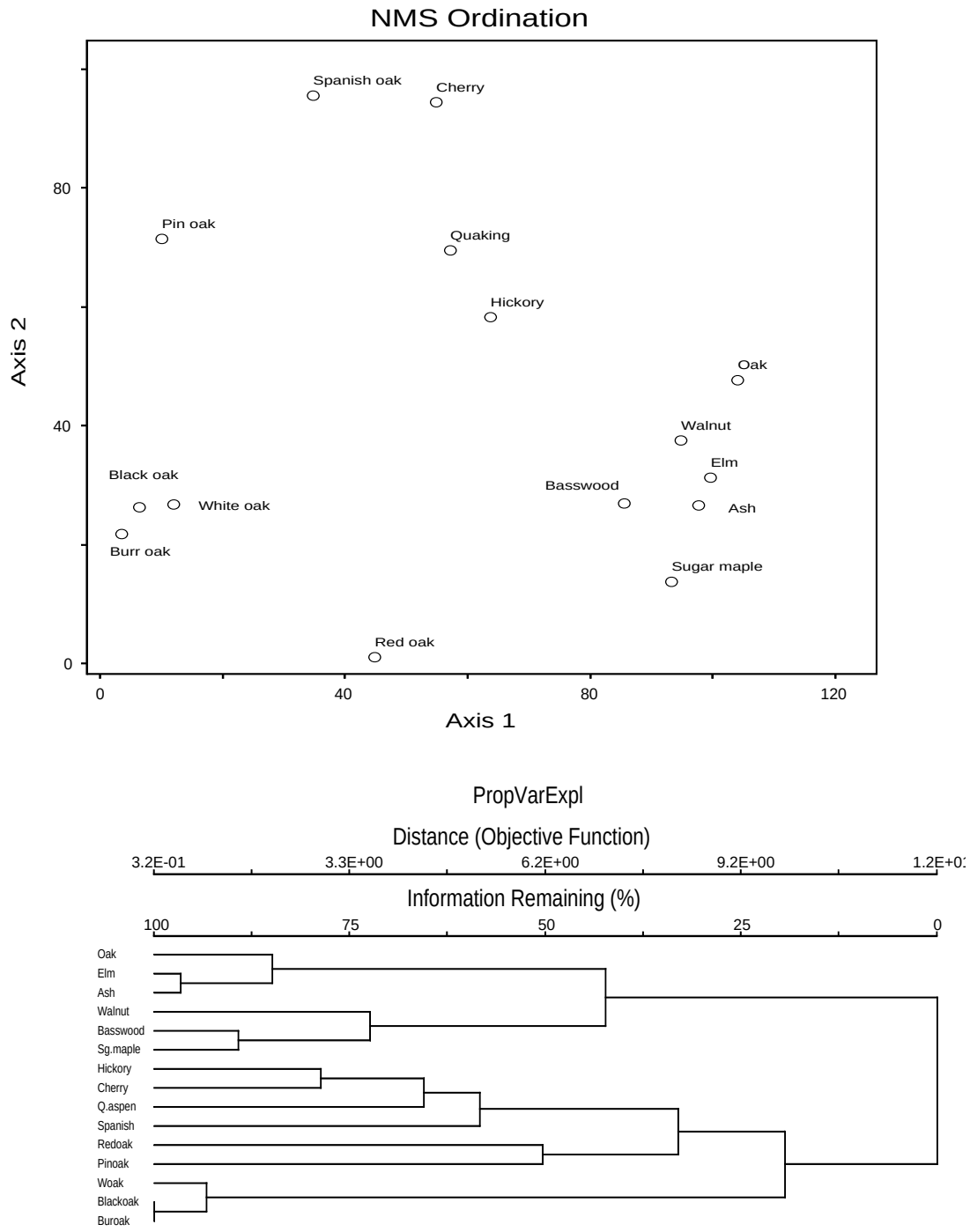


Figure 8. Non Metric Multi-dimensional Scaling ordination (upper) and Ward's Cluster analysis (lower) of section line tree species summaries from the McHenry County Public Land Survey. NMS: < 5 % of 20 random runs with stress < observed stress for a two-dimensional solution, cumulative r^2 between ordination and original distances = 0.688. Ward's Cluster Analysis: < 0.05 % chaining.

Table 1. Year of survey and species translations for bearing trees identified by Deputy Surveyors for the Public Land Survey of McHenry County, Illinois. Black oak (*Quercus velutina*) may include *Q. coccinea*.

Common name	Scientific Name	1833 Lucius Lyons	1837 James Thompson	1937 Ignatius Sprigg	1837-38 James Galloway
Bur oak	*Quercus macrocarpa*	Bur oak	Bur oak	Bur oak	Bur oak
White oak	*Quercus alba*	White oak	White oak	White oak	White oak
Black oak	*Quercus velutina*	Black oak	Black oak	Black oak	Black oak
Elm	*Ulmus sp.*			Elm	
Sugar maple	*Acer saccharum*			Sugar tree	Sugar tree
Hickory	*Carya*	Hickory	Hickory	Hickory	Hickory
Black walnut	*Juglans nigra*			Black walnut	
Basswood	*Tilia americana*		Lynn	Linn	Linden
Cherry	*Prunus*		Cherry		Cherry
Ash	*Fraxinus sp.*		Ash	Ash	Ash
Red oak	*Quercus rubra*	Red oak		Red oak	Red oak
Walnut	*Juglans*			Walnut	Walnut
Soft maple	*Acer saccharinum*				Maple
Hill's oak	*Quercus coccinea*	Pin oak		Pin oak	Pin oak
Ironwood	*Ostrya virginiana*			Ironwood	
Bur oak			Overcup oak		
Unknown oak					Swamp black
Unknown					Spanish oak
Quaking aspen	*Populus tremuloides*			Quaking asp	Quaking asp
Tamarack	*Larix laracina*				Tamarack
Unknown					Water oak

Table 2. Coverage of pre-European landscape features of McHenry Co., Illinois.
Aquatic features may be under-represented.

Vegetation type	Community	Hectares	%
Woody		**74279.11**	**46.95**
	Timber	69404.50	43.87
	Scattering timber	4417.63	2.79
	Barrens	453.00	0.29
	Brush	3.99	0.00
Prairie		**79374.79**	**50.17**
	Prairie	57268.91	36.20
	Brushy prairie	36.21	0.02
	Wet prairie	22069.68	13.95
Wetland		**2975.79**	**1.88**
	Swamp	2830.35	1.79
	Marsh	125.37	0.08
	Slough	20.07	0.01
Aquatic		**1573.94**	**0.99**
	Lake/pond	1117.86	0.71
	River/creek	456.08	0.29
Total		**158203.63**	**100.00**

Table 3. Tree densities associated with landforms of different geographic areas of McHenry County, Illinois based on data collected by the Public Land Survey. Sample size is the number of corners.

Location	Principal landform	Sample size	Density	std.dev.	std.err.	
Western	Altonian drift	107	29.02	63.07	6.1	
West central	Fox Lake Moraine	109	35.01	71.39	6.84	
West central	Blodget Moraine north	73	35.8	40.87	4.78	
West central	Blodget Moraine south	55	55.17	81.21	10.95	
West central	Barlina Moraine	22	96.9	102.97	21.95	
North central	Park Ridge north	56	42.27	66.9	8.94	
Central	Park Ridge south	189	60.68	99.9	7.27	
Northeast	North of Nippersink Creek	68	64.87	99.03	12.01	
East	East of Fox River	77	39.43	67.11	7.65	
Southeast	Gilberts Moraine	43	44.73	69.93	10.66	

Table 4. Abundance, basal area and importance values of bearing tree species by Public Land Survey Vegetation types.					
Barrens	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	30.00	78.95	4.20	78.17	78.56
Black oak	8.00	21.05	1.17	21.83	21.44
Total	38.00	100.00	5.38	100.00	100
Prairie	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	40.00	78.43	5.61	80.31	79.37
Black oak	7.00	13.73	0.56	8.08	10.90
White oak	4.00	7.84	0.81	11.61	9.73
Total	51.00	100.00	6.99	100.01	100
Wet Prairie	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	1.00	50.00	0.05	12.89	31.44
White oak	1.00	50.00	0.34	87.11	68.56
Total	2.00	100.00	0.39	100.00	100
Marsh	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	5.00	71.43	0.24	86.89	79.16
Hickory	2.00	28.57	0.04	13.11	20.84
Total	7.00	100.00	0.28	100.00	100
Timber	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	1150.00	57.96	156.76	52.62	55.29
White oak	462.00	23.29	80.99	27.19	25.24
Black oak	302.00	15.22	52.63	17.67	16.44
Red oak	25.00	1.26	3.70	1.24	1.25
Hickory	13.00	0.66	0.86	0.29	0.47
Pin oak	7.00	0.35	0.91	0.30	0.33
Basswood	5.00	0.25	0.62	0.21	0.23
Spanish oak	4.00	0.20	0.66	0.22	0.21
Ash	4.00	0.20	0.35	0.12	0.16
Quaking aspen	3.00	0.15	0.24	0.08	0.12
Ironwood	3.00	0.15	0.12	0.04	0.10
Sugar maple	2.00	0.10	0.17	0.06	0.08
Sw blk oak	1.00	0.05	0.29	0.10	0.07
Cherry	2.00	0.10	0.07	0.02	0.06
Overcup	1.00	0.05	0.05	0.02	0.03
Total	1984.00	100.00	298.43	100.18	100
Scattering					
Timber	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	160.00	61.78	19.36	55.27	58.52
White oak	50.00	19.31	8.09	23.11	21.21
Black oak	43.00	16.60	6.78	19.34	17.97
Pin oak	4.00	1.54	0.71	2.02	1.78
Hickory	2.00	0.77	0.09	0.26	0.52
Total	259.00	100.00	35.03	100.00	100

Table 5. Percent linear cover and relative cover of woody undergrowth species recorded in Timber, Scattering timber and barrens in McHenry Co., Illinois. Total species cover exceeds total linear landscape cover of woody undergrowth.

Species	Timber % cover	Timber rel. cover	Scattering Timber % cover	Scattering Timber rel. cover	Barrens % cover	Barrens rel. cover
Black oak	11.98	14.16	24.81	24.90	55.33	39.08
Oak	18.97	22.41	32.13	32.25	23.74	16.77
Hazel	40.95	48.37	23.48	23.57		
Bur oak	1.46	1.72	5.67	5.69	41.57	29.36
White oak	0.79	0.93	2.10	2.11	20.93	14.78
Willow	2.97	3.51	4.44	4.46		
Redroot	0.72	0.84	3.80	3.81		
Quaking asp	0.63	0.75	1.91	1.92		
Vines	2.03	2.39		0.00		
Briers	1.22	1.45	0.45	0.45		
Swamp dogwood	0.24	0.29	0.84	0.84		
Hickory	0.76	0.90				
Spice	0.58	0.68				
Sumac	0.29	0.35				
Red oak	0.25	0.29				
Redbud	0.23	0.27				
Grass	0.12	0.14				
Dogwood	0.12	0.14				
Prickle ash	0.12	0.14				
Pin oak	0.11	0.13				
Swamp willow	0.07	0.08				
Cherry	0.05	0.06				
Total cumulative cover	84.66	100.00	99.63	100.00	141.57	100.00
Total landscape cover (max. = 100 %)	71.144904		73.99618		100	

Table 6. Abundance, basal area and importance values of bearing tree species by tree density classes.					
Open savanna	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	658.00	69.85	93.26	64.11	66.98
White oak	152.00	16.14	31.59	21.71	18.93
Black oak	118.00	12.53	18.04	12.40	12.46
Red oak	7.00	0.74	1.19	0.82	0.78
Pin oak	2.00	0.21	0.36	0.25	0.23
Tamarack	1.00	0.11	0.45	0.31	0.21
Spanish oak	1.00	0.11	0.40	0.27	0.19
Hickory	2.00	0.21	0.12	0.08	0.15
Overcup oak	1.00	0.11	0.05	0.03	0.07
Total	942.00	100.00	145.46	100.00	100.00
Savanna	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	540.00	54.71	74.38	49.07	51.89
White oak	232.00	23.51	40.24	26.55	25.03
Black oak	181.00	18.34	32.40	21.38	19.86
Red oak	10.00	1.01	2.47	1.63	1.32
Pin oak	8.00	0.81	1.15	0.76	0.78
Hickory	10.00	1.01	0.58	0.38	0.70
Sugar maple	2.00	0.20	0.17	0.11	0.16
Ironwood	1.00	0.10	0.07	0.05	0.07
Ash	1.00	0.10	0.05	0.03	0.07
Cherry	1.00	0.10	0.03	0.02	0.06
Water oak	1.00	0.10	0.02	0.01	0.06
Total	987.00	100.00	151.58	100.00	100.00
Woodland	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	194.00	58.08	24.44	51.71	54.90
White oak	81.00	24.25	13.25	28.04	26.15
Black oak	53.00	15.87	8.77	18.56	17.21
Red oak	3.00	0.90	0.34	0.72	0.81
Ash	1.00	0.30	0.20	0.43	0.36
Basswood	1.00	0.30	0.20	0.43	0.36
Hickory	1.00	0.30	0.05	0.11	0.20
Total	334.00	100.00	47.26	100.00	100.00

Table 6.	continued				
Forest	**Abundance**	**Rel. abund.**	**Basal area**	**Rel. BA**	**IV**
Bur oak	145.00	45.17	14.90	40.43	42.80
White oak	97.00	30.22	11.18	30.32	30.27
Black oak	44.00	13.71	8.00	21.71	17.71
Red oak	8.00	2.49	0.57	1.56	2.02
Hickory	7.00	2.18	0.50	1.35	1.77
Basswood	4.00	1.25	0.42	1.13	1.19
Pin oak	4.00	1.25	0.23	0.63	0.94
Spanish oak	3.00	0.93	0.34	0.91	0.92
Quaking aspen	3.00	0.93	0.24	0.64	0.79
Swamp blk oak	1.00	0.31	0.29	0.79	0.55
Ash	2.00	0.62	0.10	0.27	0.45
Ironwood	2.00	0.62	0.05	0.14	0.38
Cherry	1.00	0.31	0.04	0.11	0.21
Total	321.00	100.00	36.86	100.00	100.00