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PRESETTLEMENT FOREST COMPOSITION OF THE CENTRAL SANGAMON RIVER BASIN, ILLINOIS

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ABSTRACT

Reconstruction of original forest composition from records of the United States General Land Office Surveys of central Illinois, and comparison with topography, soils, and present forest studies indicate that presettlement forests on uplands and on the windward sides of major streams were dominated by black oak and hickory, with increased frequency of white oak on the leeward sides of streams and on slopes. Both slope and upland forests show greater amounts of black oak and hickory than do present forest stands, reflecting a comparatively xeric forest despite relatively mesic climatic conditions of the "Neoglacial" or "Little Ice Age" just ending; forest composition is attributed to fires burning into the forest from adjacent upland prairies.

INTRODUCTION

At the time of European settlement (1819-1823), the landscape of central Illinois was dominated by tallgrass prairie with forest limited to the floodplain, steeper slopes bordering the streams, and isolated "prairie groves" on the uplands. The high fertility of the land and its great potential economic value attracted intensive settlement and, as a result, the tallgrass prairie has been almost entirely destroyed as a community. The origin and history of the Prairie Peninsula, however, have long been of interest (Geis and Boggess 1968). The distribution of prairie and forest prior to settlement was mapped by Vestal (1931) from soil survey reports and refined considerably by Anderson (1970) on the basis of United States General Land Office Survey records. Although prairie covered approximately 70% of central Illinois and has been frequently studied (Anderson 1970), the other 30% of the region, forested during presettlement times, is of less economic value, and has generally been neglected. This study examines the distribution and composition of the presettlement forest in central Illinois and suggests some factors that may have been instrumental in its development.

Many studies of the modern vegetation have been conducted in central Illinois, although for the most part in the area east of the limit of Wisconsinan glaciation (Calef 1953, Boggess 1964, Boggess and Bailey 1964, Boggess and Geis 1967, Root *et al.* 1971). This study of the presettlement vegetation of central Illinois covers the relatively homogeneous Sangamon River basin from south and west of the limit of Wisconsinan glaciation (Fig. 1) to its confluence with Salt Creek, where the soils and topography become more similar to those bordering the Illinois and Mississippi River valleys (Schwegman 1973). This area includes 1,750 km^2 (676 mi^2) and has basically uniform topography, substratum, and climate.

The Sangamon River basin is underlain by Illinoian drift covered by as much as 20 to 90 m of Wisconsinan age loess. Because the area is developed on an older land surface, it has better established drainage patterns than the more recently glaciated areas to the north and east. The topography is generally flat, except for the relatively steep valley slopes bordering the Sangamon River and its tributaries which are incised 15 to 30 m below the general upland.

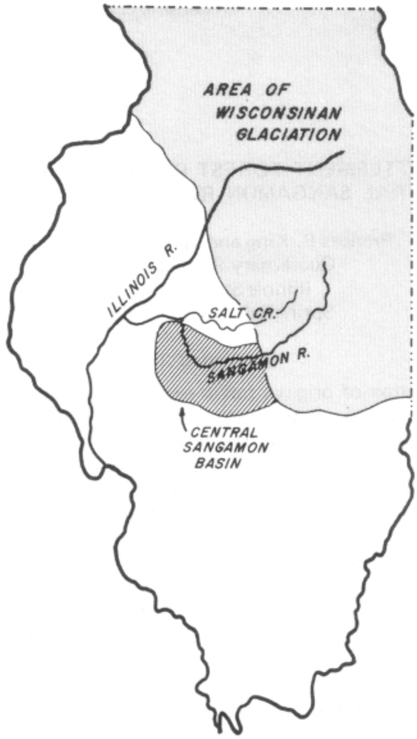

Fig. 1. Map of Illinois showing the central Sangamon River Basin.

The soils of the upland forests and slopes, formed from thick loess, for the most part belong to the Clary-Clinton-Keomah and Stookey-Alford-Muren soil associations. They are acid, with a tendency to be low in organic matter and nutrients, and have good to very good water-holding capacities. They are similar to the forest soils of eastern Illinois in fertility, texture, permeability, and drought resistance, although somewhat better drained (Fehrenbacher *et al.* 1968). Windblown sand occurs in dunes on the uplands bordering the Sangamon River Valley in this area, with the maximum extent of sand being attained on the eastern and southern borders of the valley (Bergstrom *et al.* 1976).

The climate of central Illinois is dominated by dry continental air extending from the western Plains. During the summer, this air mass is contracted westward by the northward movement of moist Gulf air bringing normal summer precipitation; if this northward movement fails to occur the dry western air predominates producing droughts and higher temperatures (Borchert 1950). The climate of Springfield is typical of the area (Denmark 1969): Average annual temperature, 12°C (53.6°F); growing season, 186 days; average annual precipitation, 88.47 cm (34.83''), highest between April-July; average relative humidity (noon), 59%; prevailing winds and speed, south 19.2 km/h (12 mph)-annual.

Transeau (1935) reported many distinctive differences between the prairie region and adjacent forested areas: A lower annual and seasonal precipitation/evaporation ratio in the prairie, lower midsummer relative humidity, a higher percent of the annual precipitation coming during the growing season rather than the winter, and greater variability of precipitation in both areal extent and timing. On a regional basis, these factors favor the establishment of prairie over forest. Once prairie is established, other factors become important in the continued exclusion of forest: The superior water utilization by grasses, the shading out of young tree seedlings, the incapability of seedling roots to penetrate thick prairie sod, and the tolerance of the prairie plants to fires which would kill young tree seedlings. Trees, therefore, are primarily confined to slopes where erosion breaks the sod cover, and young trees are protected from sun and wind dessication as well as from sweeping prairie fires.

Few remnants of the presettlement forest remain in existence today; those that do occur primarily adjacent to streams and only rarely on the flat uplands (Gleason 1913, Boggess and Geis 1967). The valley slope and upland forests belong to the Oak-Hickory association described by Braun (1950). The dominant species are white oak *(Quercus alba),* with red oak *(Q. rubra),* black oak *(Q. velutina),* shagbark hickory *(Carya ovata),* slippery elm *(Ulmus rubra),* and American elm *(U. americana).* The slightly drier conditions on the upper south-facing slopes are frequently reflected by the absence of more mesic species such as red oak and basswood *(Tilia americana)* (Bell 1974) from these areas. The floodplain forests are dominated by silver maple *(Acer saccharinum),* with green ash *(Fraxinus pennsylvanica),* hackberry *(Celtis* spp.), bur oak *(Q. macrocarpa),* and shingle oak *(Q. imbricaria)* among the more common species (Bell 1974, Johnson and Bell 1975).

METHODS

The data used in the reconstruction of the presettlement forest composition of the central Sangamon drainage were compiled from the field notes of the original United States General Land Office Survey (1819-1823) on file in the State Archives, Springfield, Illinois. The surveys were the first step in dividing the land for settlement and consisted of setting up townships each six miles square divided into 36 mile square sections.

The instructions applicable to this area during the period of the survey were issued in 1815 by Surveyor General Edward Tiffin with additional rather vague directives issued periodically thereafter (Stewart 1935). Each 40 chains (½ mi., 0.8 km) a marker was set and two trees emblazened with the survey data. The distance, diameter, and species of these trees were recorded. At the end of each mile, the soils and vegetation (trees and undergrowth) of that mile were described and the suitability of the land for settlement evaluated. The surveyors' instructions included criteria for choosing bearing trees if they occurred within a "reasonable" distance. "Reasonable" distance was not specified in the initial instructions, but by 1840 it was defined as within 10 chains (⅛ mi., 400 m) (Stewart 1935).

Presettlement forest composition and structure were reconstructed by methods outlined by Cottam and Curtis (1956). To make the survey data compatable with modern forest studies in central Illinois, importance values (I.V.) were calculated by adding the relative density and relative dominance (basal area) of each species (Boggess and Geis 1967). Based on the calculation of random pairs (Cottam and Curtis 1956, Anderson and Anderson 1975), tree density for the total area was 36 trees/ha. However, random pairs does not take into consideration the large number of points (up to 64%) that have only one tree, a second being too distant to include, and is therefore biased towards too high a tree density. For this reason, tree density was determined by applying the formula $(Q_1/0.5)^2$ = Mean Area, where Q_1 is the distance to the nearest tree (Cottam and Curtis 1956, Delcourt and Delcourt 1974). Surveyor bias, a frequent problem in some surveys, was found to be insignificant when checked by either chi-square (Bourdo 1956) or by analysis of variance (Delcourt and Delcourt 1974).

Topographic information (slope, category aspect, elevation) was recorded for each witness corner from the following USGS 15-minute topographic maps: Divernon Quad. (1922), Taylorville Quad. (1923), Waverly Quad. (1924), Petersburg Quad. (1933), Tallula Quad. (1940), Springfield Quad. (1940), Mechanicsburg Quad. (1954). Soil types were determined from county soil maps (Hopkins *et al.* 1912, Fehrenbacher *et al.* 1950, Fehrenbacher and Odell 1953). Since the composition of bottomland forests changes in response to a moisture and flooding gradient (Bell 1974), the relationship between vegetation and stream size was examined by ranking the streams (following Strahler 1957) with the smallest streams (on

15-minute topographic maps) ranked 1, and the stream reach below the confluence of two like order streams ranked the next higher order, etc. The rank of the stream was determined for each bottomland point at which witness trees were recorded.

RESULTS

Data from approximately 2,000 quarter section and section corner points was used in the analysis. Upland (level) points accounted for 65.2% of the total points, while valley slope and bottomland were 14.3% and 20.5% respectively. Prairie occurred at 67.4% of all points, including not only the majority of upland points (76%), but the majority of bottomland points as well (65.8%) and 29% of the points occurring on slopes, despite environmental factors favoring the growth of trees in slope situations. The slope angle was also found to be a critical factor in determining vegetation cover. In a sample of 944 points for which slope was determined, most points with a slope in the 5-7% category or greater were forested while relatively flat-lying points were more often prairie covered (Fig. 2). Points in the 5-7% slope category were occupied by both forest and prairie, with 88% of such points on the north and east sides of second-order or larger streams being forested, compared to 35% of those on the south and west sides of such streams. This distribution may be interpreted as the blockage by stream valleys of prairie fires being blown towards the northeast before prevailing winds, a phenomenon originally described by Gleason (1913, 1923).

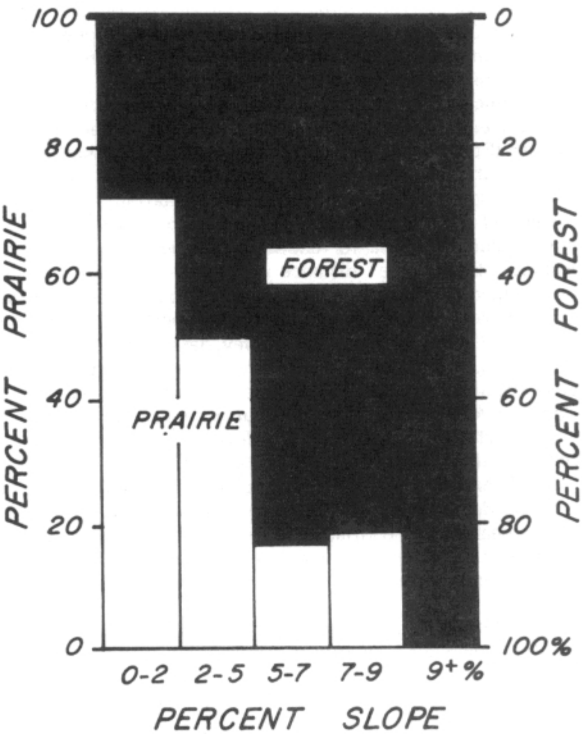

Fig. 2. Relationship between slope category and type of vegetation based on presettlement vegetation of the central Sangamon River Basin, Illinois.

As in all GLO surveys, the surveyors in central Illinois were obligated to choose witness trees at least large enough to have room for their enscribed information (Bourdo 1956, Anderson and Anderson 1975). As a result, tree diameters are over-represented in the 12" (30.5 cm) diameter class and to some extent in the 10" (25.4 cm) and 14" (35.6 cm) diameter classes, while the 8" (20.3 cm), 6" (15.2 cm) and 4" (10.2 cm) classes are increasingly under-represented. The larger diameters tend to be grouped at 18" (15.7 cm), 24" (61.0 cm), 36" (91.4 cm), and so forth into 6" diameter increments. Larger diameters also tend to be under-represented since the surveyors were also interested in the longevity of the potential witness tree (Bourdo 1956). When allowances are made for bias towards selecting trees of certain diameters, the diameter class distribution in the central Sangamon drainage approximates that of an undisturbed old-growth forest in which the smallest diameter class is most highly represented and frequency falls off with increasing age and size (Bourdo 1956). Diameter class distributions between uplands and slopes are nearly identical. It appears that only the most catastrophic environmental events might be recorded in such a tree diameter record, and none is evident.

Forest density, calculated from the survey data, is low (random pairs: 36 trees/ha; nearest tree: floodplain forest 20.6 trees/ha, slopes 41.5 trees/ha, upland forests 10 trees/ha) compared to the 84-108 trees/ha greater than 13" in diameter found in recent forest studies in Illinois (Boggess 1964; Boggess and Geis 1966, 1967; Jackson and Petty 1971; Root *et al.* 1971). These densities are however more similar to those of other midwestern presettlement forests reported by Anderson and Anderson (1975) (84 trees/ha total or 15.8 trees/ha in savannah) or Cottam (1949) (35.8 trees/ha for oak openings in southwestern Wisconsin).

TABLE 1

RELATIVE IMPORTANCE VALUES FOR PRESETTLEMENT FORESTS OF THE CENTRAL SANGAMON BASIN

SPECIES	FLOODPLAIN	SLOPE	UPLAND
Ulmus spp. (elm)	44.6	14.4	12.0
Platanus occidentalis (sycamore)	24.0	< .1	0.1
Quercus velutina (black oak)	25.6	67.6	78.8
Carya spp. (hickory)	19.0	26.0	41.7
Q. alba (white oak)	14.8	69.5	50.8
Acer saccharinum (maple)	11.6	0.7	–
Gleditsia triacanthos (honey locust)	10.3	2.5	1.0
Fraxinus spp. (ash)	9.9	0.9	1.3
Juglans nigra (black walnut)	19.5	4.1	4.1
Celtis spp. (hackberry)	5.4	3.1	0.2
Q. palustris (pin oak, spanish oak)	2.7	1.2	3.2
Q. rubra (red oak)	3.3	–	0.1
Populus deltoides (cottonwood)	2.4	–	–
Acer saccharum (sugar maple)	0.9	2.0	0.1
Morus rubra (mulberry)	0.9	1.4	0.1
Prunus spp. (cherry)	0.9	1.6	1.2
Aesculus glabra (buckeye)	0.8	0.8	0.4
U. rubra (slippery elm)	0.8	0.1	0.1
Tilia americana (basswood, linden)	–	1.2	7.6
Q. macrocarpa (bur oak)	–	0.7	–
Gymnocladus dioicus (Kentucky coffee tree)	–	0.2	–
Q. marilandica (blackjack oak)	–	0.7	0.1
Cercis canadensis (redbud)	–	0.1	–
Sassafras albidum (sassafras)	–	–	0.5

TABLE 2

IMPORTANCE VALUES FOR PRESETTLEMENT UPLAND FORESTS COMPARED TO PRESENT FOREST STANDS FROM CENTRAL ILLINOIS (I.V. GREATER THAN 5.0)

	PRESENT				PRESETTLEMENT	
SPECIES	BROWNFIELD WOODS[1] (PRAIRIE GROVE)	FUNK FOREST[2] (INTERMEDIATE)	ALLERTON PARK[3] (STREAMSIDE FOREST)	HART WOODS[4] ("XEROPHYTIC" STREAMSIDE FOREST)	SLOPE	UPLAND
Sugar maple	81.4	57.9	8.4	–	–	–
Red oak	24.0	5.4	12.2	11.1	–	–
Basswood	14.1	13.0	–	–	–	–
Hackberry	13.8	8.4	–	–	–	–
Ash	16.3	8.4	8.1	–	–	–
Black cherry	–	–	5.3	6.5	–	–
Silver maple	–	–	–	7.0	–	–
Elm	15.4	35.1	25.2	14.2	14.4	12.0
White oak	–	29.0	50.3	98.1	69.5	50.8
Black oak	9.4	7.3	30.6	57.4	67.6	78.8
Hickory	–	–	31.6	–	26.0	41.7

[1]Boggess and Bailey 1964.

[2]Boggess and Geis 1966.

[3]Boggess and Geis 1967.

[4]Root *et al.* 1971.

The dominant trees in the presettlement forest were black oak, white oak, and hickory, with high percentages of elm on the floodplain and walnut *(Juglans nigra)* on the terraces. Black oak was more commonly recorded than was any other species, including white oak. Some blackjack oak *(Q. marilandica)* was encountered on slopes and uplands as well as small amounts of sugar maple *(Acer saccharum)* and red oak on the slopes (Table 1).

As might be expected from modern studies, the presettlement floodplain forest possessed a large component of flood tolerant species: sycamore *(Platanus occidentalis)*, cottonwood *(Populus deltoides)*, silver maple, ash, hackberry, honey locust *(Gleditsia triacanthos)* and hawthorn *(Crataegus* spp.) (Table 1). However, there is also a high frequency of upland types such as white oak, black oak, and hickory, possibly indicating the non-specificity with which the land surveys reflect vegetation types, especially in areas of steep environmental gradients. A witness corner, occurring within a floodplain but near its edge, may contain both upland-slope and floodplain taxa.

When importance values of major tree species are compared with values from recent studies on forest stands in central Illinois, both the presettlement slope and upland forests appear most similar to a "xerophytic streamside forest" (Root *et al.* 1971) rather than to more mesic upland forest groves or streamside forests (Table 2).

If the distribution of major tree taxa are compared to slope and soil factors and their geographical relationship to major (perennial) streams examined (Fig. 3), several patterns emerge. Relatively fire-tolerant black oak was generally more abundant on the south side of major streams and on uplands. White oak, which requires higher levels of soil moisture, was most frequent on the north side of streams despite the relative dryness of such south facing slopes. Hickory was more abundant on the south sides of streams than on the north and although not identified to species by the surveyors, was probably shagbark hickory *(Carya ovata)* which sprouts vigorously after burning with relatively fire resistant new growth and rapidly fills vacancies in a forest (Curtis 1959). The species dominant on sandy soils (including sandy loams as well as dune sands) were influenced at least to some degree by topographic location (Fig. 3) and suggest that such areas may have had sufficiently good soil to support white oak, in addition to the black oak generally favored on poor sandy soils (Fowells 1965, Auclair 1976).

DISCUSSION

Climate is without doubt the single most important factor in the vegetational history of the Prairie Peninsula. The eastward expansion of the prairie in response to the drier and possibly warmer conditions during the "Hypsithermal" period, dating approximately 8000-4500 BP, is increasingly well documented (King 1977, Wright 1976). This dry period was followed by a return to more mesic climatic conditions culminating in a period of wetter and/or cooler conditions known as the "Neoglacial" or "Little Ice Age." King *et al.* (1976) speculate that the onset of this wetter/cooler period may have coincided with increases of arboreal pollen recovered from bottom sediment cores from Lake Michigan, reflecting advances of the forests surrounding the lake. Dated at about 800 BP, these wetter/cooler conditions would thus precede the establishment of Brownfield Woods, an upland mixed mesophytic forest, dated by Vestal and Heerman (1945) as about 400 to 600 years ago, or Trelease Woods, dated at about the same age on the basis of soil development (Boggess and Geis 1967). The "Neoglacial" did not end until the early 19th century, and the GLO surveys were therefore made towards the end of a relatively cool, moist period. At the time of the surveys (1815-1850), forests throughout the Midwest were encroaching onto the prairies (McComb and Loomis 1944, Howell and Kucera 1956, Boggess and Geis 1967).

In the present study, the distribution of prairie and forests suggests that streams as small as second-order were large enough to stop prairie fire advancement, even though at present such streams are dry during the fall when prairie fires are most likely to occur. It is likely that during late presettlement times such small streams may have actually been perennial rather than intermittent.

Prior to EuroAmerican settlement, the central Sangamon basin was primarily prairie, with

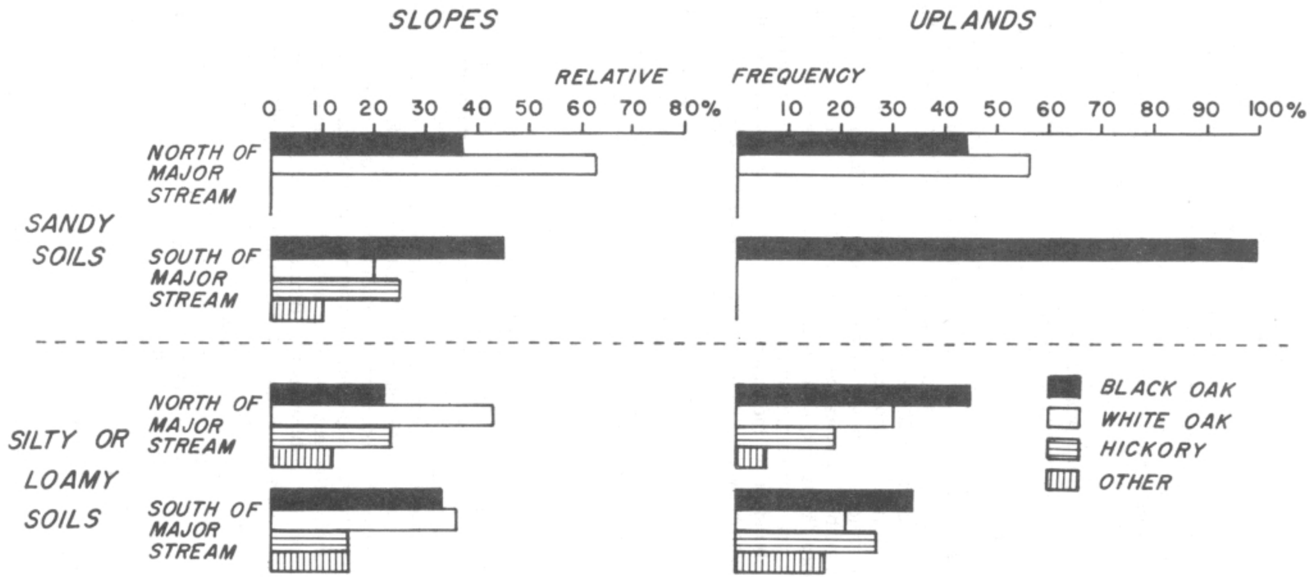

Fig. 3. Distribution of dominant tree taxa by topography, soil type, and geographical relationship to perennial (modern) streams.

forest limited to floodplains, slopes and to small upland patches. Compared to present forest stands, the presettlement slope and upland forests were both most similar to a "xerophytic streamside forest" (Root *et al.* 1971) even though I.V. for black oak compared to white oak are much higher than in any available modern forest analog from central Illinois. The upland forests are composed of more dry site species than those of the slopes, with higher percentages of black oak compared to white oak. This contrasts with present studies showing black oak to be more frequent on steeper slopes with less favorable moisture relations and less organic carbon (Soeriangera 1965, Root *et al.* 1971). At least in some instances it is clear that witness points lying on the north and east sides of streams were sheltered from fires spreading from the south and west, as shown by the higher number of forested points on the leeward sides of such streams, as well as by the relative distributions of black and white oak.

Forest succession in the Midwest may begin with red oak, white oak, bur oak or black oak as the pioneer species depending on how mesic the site. Succession may proceed through stands dominated by red elm to dominance by sugar maple on the most mesic sites, to white oak, shagbark hickory and black cherry on intermediate sites, or to bur oak and black oak on the most xeric (Peet and Loucks 1977). Any site may be maintained in a pre-climax condition by disturbance. Bur oak tends to favor calcareous soils (Fowells 1965) which do not occur widely in the Sangamon drainage. However, the 3 bur oak trees recorded by the surveyors average 84 cm (33") in diameter (compared to an average of 38 cm for all species) suggesting considerable antiquity on the part of these individuals. Black oak is extremely shade intolerant and unable to reproduce under shade (Fowells 1965). The main stem is susceptible to ground fire, but sprouts readily develop from the root collar. White oak is more shade tolerant than black oak and while sprouting prolifically and vigorously after burning, regenerates rather poorly from seed (Fowells 1965). Auclair (1976) found white oak to be restricted to protected locations on the lee of slopes with low moisture and fire stress. Red oak and sugar maple, although insignificant in the presettlement forests of central Illinois, are of interest because of their importance in modern forest stands. Red oak, while somewhat shade tolerant, is extremely susceptible to burning and regenerates poorly. Sugar maple is extremely shade tolerant and rapidly responds to openings in a forest, but it is also thin-barked and readily damaged by fire (Boggess and Geis 1966, Auclair and Cottam 1971). Wuenscher and Valiunas (1967) studying the River Hills region of central Missouri, concluded that the increase in sugar maple that has been observed since presettlement times is due to the absence of fire.

Curtis (1959) found I.V. for black oak and white oak in Wisconsin, comparable to those of the presettlement forests of the central Sangamon basin, only in southern dry forests and oak barrens, both of which he classifies as fire dependent, otherwise succeeding to more mesic forest types. Auclair (1976) also, in Wisconsin, found presettlement vegetation closely correlated with edaphic features except that the species composition of the "savannah" was related not to edaphic conditions, but to the fire-resistance of the individual species. In general, the soils of the central Sangamon drainage seem to be suitable for more mesic forests since similar soils support such forests at present (Boggess and Bailey 1964, Root *et al.* 1971, Boggess and Geis 1966), and some factor other than soils must have been instrumental in determining the forest composition.

It appears from our examination of the GLO survey records of central Illinois, that prior to settlement, the forests were dominated by fire tolerant trees, primarily black oak, white oak, and hickory. Sugar maple, a climax species with low fire tolerance, were rarely encountered. White oak, a tree of intermediate fire resistance was less important than in present forest stands which have undergone decreased burning since settlement. These presettlement forests probably became established at an earlier time in response to more favorable climatic conditions, but were maintained in their relatively early successional stage by fires burning into the forests from the adjacent prairies.

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