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American Midland Naturalist, Vol. 122, No. 1. (Jul., 1989), pp. 103-113.

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An Unusual Oak Savanna in Northeastern Wisconsin: The Effect of Indian-caused Fire

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ABSTRACT.—Evaluation of the impact of native Americans on vegetation has largely relied on historical accounts of fire use. Remnant vegetation communities may also provide evidence. A large (49 km²), disjunct oak savanna in northeastern Wisconsin was recorded by the original public land survey in 1834. Surrounding vegetation was mixed conifer-hardwood forest typical of northern Wisconsin. The oak savanna was not associated with unusual soil, topographic or climatic conditions of the area but instead was associated with Potawatomi and Winnebago Indian agricultural villages. A remnant woodlot (89 ha) is still dominated by *Quercus alba* but the canopy has closed and the stand has apparently been invaded by *Carya ovata*. This pre-European settlement oak savanna is strong evidence that native Americans influenced vegetation through fire in this region.

INTRODUCTION

The impact of native American Indians on vegetation before European settlement in North America has been studied extensively. Day (1953) in the northeastern United States, Curtis (1959) in the Midwest, Grimm (1984) in Minnesota, Delcourt *et al.* (1986) in eastern Tennessee, Barnett and Arno (1982) and Lewis (1980) in the northern Rockies, Gruell (1985) in the interior West, and Pyne (1982) all concluded that Indians had a substantial impact on vegetation, especially through their use of fire. In contrast, Russell (1983) concluded that Indian fires in the northeastern United States did not have a widespread influence on vegetation. All of these authors relied on historical accounts by Europeans of Indian uses of fire. Reports of Indian-caused fires (especially in the Midwest and northern Rockies) are largely from regions where fire-tolerant vegetation such as prairie or savanna was common. Therefore, it could be argued that Indian-caused fires only supplemented natural fire causes such as climatic drought, droughty soil or flammable vegetation.

We report the presence of savanna vegetation as an apparent result of Indian-caused fires in northeastern Wisconsin, a region where fire-tolerant vegetation is uncommon. Our conclusions do not rely solely on historical accounts but also draw upon knowledge of presettlement vegetation, Indian settlements, soil patterns and remnant vegetation.

STUDY AREA

Presettlement vegetation in northern Wisconsin was dominated by mixed conifer-hardwood forests of hemlock, sugar maple, yellow birch, white and red pine and (to the E) beech (Finley, 1976). Southern Wisconsin had predominately oak forest, oak savanna and prairie with mesic forest generally restricted to locations protected from fire such as along lakes (Curtis, 1959) or in moister climatic areas such as southwestern Wisconsin (Cottam and Kline, 1981). Oak savanna and forest occurred in only two locations in northern Wisconsin

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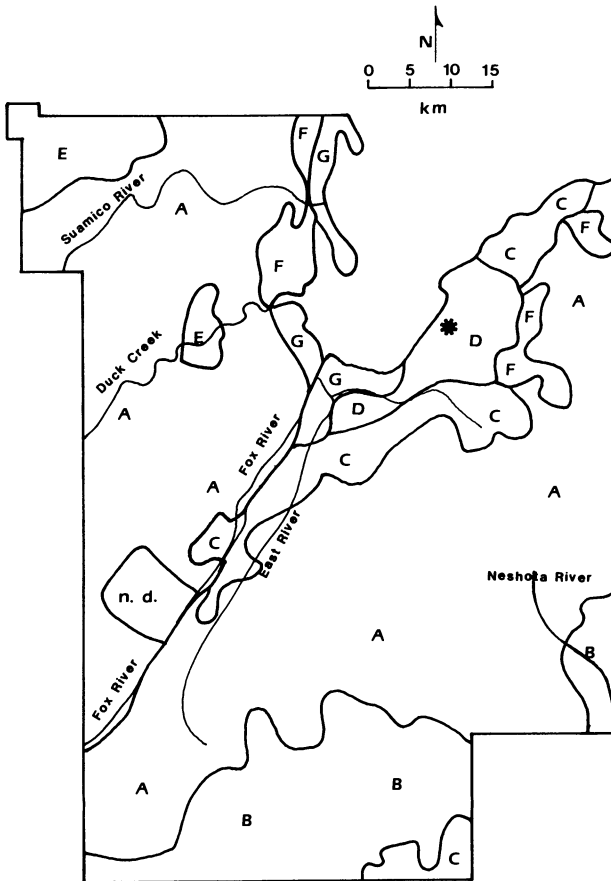


FIG. 1.—Presettlement vegetation (ca. 1834) in Brown County, Wisconsin, taken from Finley (1976). Vegetation types are A = northern hardwood-conifer forest, B = northern hardwood forest, C = oak forest, D = oak savanna, E = brush, F = conifer swamp, G = marsh/wet prairie, n.d. = no data. * = Church Road woodlot

(Finley, 1976), a small area in southern Shawano County (T26N, R14E, Sec. 11) on sandy soil (Hole, 1977) and a large area in Brown County (Fig. 1).

Presettlement vegetation in Brown County was mostly mixed conifer-hardwood forest with some deciduous forest in the southern portion of the county. Oak forest was present in several locations along the Fox River and adjacent to a large oak savanna along the eastern shore of Green Bay. Conifer swamps were scattered throughout the county (Fig. 1).

Soils in Brown County were formed from glacial till and lake sediment with mostly clay loam to clay subsoils (Fig. 2). The predominant soil (39% of the county) is the Kewaunee-Manawa association with clayey subsoils on variable slopes and variable drainage. The Shawano-Boyer-Sisson association (13%) consists of sandy and loamy subsoil that is well to excessively drained on variable slopes. The Oshkosh-Allendale-Kolberg Association (4%) has deep, variably drained, clayey and sandy subsoil and Namur-Summerville-Kolberg

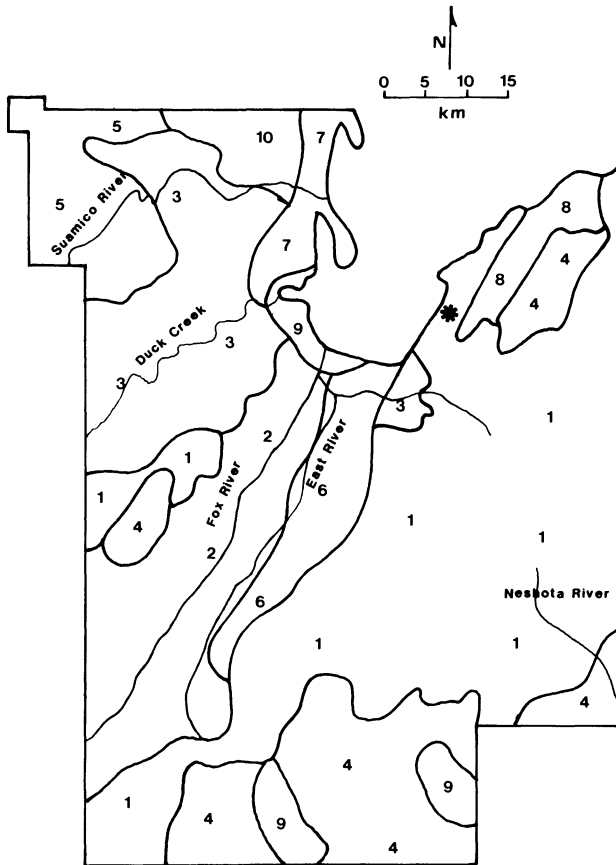


FIG. 2.—Soil associations of Brown County, Wisconsin, taken from Link *et al.* (1974). Soil associations are 1 = Kewaunee-Manawa, 2 = Oshkosh-Manawa, 3 = Shawano-Boyer-Sisson, 4 = Waymor-Hochheim, 5 = Onaway-Solona, 6 = Oshkosh-Allendale-Tedrow, 7 = Tedrow-Roscommon, 8 = Namur-Summerville-Kolberg, 9 = Carbondale-Cathro-Marsh, 10 = Shawano-Tedrow-Roscommon. * = Church Road woodlot

Association has (3%) shallow soil with shallow to clayey subsoil over limestone bedrock (Link, 1974).

Brown County has had a long history of European settlement beginning with French fur traders in the 1660s. In 1665, Indians gathered at Green Bay at the suggestion of the Fox tribe to make the area a center for the fur trade (Keesing, 1939). By the 18th century, Green Bay was one of Canada's most important fur trade centers (Kay, 1977). The Menominee tribe lived on the western shore of Green Bay in mixed conifer-hardwood forests and were hunter-gatherers. In contrast, the Potawatomi and Winnebago tribes were agriculturalists and lived on the E shore of Green Bay in mostly oak forest and oak savanna. The Sauk and Fox tribes, which were also hunter-gatherers, lived along the upper Fox River. Data on Indian populations are limited but suggest that in 1824 there were ca. 4800 Indians in the Green Bay region with 2300 Winnebago, 900 Potawatomi, 1400 Menominee and 200 Sauk (Shea, 1857). The number of Indians had apparently been increasing since 1728

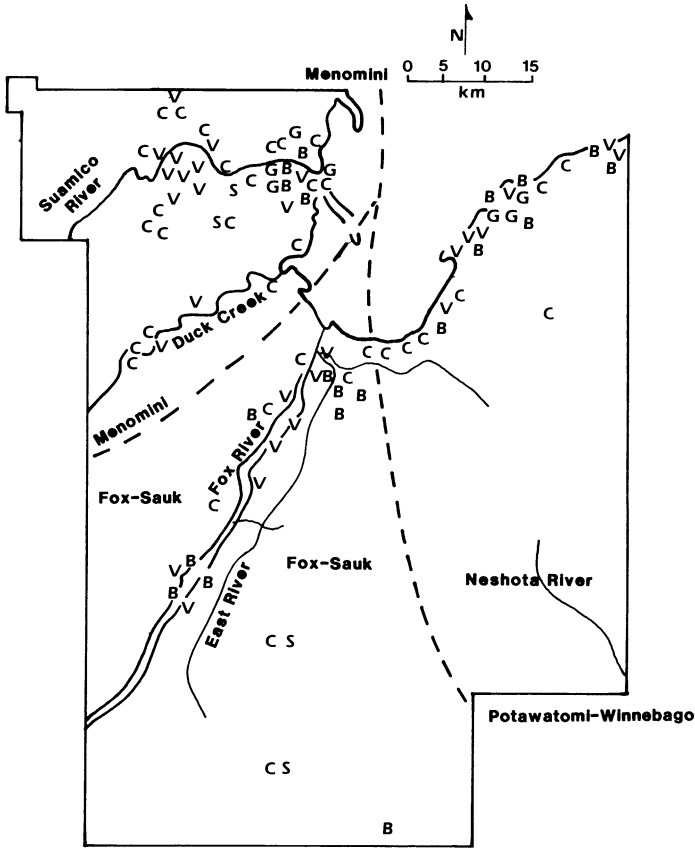


FIG. 3.—Location of Indian settlements in Brown County, Wisconsin, with approximate tribal boundaries. Symbols represent burials (b), gardens (g), maple sugarbushes (s), campsites (c) and villages (v)

when only 430 Indians were censused in the region. Kay (1984) found the same population trend for the upper midwestern U.S. From the 1820s to Indian removal in 1848, the Indian population was approximately stable in the Green Bay region (Thwaites, 1911a, b; Shea, 1857).

Indian settlement in Brown County was extensive by 1770. Historical documents note 28 villages, 35 campsites, seven gardens, four sugarbushes and 20 burial sites in the county (Brown, 1880s; Martin, 1913). Kay (1977) indicated that campsites were probably small, seasonal hunting camps while villages were larger and associated with agricultural activities. It is not possible to determine when these sites were occupied and it is unlikely that all settlements were occupied simultaneously. Most sites were located along the eastern shore of Green Bay (Potawatomi and Winnebago tribes), along the Suamico River on the W shore of Green Bay (Menominee tribe) and along the Fox River (Sauk tribe) (Fig. 3).

METHODS

Copies of the original public land survey were used to reconstruct presettlement vegetation in four townships adjacent to the W side of Green Bay (T23N, R22E; T24N, R22E; T24N,

R21E; T25N, R22E). These townships were first surveyed in July and November 1834 after the Indians were removed and before extensive European settlement began. These townships included an area of oak savanna, as well as surrounding vegetation more typical of northern Wisconsin. Data from the land survey were transferred to base maps and homogeneous stands were delineated. Tree size and number were converted to species importance percentages (average of relative frequency, dominance and density) for each vegetation type (see Cottam and Kline, 1979). When stands had Bray-Curtis similarity indices more than 80% (Mueller-Dombois and Ellenberg, 1974), they were combined into the same community type. Maps based on the survey notes were also available from R. W. Finley (pers. comm.) for surrounding townships.

Historical documents maintained at the Green Bay Area Historical Research Center (University of Wisconsin-Green Bay) and elsewhere were examined to locate Indian settlements and references to vegetation disturbance.

In the spring of 1975, all remnant woodlots in the original oak savanna location were examined to determine present vegetation and locate oak savanna remnants. One woodlot of 89 ha (Church Road woodlot; T24N, R21E, Sec. 13, NW $\frac{1}{4}$, S $\frac{1}{2}$) was located which retained large, widely scattered open-grown oaks with little evidence of lumbering. In the summer of 1981, this woodlot was surveyed using 20 sets of nested quadrats placed along two transects across the length of the woodlot. Trees (stems > 10 cm dbh) were counted in a 10 × 25-m quadrat, saplings (\leq 10 cm dbh) in a 5 × 25-m quadrat, shrubs (0.5–3.0 m tall) in a 2.5 × 10-m quadrat and woody seedlings (<0.5 m tall) in a 1 × 1-m quadrat. Subsoil samples from the upper 0.5 m of the profile were collected in three sites, combined and sent to the University of Wisconsin-Milwaukee state soil testing laboratory for nutrient and texture analysis. Since the stand is located on private property, it was not possible to core the large oaks. Tree ages were estimated from growth rates from borings of fallen trees or stumps in the stand. Small-scale maps of presettlement vegetation (Finley, 1976) and soil (Hole, 1977) were compared to locate other possible sites of vegetation with similar characteristics in northern Wisconsin. Similarity indices (S.I.) were used to compare study area presettlement vegetation with Curtis' undisturbed vegetation types for Wisconsin (Curtis, 1959).

An analysis of variance was conducted to examine surveyor's bias for or against tree species (see Delcourt and Delcourt, 1974). The surveyors probably were biased in favor of larger trees when they were available. However, the extent of this likely bias is difficult to determine. Therefore, comparison with present-day stand density must be generalized. The General Linear Models (GLM) (analysis of variance) program of SAS (Barr *et al.*, 1979) was used by vegetation type for each species with diameter and distance as dependent variables to address tree species bias. To examine climatic effects, weather data from 1978 and 1979 from the University of Wisconsin-Green Bay (ca. 10 km S of the remnant stand) and Austin Straubel Field (ca. 40 km W of the remnant stand) were compared using the GLM program. Monthly rainfall, monthly maximum temperatures, monthly minimum temperatures, average (by day) maximum temperatures and average (by day) minimum temperatures were compared for these two stations.

RESULTS

Surveyor's records.—Analysis of variance revealed no evidence of surveyor's bias toward or against a particular tree species; therefore, the surveyor's notes appear to represent accurately the species composition of the presettlement vegetation.

The study area had a wide variety of vegetation types. Oak savanna bordered Green Bay and covered about 49 km² (Fig. 4). Oak savanna was dominated by white oak [*Quercus alba*, importance percentage (I.P.) = 40.6] and black-red oak (*Q. borealis* and *Q. velutina*,

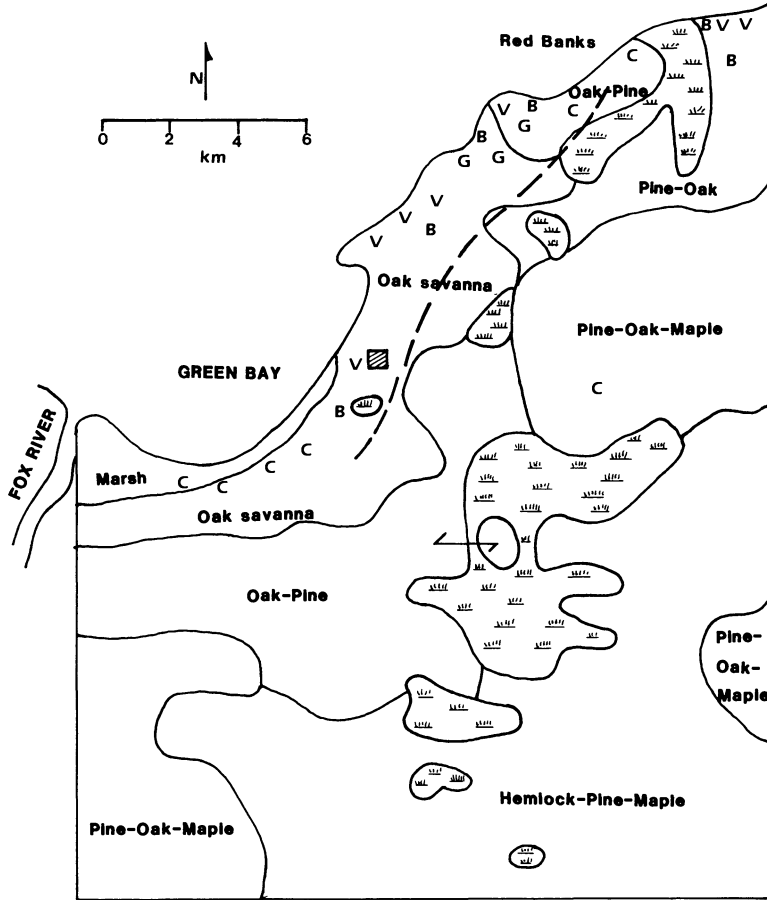


FIG. 4.—Presettlement vegetation types and Indian settlements in a portion of Brown County, Wisconsin in 1834 and location of Church Road woodlot (▨). Symbols represent Niagara Escarpment (---), ash-tamarack swamp forest (▨▨▨▨), Indian burial (B), Indian garden (G), Indian campsite (C) and Indian village (V)

34.8) (Table 1). Eight tree taxa were present with a density of 22 trees/ha). Based on density, this community would be a savanna according to Anderson and Anderson (1975). The surveyors frequently referred to “enter oak opening” and then “leave oak opening” (e.g., A. G. Ellis, T24, R21, Sec. 34/35 to Sec. 25/36). The section line summaries stated that the land was “first rate, openings, fair portion timbered (oak)” (e.g., A. G. Ellis, T24, R21, Sec. 12/13) or “land first rate, openings, rolling with fair quantity of white oak” (e.g., A. G. Ellis, T24, R21, Sec. 34/35). The surveyors notation of entering and leaving the savannas (openings) along the section lines were used to map the extent of the savannas.

Pine-oak forest mostly surrounded the oak savanna and covered 80 km². Dominant tree species were pine (probably white pine, *Pinus strobus*, I.P. = 35.5), white oak (29.4) and aspen (*Populus* sp., 12.0). Seven tree species were present with a tree density of 152 trees/ha.

TABLE 1.—Importance percentages (I.P.) for major tree species (I.P. > 8) by vegetation type on the study area in 1834

Species	Vegetation type				
	Oak savanna	Pine-oak	Hemlock-pine-maple	Pine-oak-maple	Ash-tamarack
<i>Quercus alba</i> L.	40.6	29.4	2.3	16.6	—
<i>Q. borealis</i> Michx. and <i>Q. velutina</i> Lam.	34.8	7.2	2.8	11.5	—
<i>Populus</i> sp.	7.6	12.0	1.0	7.4	4.9
<i>Acer rubrum</i> L.	—	10.7	2.4	—	4.4
<i>Pinus strobus</i> L.	—	35.5	19.7	18.0	—
<i>Tsuga canadensis</i> (L.) Carr.	—	—	29.2	0.6	1.0
<i>Fagus grandifolia</i> Ehrh.	—	—	9.7	8.8	—
<i>Betula</i> sp.	—	3.2	7.5	2.4	2.4
<i>Fraxinus nigra</i> Marsh.	—	2.1	4.6	2.9	29.6
<i>Larix laricina</i> (Du Roi) K. Koch	—	—	—	—	28.8
<i>Thuja occidentalis</i> L.	—	—	0.4	—	15.8
<i>Acer saccharum</i> L.	—	—	12.0	15.9	—
I.P. (of 100)	83.0	100.0	91.6	84.1	86.9
Number of trees in sample	57	43	175	155	60
Number of taxa	8	7	13	14	10
Density (trees per hectare)	22.0	152.1	205.2	164.7	290.6
Statistics (F value)	2.15	0.91	0.82	0.96	1.36

Pine-oak-maple forest occurred generally E and N of the pine-oak community and covered 75 km². This community had 14 tree taxa, 165 trees/ha and was dominated by pine (I.P. = 18.0), white oak (16.6), sugar maple (*Acer saccharum*, 15.9) and black-red oak (11.5). Shade-tolerant species [sugar maple, beech (*Fagus grandifolia*) and basswood (*Tilia americana*)] averaged 25 cm dbh while shade-intolerant species (pine, white oak and black-red oak) were larger at 43 cm ($P \leq 0.01$, $t = 74.45$).

Hemlock-pine-maple forest, the most common vegetation type, occurred in the southeastern one-third of the study area (106 km²). Tree density (205 trees/ha) was highest for an upland community in the study area. Dominant species were hemlock (*Tsuga canadensis*, I.P. = 29.2), pine (19.7), sugar maple (12.0) and beech (9.7).

Ash-tamarack swamp forest covered scattered low-lying areas (39 km²) throughout the study area. Tree density was high (291 trees/ha) and 10 species were present. Black ash (*Fraxinus nigra*, I.P. = 29.6) and tamarack (*Larix laricina*, 28.8) were the two dominant species. Treeless wet marsh (8 km²) was present adjacent to Green Bay.

The distribution of vegetation types did not correlate with soil associations. For example, all vegetation types were found on Oshkosh-Allendale-Tedrow and Kewaunee-Manawa soils. The Waymor-Hochheim and Namur-Summerville-Kolberg soils were present in adjacent, parallel bands in the northern portion of the study area. All vegetation types occurred on these associations except hemlock-pine-maple. A small area of Shawano-Boyer-Sisson association was present with oak forest and savanna.

The only significant topographic feature is the dolomitic Niagara Escarpment which forms part of the western border of the Namur-Summerville-Kolberg association. The Escarpment (relief less than 20 m) bisects the oak savanna vegetation type (Fig. 4).

Climatic differences are minor between the University of Wisconsin-Green Bay station (in the southern portion of the oak savanna) and Austin Straubel Airport (in northern

TABLE 2.—Church Road woodlot: importance percentages (I.P. > 2) and densities

	Tree layer		Sapling layer		Shrub layer		Seedling layer	
	I.P.	No./ha	I.P.	No./	I.P.	No./m ²	I.P.	No./m ²
				10 m ²				
<i>Quercus alba</i> L.	55	102	5	0.1	5	0.1	11	1.6
<i>Q. borealis</i> Michx.	6	10	7	0.1	3	—	2	0.1
<i>Carya ovata</i> (Mill.) K. Koch	31	66	37	1.5	10	0.2	5	0.4
<i>Prunus virginiana</i> L.	—	—	12	0.2	17	0.5	26	5.6
<i>Cornus racemosa</i> Lam.	—	—	13	0.3	34	1.3	26	5.6
<i>Lonicera</i> sp.	—	—	4	0.7	10	0.2	2	0.2
<i>Rhus radicans</i> L.	—	—	—	—	—	—	17	4.4
Total importance percentages (of 100)	92	—	78	—	79	—	89	—
Number of species	5	—	16	—	23	—	17	—
Total density	—	190	—	2.6	—	2.4	—	19.0

hardwood-conifer forest). No significant differences ($P \leq 0.05$) exist in monthly rainfall or monthly minimum or monthly average minimum temperatures. Monthly maximum and average monthly maximum temperatures were significantly different between the stations with the University station being warmer. This was most pronounced in the winter while summer temperatures were similar. Climatic differences do not appear to be responsible for the oak savanna.

Indian sites in the study area were numerous and mostly located adjacent to Green Bay (Fig. 4). There were seven villages, eight campsites, three gardens and seven burial sites (Brown, 1880s; Martin, 1913). Some sites were extensive: the Winnebago village at Red Banks had several hundred hectares of cleared fields which were still visible in 1905 (Neville, 1905). The other villages were Potawatomi (Martin, 1913), but both tribes were agricultural.

Church Road woodlot.—This woodlot covered 89 ha in 1981 (Fig. 4). The tree layer was dominated by white oak (I.P. = 55) and shagbark hickory (*Carya ovata*, 31) (Table 2). Tree density was 190 trees/ha with five species. The largest trees were white and red oak (63–74 cm dbh). Their form suggests that they were open-grown and their age (estimated from growth rates from several stumps and fallen trees) predates local European settlement at about 1840. Shagbark hickory was the dominant sapling (37) followed by gray dogwood (*Cornus racemosa*, 13) and chokecherry of sapling size (*Prunus virginiana*, 12). White and red oak saplings were scarce (5 and 7, respectively). Sapling density was ca. 2.6 stems/10 m². The shrub layer was dense and dominated by gray dogwood (34), chokecherry (17), shagbark hickory (10) and *Lonicera* (10). Red and white oak of shrub size were infrequent. Shrub density was 2.4 shrubs/10 m². Seedlings were frequent (19/m²). Gray dogwood (26), chokecherry (26) and poison ivy (*Rhus radicans*, 17) were dominant. White oak (11) was a common tree seedling while shagbark hickory (5) and red oak (2) were less frequent.

Soil analysis indicated a soil texture of 16% sand, 38% silt and 46% clay with a soil chemistry of 66 ppm P, 103 ppm K and pH of 7.2. These values are typical for soils in this area. The U.S. Soil Conservation Service mapped the woodlot soil as Kewaunee silty clay loam with a 2–6% slope (Link, 1974). Our soil analysis agrees with this map designation.

Thus, the Church Road woodlot is a white oak-shagbark hickory forest developed from a white oak-red oak savanna. The understory has a dense shrub layer characteristic of southern Wisconsin oak forests (Curtis, 1959). Hickory and white oak are reproducing well

while red oak appears to be maintaining its low level of importance. In contrast, oak-hickory woodlots in S-central Michigan had little oak reproduction (Dodge and Harmann, 1985).

DISCUSSION

Presettlement vegetation types in the study area were similar to the typical vegetation of northern Wisconsin with the exception of the oak savanna which was most closely related to southern Wisconsin oak forest. For all upland vegetation types, except the oak savanna, similarity indices (S.I.) were closer to northern than to southern Wisconsin vegetation types of Curtis (1959). For instance, Curtis' northern dry mesic forest was the most closely related type to the pine-oak forest (S.I. = 57.9), hemlock-pine-maple forest (53.2) and the pine-oak-maple forest (56.8). The major difference was greater dominance of white oak in presettlement forests of northeastern Wisconsin than in Curtis' types. Presettlement forests in western Wisconsin (Barnes, 1974), southwestern Wisconsin (Cottam and Kline, 1979), southeastern Wisconsin (Dorney, 1981a), central Illinois (Rogers and Anderson, 1979) and southern Indiana (Leitner and Jackson, 1981) also had major white oak components. In contrast, the oak savanna was more similar in composition to Curtis' southern dry forest (S.I. = 75.1) than the southern oak savanna (53.7) which was dominated by bur oak (*Quercus macrocarpa*).

The vegetation pattern of the study area was closely associated with Indian sites of the agricultural Potawatomi and Winnebago tribes. Soil associations, climate and topography appeared to have had little effect on the vegetation pattern. This leaves Indian-caused fires as the likely cause of the vegetation pattern.

Historical accounts of Indian fires in Wisconsin are few. A grass fire in 1831 supposedly set by Menominee Indians burned a house near Lac Butte des Morts (ca. 150 km S) (Thwaites, 1907). The use of fire by the Winnebago tribe in Wisconsin was reported by Lathrop (1856) in Racine County (near the Wisconsin-Illinois border), by Schafer (1929) along the Mississippi River to drive game and by Beltami (1828) while traveling in western Wisconsin, who reported annual Indian fires to clear brush for hunting.

Further evidence for Indian-caused fires comes from the present of herbaceous species in the area. Prairie grasses and forbs can be found widely scattered throughout the area of the original savanna. Species noted in the area were *Andropogon gerardi*, *Solidago rigida*, *Lithospermum canescens* and *Dodecatheon media* (also present in the Church Road woodlot). These prairie species probably represent herbaceous species originally present in the savanna.

The Church Road woodlot represents the last remnant of the presettlement oak savanna. The large, open-grown white oaks and isolated prairie flora indicate that little human disturbance (other than fire suppression) has occurred since settlement. With fire suppression, the woodlot has changed. The presettlement savanna had many black-red oaks (I.P. = 35) while the present woodlot has few (6). Shagbark hickory (31) has increased in dominance from an I.P. of less than 1 to 31. White oak was and remains the dominant species. Tree density has increased from 22 trees/ha to 190 trees/ha. Similar changes also occurred in southern Wisconsin oak savanna remnants (Cottam, 1949; Ward, 1956). Due to its status as the last surviving remnant of this unusual oak savanna, this woodlot warrants preservation and restoration as the last evidence of Indian settlement in this region.

The evidence of Indian-caused fires in southeastern Wisconsin is less clear (Dorney, 1981b). Village locations revealed little preference for major vegetation types. Since the vegetation of southeastern Wisconsin was a mixture of oak forest, savanna, prairie and deciduous mesic forest, the influence of Indian fires would not be as obvious as it appears in northeastern Wisconsin. Similarly, there was no apparent effect of Indians on vegetation on the W side of Green Bay where the Menominee lived. This may reflect the fact that the

Menominee were hunter-gatherers in contrast to the agricultural Winnebago and Potawatomi.

Previous work concerning the effect of Indian-caused fire on vegetation pattern has involved extensive review of historical records. However, Russell (1983) has pointed out that these records provide little direct historical evidence for Indian-caused fires. She concluded that widespread Indian burning was unlikely and that Indian-caused fires were probably at most a local event. The oak savanna in Brown County covered a rather large area of fire-disturbed vegetation closely associated with settlements of agricultural Indians. This is strong evidence for the effect of Indian-caused fire on vegetation to areas beyond the settlements themselves. However, the impact of these fires was not too widespread in Brown County since most of the county's presettlement vegetation was typical for northern Wisconsin. Examination of historical records in areas of intense, agricultural Indian settlement could reveal other examples of this phenomenon and help put into perspective the importance of Indian-caused fires in the early North American landscape.

Acknowledgments.—We appreciate the assistance of Brian Dorney and Richard Johnson as well as the editorial advice of Keith White and Forest Stearns. We are especially grateful for the editorial advice of the late Robert S. Dorney whose encouragement and support will be sorely missed. Keith White kindly supplied the weather data from the University of Wisconsin-Green Bay station. We also thank the Rev. E. Mulhall, pastor of the Holy Cross Church, for permission to survey the Church Road woodlot.

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