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Dynamics of Species Composition and Importance from 1965–1998 in Baber Woods Nature Preserve, Edgar County, Illinois: Evidence of the Effects of Fire Suppression

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ABSTRACT

Presently *Acer saccharum* (sugar maple) dominates the overstory of Baber Woods Nature Preserve with an importance value (IV) of 75.4 (possible 200), more than half the total density (148.4 of 289.4 stems/ha), and numerous individuals in the smaller diameter classes. Second is *Quercus alba* (white oak) with an IV of 45.9, one-third of the basal area (9.28 of 26.95 m^2/ha), which dominates the larger diameter classes, and averages 56.9 cm dbh. Total IV for all oaks combined was 64, and 30 for all hickories combined. Since Baber Woods was first surveyed in 1965, sugar maple has continued to increase in importance, with a corresponding decrease in the importance of oaks and hickories. Data suggest that this woodlot was an open white oak savanna in presettlement time. Fire suppression has resulted in canopy closure and an increase in shade-tolerant, fire-sensitive mesic species like sugar maple.

INTRODUCTION

The reduction in fire frequency in the forests of eastern United State has completely changed the composition and structure of many forests, open woodlands, and savannas. Soon after settlement by Europeans, periodic fires all but ceased in North America. Savanna and open woodlands became closed-canopy forests, while the closed-canopy forests of presettlement times became more mesic. Overall this resulted in an increase in shade-tolerant, fire-sensitive tree species, and a decrease in oak regeneration (Abrams 1992, 2005; Anderson 1991; Ebinger and McClain 1991). As a result, the composition of many fragmented woodlots changed to forests dominated by mesic, shade-tolerant, fire-sensitive species at the expense of the mostly more xeric oaks and hickories (Ebinger 1986, Ebinger and McClain 1991). The closing of the forest canopy also caused a dramatic change in the species composition and structure of the woody understory and the ground layer species, and a corresponding loss in the wildlife depending on these species (Ebinger 1997).

In particular, *Acer saccharum* Marsh. (sugar maple) has increased in importance in many of the original oak-hickory forests that covered vast areas of the United States (Curtis 1959; Abrams 1992, 2005). These changes have been accelerating during the past 50 to 75 years. If this trend continues, many of the oak-hickory forests, their understories, and the wildlife that depends upon them will be in serious trouble. Even the best quality oak-hickory communities on mesic sites are apparently undergoing an irreversible change as sugar maple and other mesic, shade-tolerant species replace many of the original forest components. Very little research has been done concerning methods to reverse this trend, and the problem now concerns many ecologists and managers of natural areas.

Many forests currently designated as Illinois nature preserves, or designated as natural area inventory sites have been surveyed. These studies have been useful in determining forest structure and composition, understanding changes in forest vegetation since the time of

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European settlement, and determining potential threats to these forests. Similar studies have also been conducted on some of the few remaining woodlands, savannas and prairie groves in the state.

Few studies have documented changes in Illinois forests over an extended period of time. Presently, the most intensively studied natural areas are those managed by the University of Illinois. Three woodland surveys have been completed in Brownfield Woods, Champaign County, a remnant of a streamside prairie grove (Telford 1926, Boggess and Bailey 1964, Eddington 1991). Trelease Woods, also part of this grove, has been surveyed twice (Boggess 1964, Pelz and Rolfe 1977). In addition, Hart Memorial Woods along the Sangamon River in Champaign County has also been surveyed twice (Root et al. 1971, Johnson et al. 1978). Funks Forest Natural Area, a prairie grove remnant in McLean County, has been examined three times (Calef 1953, Boggess and Geis 1966, Cox et al. 1972).

Baber Woods Nature Preserve, an upland forest in Edgar County, has been surveyed three times during the past 40 years. Complete surveys of the 16 ha preserve were completed in 1965 (McClain and Ebinger 1968), 1983 (Newman and Ebinger 1985), and most recently in 1998. The results of the 1998 survey are presented here and compared with results of previous surveys.

DESCRIPTION OF THE STUDY AREA

Baber Woods Nature Preserve is located in the southwestern corner of Edgar County, about 7 km southeast of Kansas, Illinois (NW1/4 S18 T12N R13W). It is located at the northern edge of the Shelbyville moraine, the terminal moraine of Wisconsin glaciation in the Grand Prairie Section of the Grand Prairie Natural Division (Schwegman 1973), which is part of the Prairie Peninsula Section of the Oak-hickory Forest Region (Braun 1950), and the prairie peninsula of Transeau (1935). The topography is gently rolling, ranging from 230 to 244 m above sea level. The woodlot is well drained, and, except for a few small depressions, there is no standing water even during wet periods. Drainage is by four small streams that are dry except immediately after a rain (Figure 1).

This woodlot represents a remnant of a much larger tract of savanna, woodland, and forest that occupied most of the Shelbyville moraine in presettlement times (Government Land Office survey records). The Baber family purchased a section of the timber in 1835, and by 1894 had obtained the entire tract. Used as a source for fence rails, fire wood, and lumber, none of the woodlot was completely cut except for a 1 ha lot in the southwest corner of the present preserve. According the Mr. Adin Baber, who donated the woods for preservation, the woodlot has been left undisturbed since 1898 (McClain and Ebinger 1968).

METHODS

Survey and analysis procedures follow those of McClain and Ebinger (1968), except that metric units are now used. During the summer of 1998 the woodlot was surveyed using the same quadrates (50 m $\times$ 50 m) that were used by McClain and Ebinger (1968) and Newman and Ebinger (1985). In each quadrate all living and dead-standing woody individuals $\geq$10.0 cm dbh were identified and their diameters recorded. From these data, the living-stem density (stems/ha), basal area (m^2/ha), relative density, relative dominance (basal area), importance value (IV), and average diameter (cm) were calculated for each species. Determination of the IV follows the procedure used by McIntosh (1957), and is the sum of the relative density and relative dominance. Dead-standing stem density (stems/ha), basal area (m^2/ha), and average diameter were also determined.

Woody understory composition and density (stems/ha) were determined using nested circular plots 0.0001, 0.001, and 0.01 ha in size. Two hundred sets of nested plots were located at about 15 meter intervals along eight east/west line transects. A random numbers table (single digit) determined the number of meters the 200 center points were located right (odd numbered

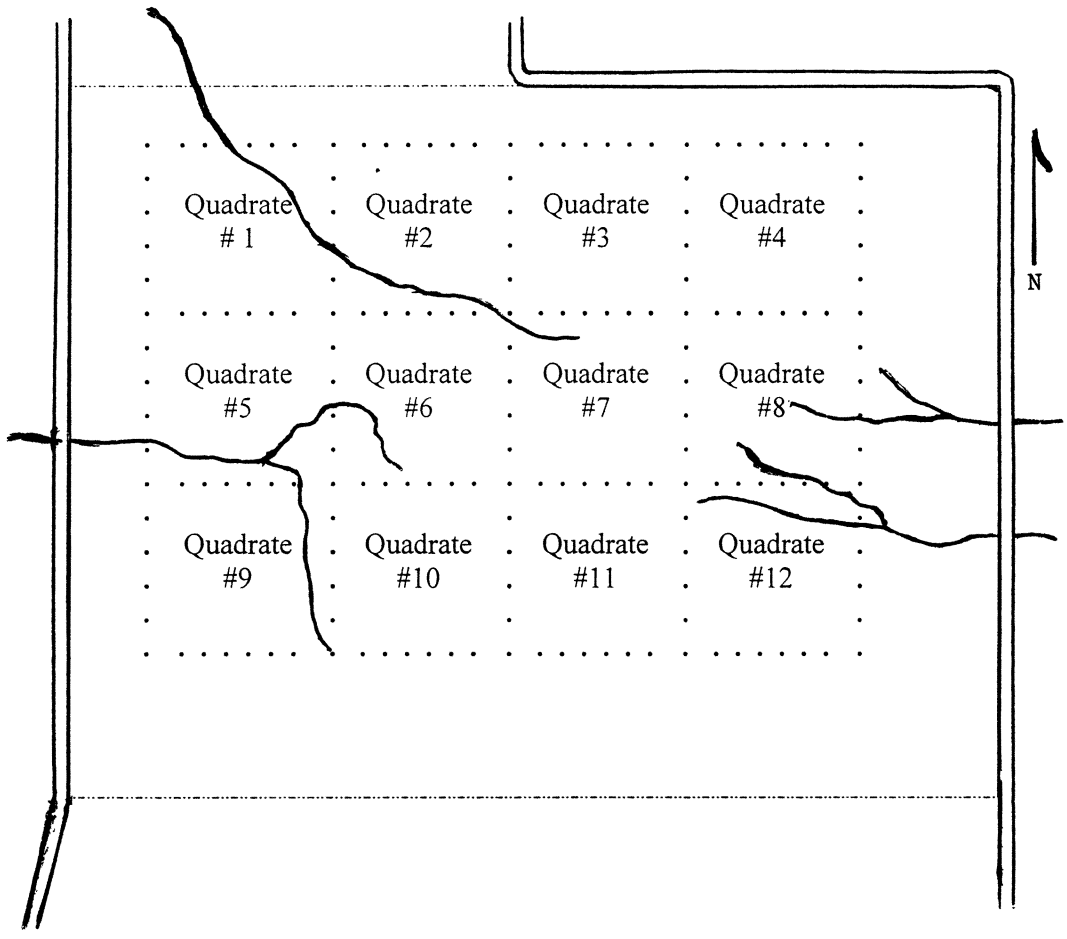

Figure 1. Map of Baber Woods showing the position of the four small streams, the surrounding roads, and the position of the 12 quadrates (100 × 100 m) used to calculate the data for Table 5.

plots) or left (even numbered plots) of the transect lines. Four additional 0.0001 ha circular plots were located 7 m from the center points along cardinal compass directions. In the 0.0001 ha plots, woody seedlings (≤50 cm tall) and all shrubs were counted; in the 0.001 ha circular plots small saplings (>50 cm tall and <2.5 cm dbh) were recorded; and in the 0.01 ha circular plots large saplings (2.5–9.9 cm dbh) were tallied. Nomenclature follows Mohlenbrock (2002).

RESULTS

Thirty woody species were encountered in the overstory and understory plots, of which nine were understory trees and shrubs. The overstory dominant was sugar maple with an IV of 75.4 (Table 1). It accounted for more than half of the total density, dominated the 10–19 through 40–49 cm diameter classes (Table 2), and averaged 21.0 cm dbh. Second in IV was *Quercus alba* L. (white oak) that accounted for one-third of the basal area (9.28 m^2/ha), dominated the larger diameter classes, and averaged 56.9 cm dbh. All other species encountered had IV's lower than 20 and were relatively minor components of the overstory.

The woody understory was also dominated by sugar maple, which accounted for one-third to one-half of the stems in the seedling and sapling categories (Table 3). Though fourth in IV in

Table 1. Density (stems/ha) basal area (m^2/ha), relative density, relative dominance, importance value, and average diameter (cm) of the woody overstory species encountered in the 1998 fall survey of Baber Woods Nature Preserve, Edgar County, Illinois

Species	Density stems/ha	Basal Area m^2/ha	Rel. Den.	Rel. Dom.	I. V.	Avg. Diam. (cm)
Acer saccharum	148.4	6.46	51.4	24.0	75.4	21.0
Quercus alba	33.3	9.28	11.5	34.4	45.9	56.9
Carya glabra	17.1	3.54	5.9	13.1	19.0	49.8
Ulmus rubra	28.2	0.73	9.7	2.7	12.4	16.8
Quercus velutina	5.9	1.71	2.1	6.3	8.4	57.0
Quercus rubra	4.8	1.71	1.7	6.3	8.0	63.3
Carya ovata	8.2	1.02	2.8	3.8	6.6	37.8
Fraxinus americana	8.9	0.73	3.1	2.7	5.8	28.3
Ulmus americana	8.5	0.22	3.0	0.8	3.8	17.0
Carya cordiformis	6.2	0.40	2.2	1.5	3.7	25.3
Celtis occidentalis	4.3	0.18	1.5	0.7	2.2	21.1
Juglans nigra	2.5	0.37	0.8	1.4	2.2	40.6
Sassafras albidum	4.0	0.10	1.4	0.4	1.8	17.0
Others (11 species)*	9.1	0.50	2.9	1.9	4.8	
Totals	289.4	26.95	100.0	100.0	200.0	

* Others included *Carya tomentosa* (mockernut hickory), *Prunus serotina* (wild black cherry), *Quercus muhlenbergii* (chinquapin oak), *Carpinus caroliniana* (ironwood), *Cercis canadensis* (redbud), *Tilia americana* (basswood), *Diospyros virginiana* (persimmon), *Platanus occidentalis* (sycamore), *Morus rubra* (red mulberry), *Crataegus mollis* (red haw), and *Asimina triloba* (pawpaw).

the overstory, *Ulmus rubra* Muhl. (slippery elm) was second in seedlings and saplings density, the majority being root-sprouts (Davis et al. 1997). *Fraxinus americana* L. (white ash) ranked third in seedlings/ha but was eighth in IV. *Asimina triloba* (L.) Dunal (pawpaw), fourth in seedlings/ha, was well represented in the sapling category, but only a few tree-sized individuals were recorded. Pawpaw has a clumped distribution in the woodlot and reproduction is mostly by root suckers following initial establishment (Larimore et al. 2003). *Toxicodendron radicans* (L.) Kuntze is the common shrub/vine, accounting for 2,910 stems/ha (Table 3).

Table 2. Density (stems/ha) by diameter classes of the woody overstory species encountered in the 1998 fall survey of Baber Woods Nature Preserve, Edgar County, Illinois

	Diameter Classes (cm)								
Species	10–19	20–29	30–39	40–49	50–59	60–69	76–79	80–89	90+
Acer saccharum	88.1	34.2	15.5	7.2	2.5	0.6	0.2	0.1	—
Quercus alba	0.4	1.9	2.7	6.2	8.2	6.7	4.3	1.7	1.2
Carya glabra	0.1	0.6	2.8	6.0	4.1	2.7	0.6	0.1	0.1
Ulmus rubra	21.8	5.1	0.6	0.6	0.1	—	—	—	—
Quercus velutina	0.3	0.5	0.3	0.9	0.8	1.3	1.3	0.4	0.1
Quercus rubra	0.3	0.3	0.2	0.6	0.8	0.6	0.9	0.4	0.7
Carya ovata	0.7	1.8	1.8	2.3	1.4	0.2	—	—	—
Fraxinus americana	2.7	3.4	1.4	0.6	0.1	0.3	0.1	0.2	0.1
Ulmus americana	6.2	2.0	0.3	—	—	—	—	—	—
Carya cordiformis	2.7	1.5	1.0	0.5	0.4	0.1	—	—	—
Celtis occidentalis	2.3	1.1	0.6	0.3	—	—	—	—	—
Juglans nigra	0.2	0.4	0.8	0.5	0.3	0.1	0.1	–	0.1
Sassafras albidum	3.0	1.0	—	—	—	—	—	—	—
Others (11 species)	5.6	1.0	0.9	0.8	0.4	0.3	0.1	—	—
Totals	134.4	54.8	28.9	26.5	19.1	12.9	7.6	2.9	2.3

Table 3. Density (stems/ha) of the woody understory species encountered in the 1998 fall survey of Baber Woods Nature Preserve, Edgar County, Illinois

Species	Seedlings	Small Saplings	Large Saplings
Acer saccharum	10680	1445	472.5
Ulmus rubra	7590	1300	113.5
Fraxinus americana	2070	45	0.5
Asimina triloba	1170	840	57.5
Prunus serotina	630	5	0.5
Carya ovata	420	5	—
Carya glabra	250	—	—
Carya cordiformis	240	40	0.5
Sassafras albidum	220	30	1.0
Celtis occidentalis	110	20	—
Morus rubra	80	5	0.5
Quercus velutina	70	—	—
Quercus alba	50	—	—
Carpinus caroliniana	50	—	5.5
Ulmus americana	30	10	4.0
Carya tomentosa	30	—	—
Ostrya virginiana	10	—	1.5
Malus ioensis	10	—	1.0
Tilia americana	—	5	—
Toxicodendron radicans	2910	—	—
Hydrangea arborescens	280	—	—
Ribes missouriense	70	—	—
Viburnum prunifolium	40	—	—
Totals	27010	3750	658.5

Dead-standing trees were relatively common, with 23.31 stems/ha and a basal area of 3.01 m^2/ha (Table 4). White ash, slippery elm, and white oak dominated this category. Most dead oaks were large individuals having diameters of 50 to 70 cm. Dead individuals of other species, in contrast, were of smaller diameters.

DISCUSSION

Sugar maple and oaks represent two distinct size classes in Baber Woods. Oaks dominate larger diameter classes, suggesting that they have been an important forest component for an

Table 4. Density (stems/ha), basal area (m^2/ha), and average diameter (cm) of dead-standing stems encountered in the 1998 fall survey of Baber Woods Nature Preserve, Edgar County, Illinois

Species	Density stems/ha	Basal area m^2/ha	Average Diameter
Fraxinus americana	5.52	0.26	22.2
Ulmus rubra	4.13	0.18	20.1
Quercus alba	3.87	0.96	51.5
Quercus velutina	1.97	0.68	64.7
Acer saccharum	1.59	0.08	21.5
Quercus rubra	1.21	0.44	66.2
Carya glabra	1.21	0.23	47.2
Sassafras albidum	1.02	0.02	15.2
Others (9 species)	2.79	0.16	
Totals	23.31	3.01	

Table 5. Distribution of sugar maple in Baber Woods Nature Preserve, Edgar County, Illinois for the surveys of 1965 (McClain and Ebinger 1968), 1983 (Newman and Ebinger 1985), and the fall of 1998. The following information is given for each quadrate (1 ha): the number of sugar maple stems present (≤10 cm dbh), the number of sugar maple stems 40 cm dbh and above, the average diameter of sugar maple stems (cm), and the importance value (I.V.) for sugar maple. The importance value is determined by adding relative density and relative dominance. The northern edge of the woods is represented by quadrates 1 through 4

	Quadrate 1			Quadrate 2			Quadrate 3			Quadrate 4		
	1965	1983	1998	1965	1983	1998	1965	1983	1998	1965	1983	1998
≤10 cm dbh	140	153	133	158	152	157	104	124	147	82	102	140
≤40 cm dbh	8	14	22	12	17	29	3	4	8	2	9	17
Av. Diameter	23.1	23.6	26.9	22.1	25.3	27.4	193	20.9	21.5	20.1	22.7	23.2
I. V.	78.1	86.2	91.4	82.4	98.6	119.5	52.6	68.1	82.6	42.1	57.5	82.0
	Quadrate 5			Quadrate 6			Quadrate 7			Quadrate 8		
≤10 cm dbh	98	134	165	91	138	168	90	100	150	45	70	119
≤40 cm dbh	7	9	15	5	6	8	3	6	12	1	4	11
Av. Diameter	20.6	20.5	22.5	19.1	19.4	20.6	18.9	21.6	22.9	19.5	20.4	20.8
I. V.	51.2	71.9	99.1	45.9	66.7	83.0	45.8	58.3	84.6	25.1	37.8	65.3
	Quadrate 9			Quadrate 10			Quadrate 11			Quadrate 12		
≤10 cm dbh	60	95	171	29	101	204	38	74	144	34	58	135
≤40 cm dbh	9	14	12	—	1	2	—	2	8	—	1	6
Av. Diameter	23.5	21.1	17.7	15.6	15.5	16.9	19.8	20.2	19.2	18.5	20.9	19.0
I. V.	40.8	53.2	73.0	13.8	39.2	74.9	25.4	45.8	72.6	20.4	34.5	58.0

Table 6. Density (stems/ha) in broad diameter classes for sugar maple, oak species, and all other species in Baber Woods Nature Preserve, Edgar County, Illinois for the survey of 1965 (McClain and Ebinger 1968), 1983 (Newman and Ebinger 1985), and the fall of 1998

	Sugar Maple			Oak Species			Other Species			Totals		
Classes	**1965**	**1983**	**1998**	**1965**	**1983**	**1998**	**1965**	**1983**	**1998**	**1965**	**1983**	**1998**
10–19 cm	42.6	58.9	88.1	7.6	3.7	1.4	50.0	62.1	44.9	100.2	124.7	134.4
20–29 cm	17.8	24.7	34.2	10.9	4.9	2.7	17.0	17.7	17.9	45.7	47.3	54.8
30–39 cm	7.3	10.6	15.5	14.7	8.3	3.3	19.0	13.2	10.1	41.0	32.1	28.9
40–49 cm	2.4	4.6	7.2	17.7	11.6	7.9	15.4	12.6	11.4	35.5	28.8	26.5
50–59 cm	0.6	1.0	2.5	16.2	13.0	9.9	5.6	7.9	6.7	22.4	21.9	19.1
60–69 cm	0.1	0.3	0.6	7.5	11.1	8.7	0.9	2.1	3.6	8.5	13.5	12.9
70–79 cm	—	—	0.2	2.7	4.4	6.6	0.3	0.6	0.8	3.0	5.0	7.6
80–89 cm	—	—	0.1	1.1	2.3	2.5	0.1	0.2	0.3	1.2	2.5	2.9
90+ cm	—	—	—	1.1	1.5	2.0	—	—	0.3	1.1	1.5	2.3
Total	70.8	100.1	148.4	79.5	60.8	45.0	108.3	116.4	96.0	258.6	277.3	289.4

extended period of time. Sugar maple, in contrast, is the common species of smaller diameter classes and has probably been increasing in importance during the past century. The large number of sugar maple seedlings and saplings suggests a continuation of this trend (Table 3).

Since the first survey in 1965, the composition and structure of Baber Woods has changed dramatically. A breakdown of species densities, large diameter classes, and average diameters by one ha blocks of the 1965, 1983, and 1998 surveys (Figure 1) suggest the time when sugar maple began to increase in importance. In nearly every one ha block sugar maple increased in stems/ha, stems exceeding 40 cm dbh, average diameter, and importance value from 1965 to 1998 (Table 5). Also, there was a general decrease in the number and size of sugar maple in the woods from the northwest corner to the southeast corner of the woods based on the 1965 survey. By the 1998 survey, however, sugar maple had increased in abundance and now dominates the entire preserve (Table 5).

Another indication of the steady increase of sugar maple in Baber Woods is its distribution by diameter classes from the 1965, 1983, 1998 survey data as compared to oaks and other species in the woodlot (Table 6). Sugar maple increased in all diameter classes between the three surveys, particularly in the 10–19 and 20–29 cm diameter classes. It also had an overall increase of near 30 stems/ha between 1965 and 1983, and an increase of 48 stems/ha between 1983 and 1998. Oak species, in contrast, decreased in number, dramatically so in the lower diameter classes, with increases occurring only in the 60 through 90 cm diameter classes. Overall, species density increased in the woodlot from 258.6 stems/ha in 1965, to 277.3 stems/ha in 1983, and to 289.4 stems/ha in 1998 (Table 6). Most of this increase was due to sugar maple and other mesic species that are shade-tolerant. Presently the oaks are common only in the larger diameter classes. Oak reproduction is sparse, and as veteran oaks die, few oaks will be available to fill canopy gaps (Ebinger 1986). Sugar maple, in contrast, with its high gap-phase-replacement-potential, will take advantage of these canopy openings.

In a walk-through survey conducted during the early spring of 1990, 26 large, open-grown white oaks were observed in Baber Woods (Ebinger and McClain 1991). All had open, round crowns and large lower branches, most within 4 m of the ground, and are probably remnants from a time when this forest was an open, upland savanna. The average diameter of these open-grown white oaks was 101.6 cm dbh, and two that had just died were cut in 1990 and aged at 313 years. Both had fire scars at 65 and 77 years, indicating that fires occurred in the past. Five other recently dead large oaks were also cut and aged. These forest-grown trees had straight trunks, no lower branches or branch scars, an average diameter of 68.2 cm, and no fire scars were present. They varied in age from 140 to 158 years, with an average age of 148 years (Ebinger and McClain 1991). These five individuals started to grow about the time European settlers were becoming common in east-central Illinois.

The data suggest that before European settlement of central Illinois, the area known as Baber Woods was an open, white oak savanna of open-grown trees maintained by periodic fires. This community was probably park-like with an understory of prairie grasses, forbs, and shrubs, the understory being kept open by wildfires, which killed the young trees. With the cessation of fire soon after the European settlers arrived, young oak trees and sprouts from oak grubs began to fill gaps in the canopy between large open-growth white oaks. These trees grew straight and tall with minimal lateral branching as light became a limiting factor. As shade increased, moisture levels within the partially closed-canopy forest increased, creating a habitat for the more mesic, shade-tolerant and fire-sensitive species such as sugar maple, elms, and ashes.

This pattern suggests that sugar maple occurred in the ravines just to the north and west of the preserve prior to European settlement, being protected from fire by the rough topography. With the cessation of fire, this fire-sensitive species started to invade the uplands that now is known as Baber Woods Nature Preserve (Ebinger and McClain 1991). Presently, the sugar maples in the northwest corner of the preserve are overall larger, and more numerous than in the remainder of the preserve (Table 5).

The reduction in fire frequency in the oak-hickory forests of the Midwest has completely changed the structure and composition of many forests, open woodlands, and savannas. Soon after settlement by Europeans, periodic fires ceased in the prairie peninsula. Savanna and open woodlands became closed-canopy forests, while the closed-canopy forests of presettlement times became more mesic (McClain and Elzinga 1994). Overall this resulted in an increase in shade-tolerant, fire-sensitive tree species, and a decrease in oak regeneration (Anderson 1991, Ebinger and McClain 1991). As a result, the composition of many woodlots changed to forests dominated by mesic, shade-tolerant, fire-sensitive species such as sugar maple and slippery elm at the expense of the oaks and hickories. The closing of the forest canopy also caused a dramatic change in the species composition and structure of the woody understory and the ground layer species, and a corresponding loss in wildlife that depend on these species (Ebinger 1997). These changes have been documented in many mesic woodlots in central Illinois as well as throughout much of the Midwest.

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