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CHANGES IN STRUCTURE AND COMPOSITION OF WOODY STRATA AT KARCHER'S POST OAK WOODS NATURE PRESERVE AFTER TWENTY YEARS

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ABSTRACT

The woody vegetation of 16-ha Karcher's Post Oak Woods Nature Preserve, Hamilton County, Illinois, was examined in September 2020 in a 100 m x 300 m and an adjacent 50 x 200 m vegetation sampling area in mature, second-growth timber. Previous studies of this portion of the site had been conducted in 2000 and 2009. In 2000, prior to any recent management, overall density of trees ≥10.0 cm diameter at breast height (dbh) was 378.1 trees/ha. *Carya* spp. (hickory) density was 255.0 trees/ha and *Quercus stellata* Wangh. (post oak) density was 78.3 trees/ha. Hickory density in the 10.0-19.9 cm diameter class was 169.4 trees/ha (66.4% of total hickory stems). Prescribed burning was conducted on 28 March 2000, 22 March 2001, 22 October 2003, 10 March 2009, and 22 February 2020. Mechanical thinning of subcanopy hickory was conducted in 2014. In 2020, overall tree density was 264.2 trees/ha, about 70% of

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baseline. Hickory density was reduced to 197.5 trees/ha while the hickory density in the 10.0-19.9 diameter class was reduced to 85.6 trees/ha. Natural mortality reduced post oak density to 41.7 trees/ha and its presence in all classes from seedling through 29.9 cm dbh was minimal. Other oak species were present only as minor components of the forest. These data suggest the forest is shifting from post oak to hickory with oak species as lesser associates.

Keywords: *Quercus stellata*, prescribed burning, *Carya* species, hickory thinning, Illinois

INTRODUCTION

Quercus stellata Wangh. (post oak) forests were once prevalent on the uplands of south-central Illinois (Tedford 1926). The post oak forests occurred primarily on Illinioan-age soils that were heavy, acidic, low in organic matter and had clay subsoil. These soils frequently contain an argillic horizon with low permeability that retards the downward percolation of water, creating a perched water table directly above the claypans at a depth that can range from several centimeters to as much as two meters, often resulting in excessive drying and slow forest growth rates. Telford (1926) reported that it could take post oaks 100 years to reach 35 cm in diameter and up to 300 years for them to reach 76 cm. The tree density within the post oak forests could be quite high with Telford (1926) reporting an average of 575 trees/ha in the forests he sampled; however, the species diversity was often low, with post oak accounting for 73.8% of the trees sampled and scrub oak, *Carya* sp. (hickory), *Quercus velutina* Lam. (black oak) and *Q. imbricaria* Michx. (shingle oak) as lesser associates. *Quercus alba* L. (white oak) was often associated with post oak on better drained sites with undulating topography and a deeper argillic horizon while *Q. marilandica* Münchh. (blackjack oak) occurs with post oak in flatwoods with shallow A horizon (IDNR 2017).

The Illinois Natural Areas Inventory (INAI) recognizes only 22 sites totaling less than 300 ha (762 acres) as Grade A or B post oak woodland or southern flatwoods with relatively little disturbance (IDNR 2022). Of those sites, 19 totaling 256 ha are southern flatwoods. Karcher's Post Woods Nature Preserve and a privately-owned site in Saline County are the only post oak dominated sites recognized by the INAI as forest or woodland. These sites are distinguished from flatwoods by theirs undulating topography, greater depth of the A horizon to the argillic horizon, and canopy cover that ranges from 60-80%.

Study Site Description

Karcher's Post Oak Woods Nature Preserve is located in Dahlgren Township (T4S R5E; 38.207355N, -88.618197W) about eight miles northwest of McLeansboro, Hamilton County, Illinois in the Mount Vernon Hill Country Section of the Southern Till Plain Natural Division of Illinois (Schwegman 1973). This natural division is characterized by nearly flat to gently rolling topography that was mostly timbered before European settlement, though extensive prairie inclusions were present. Four prairies were located within 4 km of the preserve with the largest, about 5 km^2 in size, described as a wet prairie by the General Land Office surveyors (GLO field Notes, Vol. 76, Illinois State Archives). The GLO notes generally described the area in the immediate vicinity of the preserve as "land flat and wet" and "land thinly timbered with post oak, otherwise prairie with scattered groves of timber."

Soils of the study site are Bluford silt loam and Belknap silt loam (Web Soil Survey 2020). Bluford silt loam is a deep, nearly level, somewhat poorly drained soil that formed in loess over mixed loess and drift. The seasonal water table is 15 to 95 cm below the surface. Belknap silt loam is a somewhat poorly drained, occasionally flooded soil that developed on silty

alluvium. It is associated with the intermittent stream that meanders through the east-central portion of the preserve. The seasonal water table is 30 to 110 cm below the soil surface. The climate is characterized by hot, humid summers and cold winters. Average annual precipitation is 105 cm. Annual frost-free growing days average 184 days.

The preserve has an undulating topography that slopes gently from southwest to northeast with elevation ranging from 134 m to 141 m above sea level. The far east-central portion of the preserve contains 3 ha of old field and 2 ha of young forest with the trees generally less than 20 cm diameter at breast height (dbh). The western portion of the nature preserve contains 11 ha of mature old- or second-growth timber. An intermittent stream flows easterly near the southern boundary of the preserve, turns northward at the west edge of the young timber, then east along the north edge of that timber and the old field. The 16-ha nature preserve was purchased by the Illinois Audubon Society in 1998 and dedicated as an Illinois Nature Preserve in November 1999.

Previous Work

The preserve is included in a 43-ha stand of timber that was purchased by Augustus Karcher in 1875. Within the stand and adjacent to the nature preserve is an 8-ha stand of timber that was harvested in 1996. Prior to harvest, the structure and composition of the stand was very similar to the nature preserve (McClain and Ebinger 2003). Cross sections from the stumps of harvested trees were analyzed to determine the age of the trees and the fire history of the stand (McClain et. al. 2010). That study indicated the stand experienced three distinct periods: (1) a fire era from 1776-1850 when fires were of landscape scale with a fire return interval of 1.97 years; (2) a fire-free period from 1851-1884 which coincided with a period of rapid settlement of

Hamilton County and (3) a second fire period from 1885-1996 with generally lower intensity fires confined to woodlots and a fire return interval of 1.44 years. Fires occurred nearly annually from 1904 and 1972. The exception being a fire-free period from 1957 through 1963. Three post oak cohorts were identified: 211-224 years old, 137-151 years old, and 104-115 years old. Post oak recruitment declined considerably after the last cohort and was replaced in more recent times by hickory, *Prunus serotina* Ehrh. (wild black cherry), black oak, and *Sassafras albidum* (Nutt.) Nees (sassafras).

Prior to management of the nature preserve, a thick layer of leaf litter covered the forest floor, herbaceous vegetation was sparse, few oak seedlings were present, and hickories dominated the subcanopy strata. Prescribed burning to reduce the leaf litter was conducted on 28 March 2000, 22 March 2001, and 22 October 2003. Subsequent burns were conducted on 10 March 2009 (Edgin 2009) and 22 February 2020. The prescribed fire in March 2009 was of moderately high intensity while the February 2020 burn was of very low intensity with a patchy distribution. Prescribed burning was attempted in the spring of 2015 and 2017, but ground conditions were not favorable so the burns were cancelled. Thinning to reduce subcanopy hickory density and shading was conducted in 2014.

There were two primary goals with this study. The first was to examine the seedling, sapling and overstory strata of the old- or mature second-growth forest to verify the perceived diminishing status of post oak within various strata of the stand. A second goal was to determine whether the removal of subcanopy hickory and the re-introduction of fire promote post oak recruitment.

METHODS

Overstory Sampling

A 100 m x 300 m vegetation sampling area was established in a north-south orientation in the mature second-growth timber in the summer of 1999. In 2000, an addition 50 x 200 m area was added immediately adjacent to the east side of the 100 m x 300 m area. To facilitate the location of the area for future studies, the corners of the study area and the interior grid were marked with sections of galvanized sign post driven into the ground. The exterior boundaries were marked at 25 m intervals and the interior grid was marked at 50 m intervals. Sampling was conducted in by dividing the 4.0 ha area into 64 25 m x 25 m quadrats using string and all living and dead-standing trees $\geq$ 10.0 cm dbh were identified and their diameters recorded. From these data, tree density (trees/ha), basal area (m^2/ha), relative density, relative dominance, importance value (IV) and average diameter were determined for each taxon. Determination of IV follows the procedure used by McIntosh (1957) and is the sum of relative density and relative dominance with total possible score of 200. Dead-standing tree density (trees/ha), basal area (m^2/ha), and average diameter were determined for each taxon.

Woody Understory

Within the 4.0 ha study area, the woody understory composition including large saplings ($\geq$2.5 cm and <10.0 cm dbh), small saplings ($\geq$50 tall cm and <2.5 cm dbh) and seedlings (<50 cm tall) was sampled using stratified random plots located at 20-m intervals along five north-south transect lines which corresponded to the 25, 50, 75, 100 and 125 m locations along the north and south exterior lines of the study area. A random numbers table was used to determine the distance (m) from the transect line to the center of each stratified plot. Odd-numbered plots were located on the right side of the transect line; even-numbered on the left. Large saplings were recorded in 0.01ha plots (n = 60). Small saplings were recorded in 0.001ha plots (n = 60).

Seedlings were recorded in 0.0001 ha plots (n = 300) with four additional 0.0001 ha circular plots located 7 m from the center of each plot in each of the four cardinal compass directions. Density (stems/ha) was determined for each taxon in each understory category. Initial sampling was conducted in summer 2000. The sample was replicated in September 2009 and October 2020. Botanical nomenclature follows Mohlenbrock (2002).

RESULTS

Overstory

The 2000 overstory sample included 19 taxa with an overall tree density of 378.1 trees/ha and a total basal area of 23.24 m^2/ha (Figures 1 and 2). Post oak and *Carya ovata* (Mill.) Koch (shagbark hickory) were co-dominants with IV's of 67.0 and 63.2, respectively (Table 1). *Carya glabra* (Mill.) Sweet (pignut hickory) was third with an IV of 25.6 followed by *C. tomentosa* (Poir.) Nutt. (mockernut hickory). Post oak was most prevalent in the 20.0-59.9 cm diameter classes while hickories were most abundant in the 10.0-29.9 cm diameter classes where they accounted for 82.9% of the trees. Black oak and white oak were lesser associates having densities of 17.9 and 12.0 trees/ha, respectively. *Quercus rubra* L. (red oak) was a minor component with a density of only 3.7 trees/ha. Twelve additional taxa had a combined density of 11.2 trees/ha, total basal area of 0.311 m^2/ha and were most prevalent in the 10.0-19.9 cm diameter class. Among those taxa, wild black cherry (3.1 trees/ha), *Ulmus americana* L. (American elm, 2.7 trees/ha), and sassafras (2.0 trees/ha) had a tree density $\geq$ 1.0 trees/ha. *Celtis occidentalis* L. (hackberry), *Cornus florida* L. (flowering dogwood), *Diospyros virginiana* L. (persimmon), *Fraxinus americana* L. (white ash), *Morus rubra* L. (red mulberry), *Quercus*

bicolor (swamp white oak), shingle oak, blackjack oak, and *Ulmus rubra* Muhl. (slippery elm) were represented by only one or two trees.

The 2009 sample included 18 taxa with an overall density of 340.3 trees/ha a decline of 37.8 trees/ha from 2000 (Figure 1, Edgin 2009). Post oak density declined from 78.3 to 64.3 trees/ha with all the decrease occurring in the 20.0-49.9 cm diameter classes as post oak density shifted toward the larger diameter classes. Hickory remained most abundant in the 10.0-29.9 diameter classes though their overall density declined by 13.7 trees/ha. Black oak remained relatively unchanged in both density and distribution among diameter classes. White oak density declined slightly, but was evenly distributed among all diameter classes, though in very low numbers. Red oak was present only in the 30.0-49.9 diameter classes. Eleven additional taxa, each with only one or two trees, had a combined density of 7.2 trees/ha, total basal area of 0.176 m^2/ha and were most prevalent in the 10.0-19.9 cm diameter class.

The 2020 sample included only 13 taxa and overall tree density declined by 76.1 trees/ha from the previous sample to 264.2 trees/ha (Figure 1). Post oak density fell to 41.7 trees/ha with most of its decline occurring in the 20.0-49.9 cm diameter classes. Thinning conducted in the winter of 2014 reduced overall hickory density in 10.0-19.9 diameter class from 151.5 to 85.6 trees/ha. White oak had a slight decline but was still evenly distributed among diameter classes. Black oak density decreased from 17.8 to 10.2 trees/ha with most of the decline occurring in the 10.0-39.9 cm diameter classes. Red oak density increased between 2009 and 2020 with the increase occurring in the smaller diameter classes. Among the lesser associates, over the 20-year period, wild black cherry density decreased from 3.7 to 0.0 trees/ha and sassafras decreased from 2.0 to 1.3 trees/ha while red mulberry, hackberry, white ash and shingle oak remained unchanged with only one or two trees present in both samples. American elm, blackjack oak, flowering

dogwood, persimmon, slippery elm and swamp white oak, which were present as one or two trees in 2000 were not encountered in 2020 and one *Quercus palustris* Münchh. (pin oak) was present in 2020, but not 2000.

Dead-Standing Trees

Density among all dead-standing trees dropped over the course of 20 years from 27.7 trees/ha to 18.1 trees/ha (Table 2). However, post oak dead-standing tree density increased from 10.7 trees/ha to 13.3. Its total basal area increased from 1.2 to 2.3 m^2/ha and the average diameter increased from 34.6 to 40.3. Among dead-standing trees, post oak was the only taxon to experience an increase in both density and average diameter. Density of dead-standing black oak, shagbark and pignut hickory all decreased while their average diameters increased.

Large Saplings

Twelve species with a total stem density of 414.2 stems/ha occurred in the 2000 sample (Table 3). Shagbark hickory (300.0 stems/ha) and mockernut hickory (40.6 stems/ha) accounted for 82.2% of the total. Black oak, sassafras and American elm were the only other taxa with densities greater than 3.1 stems/ha. Thirteen taxa with a combined density of 268.0 stems/ha were encountered in 2009 with shagbark, pignut and mockernut hickory accounting for 69.4% of the total. Black oak (42.0 stems/ha) and American elm (10.0) accounted for an additional 19.4% while *Fraxinus lanceolata* Borkh. (green ash, 6.0), and slippery elm (6.0) were the only taxa with a density greater than 5.0 stems/ha. Large sapling density decreased further in 2020 to 70.2 stems/ha. Shagbark hickory (23.4 stems/ha) and red oak (10.0) accounted for 47.6% of the total. White ash (8.4), sassafras (6.7), black oak (5.0) and green ash (5.0) accounted for an additional

35.8% and were the only other taxa with densities ≥ 5.0 stems/ha. Post oak was not encountered in any of the samples and white oak decreased steadily from 3.1 to 1.7 trees/ha. Flowering dogwood density ranged from 3.1 to 4.0 stems/ha in each of the samples despite its disappearance from the overstory category.

Small Saplings

Fifteen taxa with a total of 2,359.4 stems/ha were present in the 2000 sample with green ash and shagbark hickory accounting for 60.3% of the total (Table 4). Black oak (390.6 stems/ha), sassafras (109.4) and white oak (109.4) accounted for an additional 25.8% of the total stems. American elm and persimmon were the only other taxa with densities greater than 50.0 stems/ha. *Cercis canadensis* L. (redbud) had a stem density of 31.3 stems/ha; however, all of those stems occurred in a single plot and it was not encountered in the seedling, large sapling nor overstory sample in any other year. Only seven taxa with a total stem density of 680.0 stems/ha occurred in the 2009 sample with the reduction possibly due to repeated fires in 2001, 2003 and 2009. Black oak (220.0 stems/ha), persimmon (160.0) and sassafras (140.0) accounted for 76.5% of the total. Green ash (80.0) was the only other taxon with a stem density greater than 50.0 stems/ha. Species richness and stem density rebounded somewhat in 2020 with 13 taxa and total density of 2,450.5 trees/ha. Persimmon (600.1 stems/ha), black oak (433.4), red oak (350.1), sassafras (333.4), shagbark hickory (183.4) and green ash (183.4) were the most abundant and accounted for 85.0% of the total stems/ha. Post oak was not present in 2000 and 2009 and had a density of only 33.3 stems/ha in 2020. *Lonicera macckii* (Rupr.) Maxim. (bush honeysuckle), a non-native shrub, occurred in the sample for the first time in 2020 and had a density of 100.0 stems/ha.

Seedlings

In 2000, 14 seedling species with a density of 7,156.5 stems/ha were encountered (Table 5). Shagbark hickory and *Symphoricarpos orbiculatus* Moench (coralberry), a small native shrub, were the most abundant, accounting for 36.2% and 24.0% of the total, respectively. Black oak, green ash, wild black cherry, persimmon, sassafras, white oak, and shingle oak all had densities greater than 100.0 seedlings/ha and accounted for an additional 35.8% of the total stems. Following a moderate intensity prescribed fire in 2009, species richness increased slightly to 18 taxa and total stem density increased to 18,800 stems/ha. Black oak (4,840 stems/ha), sassafras (3,840), shagbark hickory (3,680), coralberry (2,000) and pignut hickory (1,160) accounted for 82.5% of the total stem count. Persimmon, green ash, slippery elm, white oak, mockernut hickory and red mulberry and wild black cherry had densities of 120.0 to 600.0 stems/ha while post oak density was 360.0 stems/ha.

In 2020, 18 taxa had a total stem density of 18,215.0 stems/ha. Coralberry and shagbark hickory each had stem densities greater than 4,000 stems/ha and accounted for 47.7% of the total stems. Black oak, sassafras, persimmon and pignut hickory accounted for an additional 37.8% of the total stems. Post oak did not occur in the sample. Non-native shrubs, bush honeysuckle and *Elaeagnus umbellata* Thunb. (autumn olive) had densities of 99.9 and 66.6 stems/ha, respectively, and were encountered for the first time during the 20-year study.

Although the overall seedling densities were similar in 2009 and 2020, changes in the abundance of taxa were noted. Coralberry stem density, which accounted for 10.6% of the total in 2009, increased to 24.3% in 2020. Shagbark and pignut hickory density increased by 16 %

and 132%, respectively while black and white oak seedling densities were reduced by 25% and 40%, respectively, and no post oak were encountered in 2020.

DISCUSSION

Fire likely played a key role in determining the structure and composition of Karcher's Post Oak Woods Nature Preserve and the adjoining forest for nearly two centuries, and perhaps longer. During the early 20th century, the scale of the fires lessened. The last of the big fires in Hamilton County occurred in the mid 1950's, creating smoke so dense that travel on the local roads was halted for several days (McClain 2000). Since that time, the fires have been much smaller in scale and confined to local woodlots. As fire frequency, and perhaps intensity, diminished, the forests began a subtle shift from post oak to hickory as the dominant species.

A similar trend has been observed in several formerly oak-dominated forests in southeast Illinois (Edgin and Beadles 2004; Edgin and Ebinger 2009) and the reduction in fire frequency is often, unsurprisingly, associated with increases in human settlement and population growth (McClain et. al. 2010). Examination of increment core data from Emma Vance Woods in Crawford County, Illinois revealed the largest oak trees in that forest were between 200 and 250 years old, while the largest hickories were 150 years old, an age which corresponded with a period of rapid settlement by families moving into the area from Ohio.

Regarding the first goal of this study, to verify diminishing importance of post oak in the preserve, the status of post oak within various strata of Karcher's Post Oak Woods Nature Preserve does indeed appear to be diminishing over time. Post oak is a long-lived, fire resistant, shade intolerant species (McClain et. al. 2010). Because of its longevity, post oak can persist as the dominant species in a forest for quite some time, even with low recruitment, provided its

mortality is low and longevity of the competing species is much shorter than post oak (Brewer 2015). However, neither of those qualifiers exist at Karcher's. Over the course of the 20-year study, post oak density in the overstory decreased by 46.7% while the average diameter of the surviving trees increased. The decline among living overstory trees was accompanied by an increase in mortality as evidenced by the increase in density and average diameter of dead-standing trees. These data, when coupled with the relative lack of post oak recruitment in the seedling and sapling categories, do not bode well for the long-term persistence of post oak as a major component of this forest. The projection for post oak is exacerbated by the abundance of shagbark hickories, which are also a relatively long-lived tree and the most shade tolerant of the hickory species (McCarthy and Westendahl 1988).

The second goal of the study was to assess whether the removal of subcanopy hickory and re-introduction of fire promoted post oak recruitment. Prescribed fire can promote seedling recruitment which can persist for several years post fire (Dems, et al. 2021; Taft 2020). However, Karcher's prescribed fire activity alone did not provide a disturbance regime sufficient to stimulate appreciable, sustained recruitment among post oak nor any other oak species. Post oak recruitment following the 2009 prescribed burn was promising with 360.0 stems/ha encountered, but those seedlings apparently did not persist. Perhaps a 2012 drought that covered much of Illinois, including Hamilton County, had a negative effect on some seedling survivability (Refsland and Fraterrigo 2018). Precipitation was below normal in the fall 2011 and spring 2012 (Illinois Department of Natural Resources 2013; Rippey et al. 2015). For Hamilton County, abnormally low precipitation was reported in spring and early summer and drought conditions were declared on June 5. The drought conditions were categorized as severe by July 3 and extreme on August 7. Light precipitation in September eased conditions

somewhat, but drought conditions or abnormally low precipitation persisted through January 2013. Annul precipitation for Hamilton County in 2012 was 40 to 50 cm below the norm of 105 cm.

While the prescribed fire in 2009 did not produce the desired post oak seedling response, it may have affected other strata as it was of sufficient intensity to substantially reduce live stem density among the small saplings and moderately reduce large sapling density. These reductions, combined with low recruitment in subsequent years, may explain the reduction in large saplings in 2020. The prescribed fire in 2020 was of low intensity and very patchy, so most of the site remained unburned. These factors may have spared the small saplings that were present in the 2009 sample allowing a substantial increase in small sapling density in 2020. Removal of the subcanopy hickories did not appear to have much influence on post oak recruitment; although not examined closely in these studies, the herbaceous ground layer appears to be more abundant and diverse.

The decline of overstory post oak is concerning and may be attributable to several factors. The largest overstory trees may have been reached the end of their natural life, or perhaps, were weakened by the drought of 2012 which hastened their demise. Ninety five percent of respondents to a 2013 Missouri survey examining rapid white oak mortality syndrome reported the drought of 2012 as a possible contributing factor (Reed et al. 2017). Drought may also make trees, regardless of age or size, more susceptible to disease (Wood et al. 2018). Another possible factor could be low mast production and acorn viability among post oaks, an area of needed further study.

If the current trends persist, the data suggest that shagbark hickory will eventually replace post oak as the dominant overstory tree with white, red and black oak as possible lesser

associates. The next 20 years will likely determine if post oak will continue to be a major component of the forest. If post oak mortality continues at the rate observed over the past 10 years, this seems doubtful. Increasing the frequency of monitoring to a five-year rotation, rather than 10, may give a more precise representation of changes occurring in the forest and effects of management actions.

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Table 1: Relative density (Rel. Den.), relative dominance (Rel. Dom.), importance value (IV) and mean diameter (cm) for woody overstory species in Karcher's Post Oak Woods Nature Preserve, Hamilton County, Illinois in 2000, 2009 and 2020.

Species	Year	Rel. Den.	Rel. Dom.	I.V.	Mean Diam. (cm)
Quercus stellata	2000	20.7	46.3	67.0	39.9
	2009	18.9	44.6	63.5	42.4
	2020	15.8	36.6	52.4	45.2
Carya ovata	2000	43.6	19.6	63.2	17.3
	2009	53.2	25.2	78.4	18.3
	2020	44.8	23.6	68.5	22.2
Carya glabra	2000	12.4	13.2	25.6	26.6
	2009	14.4	14.8	29.2	26.7
	2020	20.1	18.7	38.8	28.9
Carya tomentosa	2000	11.3	6.6	17.9	19.6
	2009	3.2	2.5	5.7	24.0
	2020	9.7	7.6	17.3	27.2
Quercus velutina	2000	4.7	5.6	10.3	27.8
	2009	5.2	6.6	11.8	29.4
	2020	3.9	3.3	7.2	39.2
Quercus alba	2000	3.2	5.6	8.8	32.4
	2009	2.6	5.2	7.8	36.1
	2020	2.9	6	8.9	45.7
Quercus rubra	2000	1.0	1.8	2.8	33.7
	2009	0.2	0.5	0.7	40.3
	2020	1.7	3.8	5.5	31.2
Others (12 taxa)	2000	3.1	1.3	4.4	
Others (11 taxa)	2009	2.3	0.6	2.9	
Others (6 taxa)	2020	1.1	0.4	1.5	
Totals	2000	100	100	200	
	2009	100	100	200	
	2020	100	100	200	

Table 2: Density (stems/ha), basal area (m^2/ha), and mean diameter (cm) of the dead-standing trees in Karcher's Post Oak Woods Nature Preserve, Hamilton County, Illinois in 2000, 2009 and 2020.

Species	Density (Trees/ha)			Basal Area (m^2/ha)			Mean Diameter (cm)		
	2000	2009	2020	2000	2009	2020	2000	2009	2020
Quercus stellata	10.7	7.1	13.3	1.179	0.794	2.023	34.6	35.4	40.3
Quercus velutina	5.6	4.4	1.3	0.143	0.410	0.130	17.4	31.2	32.5
Carya ovata	4.0	3.8	0.5	0.125	0.084	0.063	17.2	15.5	38.7
Carya glabra	2.4	1.8	0.8	0.123	0.131	0.089	16.3	30.5	38.7
Sassafras albidum	1.6	1.1	1.0	0.019	0.014	0.013	20.8	13.8	12.7
Carya tomentosa	1.1	0.7	0.3	0.091	0.018	0.003	29.1	22.6	11.3
Prunus serotina	0.9	2.0	0.3	0.018	0.061	0.004	16.0	18.3	15.1
Quercus alba	0.7	1.8	0.3	0.022	0.136	0.014	19.7	27.3	26.3
Others/unknown	0.7	1.8	0.3	0.012	0.031	0.009	---	15.0	21.1
Totals	27.7	24.5	18.1	1.732	1.679	2.348			

Table 3: Density (stems/ha) of large saplings ≥ 2.5cm dbh and <10.0 cm dbh in Karcher's Post Oak Woods Nature Preserve, Hamilton County, Illinois in 2000, 2009 and 2020.

Species	Density (stems/ha)		
	2000	2009	2020
Quercus velutina	26.6	42.0	5.0
Sassafras albidum	18.8	4.0	6.7
Carya ovata	300.0	120.0	23.4
Fraxinus lanceolata	---	6.0	5.0
Carya glabra	---	52.0	3.3
Diospyros virginiana	3.1	2.0	---
Prunus serotina	1.6	2.0	1.7
Ulmus rubra	1.6	6.0	---
Quercus alba	3.1	2.0	1.7
Carya tomentosa	40.6	14.0	1.7
Morus rubra	1.6	4.0	---
Ulmus americana	12.5	10.0	---
Celtis occidentalis	1.6	---	---
Quercus rubra	---	---	10.0
Fraxinus americana	---	---	8.4
Cornus florida	3.1	4.0	3.3
Totals	414.2	268.0	70.2

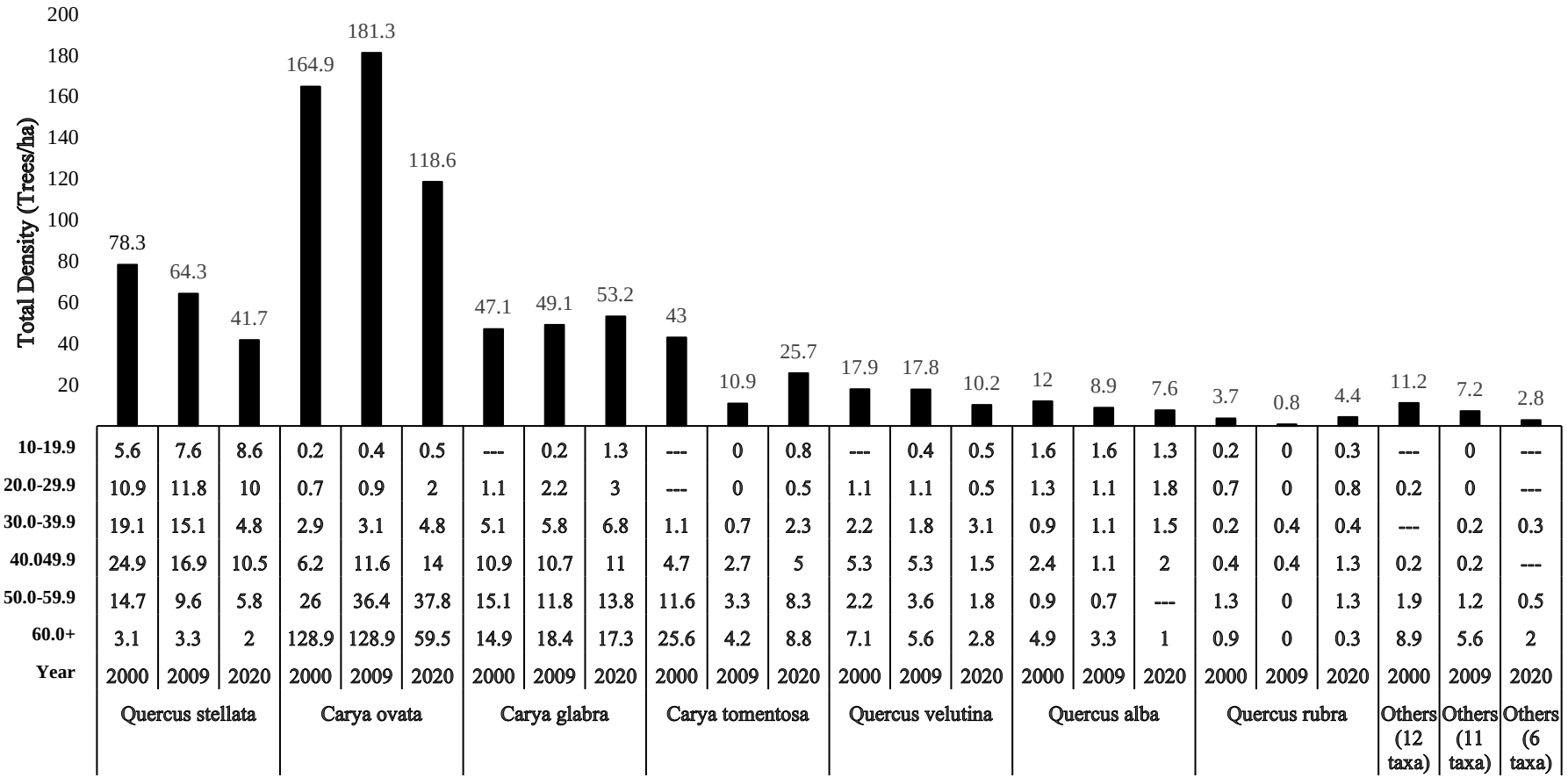
Table 4: Density (stems/ha) of small saplings ≥ 50 cm tall; < 2.5 cm dbh in Karcher's Post Oak Woods Nature Preserve, Hamilton County, Illinois in 2000, 2009 and 2020. Non-native species are in bold.

	Small Sapling Density (stems/ha)		
Species	2000	2009	2020
Quercus velutina	390.6	220.0	433.4
Sassafras albidum	109.4	140.0	333.4
Carya ovata	640.6	40.0	183.4
Symphoricarpos orbiculatus	---	20.0	---
Fraxinus lanceolata	781.3	80.0	183.4
Carya glabra	15.6	20.0	133.4
Diospyros virginiana	78.1	160.0	600.1
Prunus serotina	31.3	---	---
Ulmus rubra	31.3	---	16.7
Quercus alba	109.4	---	16.7
Quercus stellata	---	---	33.3
Carya tomentosa	15.6	---	---
Morus rubra	---	---	33.3
Quercus imbricaria	---	---	33.3
Ulmus americana	78.1	---	---
Celtis occidentalis	15.6	---	---
Quercus rubra	15.6	---	350.1
Cercis canadensis	31.3	---	---
Asimina triloba	15.6	---	---
Lonicera macckii	---	---	100.0
Totals	2,359.4	680.0	2,450.5

Table 5: Density (stems/ha) of seedlings < 50 cm tall in Karcher's Post Oak Woods Nature Preserve, Hamilton County, Illinois in 2000, 2009 and 2020. Non-native taxa are in bold.

Species	Seedling Density (stems/ha)		
	2000	2009	2020
Quercus velutina	812.5	4,840.0	1,232.1
Sassafras albidum	218.8	3,840.0	1,431.9
Carya ovata	2,593.8	3,680.0	4,262.4
Symphoricarpos orbiculatus	1,718.8	2,000.0	4,428.9
Fraxinus lanceolata	468.8	480.0	499.5
Carya glabra	93.8	1,160.0	2,697.3
Diospyros virginiana	281.1	600.0	1,531.8
Prunus serotina	375.0	400.0	532.8
Ulmus rubra	---	440.0	33.3
Quercus alba	218.8	400.0	166.5
Quercus stellata	---	360.0	---
Carya tomentosa	31.3	200.0	---
Morus rubra	---	120.0	33.3
Acer rubrum	---	80.0	---
Quercus imbricaria	187.5	80.0	199.8
Ulmus americana	62.5	40.0	---
Celtis occidentalis	31.3	40.0	333.0
Crataegus spp.	---	40.0	---
Quercus rubra	62.5	---	499.5
Lonicera macckii	---	---	99.9
Fraxinus americana	---	---	99.9
Elaeagnus umbellata	---	---	66.6
Cornus florida	---	---	66.6
Totals	7,156.5	18,800.0	18,215.1

Figure 1. Density (stems/ha) by diameter class and total stem density for overstory species in Karcher's Post Oak Woods Nature Preserve, Hamilton County, Illinois in 2000, 2009 and 2020. Diameter classes shown in 10—cm intervals (lower left margin).



	Quercus stellata			Carya ovata			Carya glabra			Carya tomentosa			Quercus velutina			Quercus alba			Quercus rubra			Others (12 taxa)	Others (11 taxa)	Others (6 taxa)
10-19.9	5.6	7.6	8.6	0.2	0.4	0.5	---	0.2	1.3	---	0	0.8	---	0.4	0.5	1.6	1.6	1.3	0.2	0	0.3	---	0	---
20.0-29.9	10.9	11.8	10	0.7	0.9	2	1.1	2.2	3	---	0	0.5	1.1	1.1	0.5	1.3	1.1	1.8	0.7	0	0.8	0.2	0	---
30.0-39.9	19.1	15.1	4.8	2.9	3.1	4.8	5.1	5.8	6.8	1.1	0.7	2.3	2.2	1.8	3.1	0.9	1.1	1.5	0.2	0.4	0.4	---	0.2	0.3
40.049.9	24.9	16.9	10.5	6.2	11.6	14	10.9	10.7	11	4.7	2.7	5	5.3	5.3	1.5	2.4	1.1	2	0.4	0.4	1.3	0.2	0.2	---
50.0-59.9	14.7	9.6	5.8	26	36.4	37.8	15.1	11.8	13.8	11.6	3.3	8.3	2.2	3.6	1.8	0.9	0.7	---	1.3	0	1.3	1.9	1.2	0.5
60.0+	3.1	3.3	2	128.9	128.9	59.5	14.9	18.4	17.3	25.6	4.2	8.8	7.1	5.6	2.8	4.9	3.3	1	0.9	0	0.3	8.9	5.6	2
Year	2000	2009	2020	2000	2009	2020	2000	2009	2020	2000	2009	2020	2000	2009	2020	2000	2009	2020	2000	2009	2020	2000	2009	2020

Figure 2. Basal area (m^2/ha) for woody overstory species in Karcher's Post Oak Woods Nature Preserve, Hamilton County, Illinois in 2000, 2009 and 2020.