

Changes Due to Fire Suppression in a *Quercus velutina* Lam. (Black Oak) Savanna at Sand Ridge State Forest, Mason County, Illinois

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ABSTRACT

Sand savannas in which *Quercus velutina* Lam. (black oak) dominated were common in the major sand deposits of Illinois. Most, however, are now dry sand forests that have been extensively degraded by fire suppression and invasion by native woody and exotic species. Degraded dry sand savannas, that are presently dry sand forests, are a dominant community of ridges and slopes on large stabilized dunes at Sand Ridge State Forest, Mason County, Illinois. In the community examined *Q. velutina*, with an importance value of 143.5, averaged 321.1 stems/ha, and accounted for 78% of the total basal area. *Quercus marilandica* Muench. (blackjack oak) was second followed by the exotic *Pinus strobus* L. (white pine) and *Carya texana* Buckl. (black hickory). Based on aerial photographs this dry sand forest had an open overstory in the early 1940s. Presently this community has a canopy exceeding 90% cover.

INTRODUCTION

In the prairie-forest interface of the prairie peninsula of Illinois the presence of prairie, savanna, woodland, and forest was determined largely by environmental factors, including extent and intensity of fire, climate, water bodies, and topography (Transeau 1935, Anderson 1991, Ebinger and McClain 1991, Abrams 1992). Other contributing factors important on a local level included soil texture, drought frequency, and browsing by large herbivores (Nuzzo 1986).

Savanna communities were extremely common in the landscape of Illinois in the 1800s, and are generally defined as having overstories of scattered, open-grown trees and a grass-dominated ground layer (Curtis 1959, Bray 1960, Nuzzo 1986, White and Madany 1978). Journals of many early travelers and settlers recount the open park-like landscape in much of the state (Bourne 1820, Engelmann 1863, Vestal 1936). Government Land Office (GLO) survey records also indicate that many "forests" were actually savanna and woodland communities based on distance of witness trees to corner posts (Cottam and Curtis 1949, Clements 1958, Hutchison 1988). Furthermore, many present day old-growth forests retain a few open-grown "wolf trees" with low branches and branch-scars, and fire scars, indicating they were formerly part of an open landscape (Curtis 1959, Ebinger and McClain 1991).

European man cleared most "black soil" savannas in Illinois soon after settlement. These savannas, with few trees, thinner sod, and often drier soil, were easier to cultivate

with wooden plows of the settlers than the dense, thick prairie sod. The few remaining "black soil" savanna communities are extensively degraded due to a massive influx of exotic species and canopy closure due to fire suppression and subsequent woody invasion of native species. In contrast, sand savanna communities are still relatively common in the northern half of Illinois on major sand deposits. These deposits are mostly on outwash plains that resulted from erosional events associated with Wisconsin glaciation (Willman and Frye 1970, King 1981). Gleason (1910), and more recently Jenkins et al. (1991), Coates et al. (1992), McClain et al. (2002), and Phillippe et al. (2009) studied the structure and composition of the Illinois River sand deposit woodlands, while Rodgers and Anderson (1979) studied the presettlement vegetation of Mason County. Mostly modified by human activity, a few nature preserves and other good quality natural areas remain on these extensive sand deposits. The present study was undertaken to determine the woody overstory and understory species composition and structure of a degraded sand savanna at Sand Ridge State.

DESCRIPTION OF THE STUDY SITE

Sand Ridge State Forest is located in northwestern Mason County about 21 km northwest of Havana and just west of Forest City, Illinois (parts of townships T22N R7W and T23N R7W). This 3,035 ha (11.7 sq. miles) state forest, with initial land purchases starting in 1939, lies within the Illinois River Section of the Mississippi River and Illinois River Sand Area Natural Division

in Mason and Cass counties (Schwegman 1973, Willman 1973). These deposits were formed about 14,500 years ago when glacial moraines and ice dams were breached. The resulting Kankakee Torrent carried extensive deposits of sand and gravel from glacial lakes in northeastern Illinois and adjacent Indiana. Most of this sand and gravel was deposited when the waters of the Kankakee Torrent slowed upon entering the broad lowlands of the Illinois River. Winds reworked these deposits, creating the present dune and swale topography (Willman 1973).

The original reason for purchasing the land for what is now the Sand Ridge State Forest was to stabilize soil on abandoned farmland, develop a wood product industry, and set land aside for recreation (Andrews 2004). During the early years, and into the 1950's, pine plantations were established, mostly on old pastureland and abandoned cultivated fields, but also in dry sand prairies and sand savannas. Presently, 1,012 ha of pine plantations exist with most of the remainder in oak-hickory dry sand forest and savanna (Andrews 2004).

Sand Ridge State Forest has a continental climate with warm summers and cold winters. Based on weather data from Havana, mean annual precipitation is 96.0 cm, with May having the highest rainfall (11.3 cm). Mean annual temperature is 10.8°C with the hottest month being July (average of 24.6°C), and the coldest January (average of -5.0°C). Frost-free days range from 140 to 206, averaging 173 days (Midwestern Regional Climate Center 2004). Soils are

primarily excessively drained Plainfield and Bloomfield sands (Calsyn 1995) that form the dune and swale topography known as the Parkland Formation (Willman and Frye 1970).

METHODS

During late summer of 2004 a 100 m by 300 m section of the state forest was surveyed by dividing the area into 48 contiguous quadrats 25 m on a side. This 3 ha area was located on a large stabilized dune having an east/west orientation, the centerline of the transect running along the ridge of the dune (N1/2 NW1/4 NE1/4 S4 T22N R7W). The GPS readings for the line transect at 0 m (40.39064°N/-089.89060°W), and at 300 m (40.39064°N/-089.89420°W) were recorded and marked with permanent metal stakes. All living and dead-standing woody individuals ≥ 10.0 cm dbh were identified and their diameters recorded. From this data, living-stem density (stems/ha), basal area (m²/ha), relative density, relative dominance, 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 (basal area). Dead-standing density (stems/ha) and basal area (m²/ha) was also determined. Multiple stemmed trees (coppice) were recorded as separate individuals. Nomenclature follows Mohlenbrock (2002).

Woody understory composition and density (stems/ha) were determined using nested circular plots 0.0001, 0.001, and 0.01 ha in size located at 15 meter intervals along randomly located east-west line transects within the study area (48 plots). Four additional 0.0001 ha circular plots were located 7 m from the center points of each of the 48 plot centers along cardinal compass directions (240 plots). In the 0.0001 ha plots, woody tree seedlings (≤ 50 cm tall) and shrubs and vines 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.

Changes in overstory cover within the state forest was measured using aerial photographs from 1939, 1957, 1969, 1988, and 1998 that were digitized to determine the extent of woody encroachment (trees and large shrubs). These photographs were

borrowed from the University of Illinois Map Library and scanned with a Microtek ScanMaker. A total of 20 stratified randomly located 5 ha circular plots (100 ha total area), representing approximately 20% of the study sites, were interpreted and then digitized using ARC/INFO.

RESULTS

Eleven tree species were encountered in the overstory (Table 1). *Quercus velutina* Lam. (black oak) dominated all diameter classes with the 10-29 cm diameter classes accounting for more than 50% of all tallied individuals, with only three stems/ha greater than 60 cm dbh. This species had an IV of 143.5, averaged 321.1 stems/ha, averaged 23.6 cm dbh, and accounted for 78.1% of the total basal area. *Quercus marilandica* Muench. (blackjack oak), second in IV (34.7), was mostly restricted to smaller diameter classes, averaged 111.6 stems/ha, and averaged 16.5 cm dbh. The remaining species were mostly in the 10-39 cm diameter classes, *Carya texana* Buckl. (black hickory) averaged 26.3 stems/ha, while *Pinus strobus* L. (white pine) averaged 26.1 stems/ha. Coppice stems accounted for about 16% of the stems encountered. *Quercus velutina* accounted for the majority, averaging 27

coppice trees/ha with 57.7 stems/ha, and accounted for about 10% of the total basal area on the site (Table 2).

Dead-standing individuals averaged 24.6 stems/ha with a basal area of 1.01 m²/ha, nearly all being oaks. *Quercus velutina* averaged 15.6 dead-standing stems/ha while *Q. marilandica* accounted for nearly all of the remainder. Most of the dead-standing individuals were in the lower diameter classes. A few dead-standing *Q. velutina* exceeded 40 cm dbh.

The woody understory averaged 15,200 seedlings/ha, 1,775 small saplings/ha, and 295 large saplings/ha (Table 3). Seedling density was relatively high, but the majority was shrubby species. *Quercus velutina* and *Carya texana* accounted for nearly all tree seedlings. Because of the relatively few saplings, the woody understory was open. Again, *Q. velutina* and *C. texana* accounted for the majority of individuals (Table 3). Woody shrubs that were important in the understory included, *Rubus allegheniensis* Porter (common blackberry), *Rhus aromatica* Ait. (fragrant sumac), *Toxicodendron radicans* (L.) Kuntze (poison ivy), and *Cornus drummondii* C. A. Mey. (rough-leaved

Table 1. Densities (stems/ha), diameter classes, basal areas (m²/ha), relative values, importance values and average diameters of the woody species at Sand Ridge State Forest, Mason County, Illinois. Other species include: *Carya tomentosa* (Poir.) Nutt., *Diospyros virginiana* L., *Juniperus virginiana* L., *Pinus banksiana* Lamb., *Pinus sylvestris* L., *Prunus serotina* Ehrh., *Ulmus americana* L.

Species	Diameter Classes (cm)						Total Stems/ha	Basal Area m ² /ha	Rel. Den.	Rel. Dom.	I.V.	Av. Diam. (cm)
	10-19	20-29	30-39	40-49	50-59	60+						
<i>Quercus velutina</i>	145.3	107.7	37.7	20.7	6.7	3.0	321.1	16.995	65.4	78.1	143.5	23.6
<i>Quercus marilandica</i>	92.0	17.0	2.3	0.3	--	--	111.6	2.601	22.8	11.9	34.7	16.5
<i>Pinus strobus</i>	12.7	8.7	2.7	2.0	--	--	26.1	1.243	5.3	5.7	11.0	23.0
<i>Carya texana</i>	20.0	3.3	1.7	1.0	0.3	--	26.3	0.849	5.4	3.9	9.3	17.9
Others (7 spp.)	5.7	--	--	--	--	--	5.7	0.080	1.1	0.4	1.5	--
Totals	275.7	136.7	44.4	24.0	7.0	3.0	490.8	21.768	100.0	100.0	200.0	

Table 2. Density (#/ha) of coppice trees and stems, coppice stems per tree, average basal area (m²/ha) of coppice stems, and the average diameter (cm) of coppice stems at Sand Ridge State Forest, Mason County, Illinois.

Species	Trees (#/ha)	Stems (#/ha)	Stems/tree	Basal Area (m ² /ha)	Avg. Diameter (cm)
<i>Quercus velutina</i>	27.0	57.7	2.1	2.721	23.4
<i>Quercus marilandica</i>	9.0	19.3	2.2	0.540	17.9
<i>Carya texana</i>	1.7	3.3	2.0	0.099	17.1
Totals	37.7	80.3		3.360	

Table 3. Density (individuals/ha) of woody understory species in a woodland community at Sand Ridge State Forest, Mason County, Illinois. (*exotic species)

Species	Seedlings	Small Saplings	Large Saplings
<i>Quercus velutina</i>	3750	575	100.0
<i>Carya texana</i>	2850	600	85.0
<i>Prunus serotina</i>	250	250	20.0
<i>Quercus marilandica</i>	250	25	30.0
<i>Carya tomentosa</i>	150	125	17.5
* <i>Pinus strobus</i>	150	25	17.5
<i>Juniperus virginiana</i>	--	100	15.0
* <i>Pinus sylvestris</i>	--	--	5.0
<i>Ulmus americana</i>	--	--	2.5
<i>Celtis occidentalis</i>	--	--	2.5
<i>Rubus allegheniensis</i>	2250	--	--
<i>Rhus aromatica</i>	1850	--	--
<i>Toxicodendron radicans</i>	1650	--	--
<i>Cornus drummondii</i>	1600	50	--
<i>Rubus occidentalis</i>	300	--	--
<i>Ribes missouriense</i>	100	--	--
<i>Viburnum prunifolium</i>	50	--	--
* <i>Lonicera maackii</i>	--	25	--
Totals	15200	1775	295.0

dogwood) (Table 3). Woody exotic shrubs were uncommon with *Lonicera maackii* (Rupr.) Maxim. (Amur honeysuckle) occurred in a few plots.

In approximately 60 years the sand savanna at Sand Ridge State Forest became a closed forest. Based on an analysis of 1939 aerial photographs approximately 50.18% of the study area was covered by trees and large shrubs. Canopy cover increased dramatically by 1957 to 68.96%, followed by an increase of 78.66% by 1969, 88.08% by 1988, and 89.50% by 1998. Woody encroachment is most obvious where pine plantations were introduced in the 1940s and 1950s. The cover in 1939 lacked introduced conifers, and only the native *Juniperus virginiana* (red cedar) was present. Conifers were not observed in the 50 sites digitized from the 1939 aerial photographs, but they were found in 35 of the 50 digitized sites in the 1998 photographs.

DISCUSSION

The woody plant communities at Sand Ridge State Forest are very different today compared to the early 1800s, mostly due to the planting of pines and reduced fire frequencies followed by the total absence of fire in recent decades (Taft 1997). In preset-

tlement times repeated fires were probably responsible for maintaining an open savanna with a sparse woody understory (Ebinger and McClain 1991, McClain and Elzinga 1994). The larger trees maintained an open-grown appearance with low branches and branch-scars. A few large, open-grown trees were still present in the study plots. Because of fire and droughty conditions, most of this present day forest was originally savanna communities with numerous prairie openings.

Presently, occasional fires and droughty conditions have allowed the perpetuation of oak species. *Quercus velutina* is reproducing with numerous seedlings and saplings in the understory (Table 3). *Quercus marilandica*, in contrast, has a very low rate of reproduction. The large number of seedlings, saplings, and small diameter trees of *Carya texana* suggests this species will increase in importance (Table 3). As canopy closure continues, shade-intolerant oaks may not effectively reproduce. *Carya texana*, a fire-sensitive but relatively shade-tolerant species, could become the dominant understory species and become more common in the lower diameter classes, particularly if management fires are not introduced on a regular basis.

Woody exotic species are common in Sand Ridge State Forest. At least 10 species of pine were planted in the 1940s and early 1950s, and many pine plantations are present (Maier 1976, Andrews 2004). The most commonly planted species was *Pinus strobus*. A few rows of this introduced exotic species were present in our study plots, indicating this species was also planted in native hardwood forests and savannas. Smaller individuals, plus occasional seedlings indicate that this species is reproducing.

Using GLO survey records, Rodgers and Anderson (1979) described the presettlement vegetation of Mason County. They found that tree density averaged 7.44 trees/ha with an average basal area of 1.19 m²/ha in savanna communities. *Quercus velutina* was, by far, the dominant woody species, accounting for more than half of the IV. *Quercus marilandica* was second in IV followed by various *Carya* (hickory) species. The many small diameter witness trees reported in the GLO survey indicate that the relatively shade-intolerant oaks and hick-

ories were reproducing, and were replacing themselves in savanna, woodland, and closed forest communities (Rodgers and Anderson 1979).

Most forests studied within the Illinois River sand deposits were closed canopy dry sand forests located on dune deposits where *Quercus velutina* and *Q. marilandica* were usually the leading dominants along with a few hickory species. *Carya texana* occasionally replaced *Q. marilandica* as second in IV in those forests (Jenkins et al. 1991, Coates et al. 1992, McClain et al. 2002). These forests probably represented sand savannas that have become closed forests due to fire suppression and woody species invasion (Considine et al. 2013). This study at Sand Ridge State Forests suggests that a combination of increased fire frequency, selective timber harvest, and possibly grazing will be necessary to restore and maintain the savanna communities that were once characteristic of this site. the 1998 photographs.

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