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Vegetation of Wind-blown Glacial Sand Deposits along the Illinois River - A Review

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Abstract: This study is a review of the vegetation of the major plant communities in the wind-blown glacial sand deposits of the lower Illinois River Valley (inland sand deposits of H. A. Gleason). Most of these studies were conducted between 1999 through 2007, with a few into the present. Approximately 1086 km^2 of sand deposits occur on the terraces and uplands surrounding the Illinois River from the "Big Bend" region near Hennepin, Putnam County, south into Greene County, Illinois. These deposits vary in size from a few hectares to the deposit centered in Mason County which covers approximately 570 km^2. Most sand deposits are now cultivated, with small remnants of protected natural vegetation in nature preserves and a state forest. These natural areas contain many high-quality sand communities, including sand ponds, sand seeps, a tall shrub fen, a sedge meadow, sand prairies, a dry gravel prairie, sand savannas, and sand forests.

Introduction

Wind-blown glacial sand deposits are common in the northern half of Illinois, the result of erosional events associated with Wisconsinan glaciation (Willman and Frye 1970; Schwegman 1973; King 1981). Sand deposits account for nearly 5% of the land surface of Illinois, the most extensive being the Kankakee River sand deposits of northeastern Illinois, and the Illinois River sand deposits in the central part of the state (Gleason 1910; Schwegman 1973). The Kankakee River sand deposits were formed when glacial lakes drained about 14,500 BP (before present) after glacial moraines were breached, resulting in the Kankakee Torrent (Willman 1973). The Illinois River sand deposits, referred to as "the inland sand deposits" by Gleason (1910), were formed when the waters of the Kankakee Torrent slowed upon entering the broad lowlands of the Illinois River below the "Big Bend" near Hennepin, Illinois (Figure 1).

These sand deposits, known as the Parkland Formation, consist of windblown sand in dunes and sheet-like deposits between and bordering dunes (Willman and Frye 1970). The Parkland Formation is usually found on terraces along major river valleys in the northern half of Illinois. These sands were reworked by wind, creating a characteristic dune and swale topography. Dunes, 1- to 12-m high, are common and occasional dunes exceed 30 m. To some extent, these dunes have migrated onto the bluffs and uplands lying east of the Illinois River terraces due to prevailing westerly winds (Gotsch 1989).

Hart and Gleason (1907), Gleason (1910), Vestal (1913), and Sampson (1921) were the first to describe the major plant communities and associated animals of these deposits. Since these early studies, only occasional articles, mostly concerned with a particular nature preserve or community type, have been published. Though most of the land is now under cultivation, a fairly extensive preserve system has maintained some of this diversity (McFall and Karnes 1995).

The plant communities of these sand deposits are highly varied and include sand ponds, sand seeps, tall shrub fen, sedge meadow, wet-mesic sand prairie, dry sand prairie, dry gravel prairie, sand savanna, and sand forest (McFall and Karnes 1995). The present review was undertaken to characterize the vegetation structure and dominant and representative species of these major plant communities in the glacial sand deposits of the

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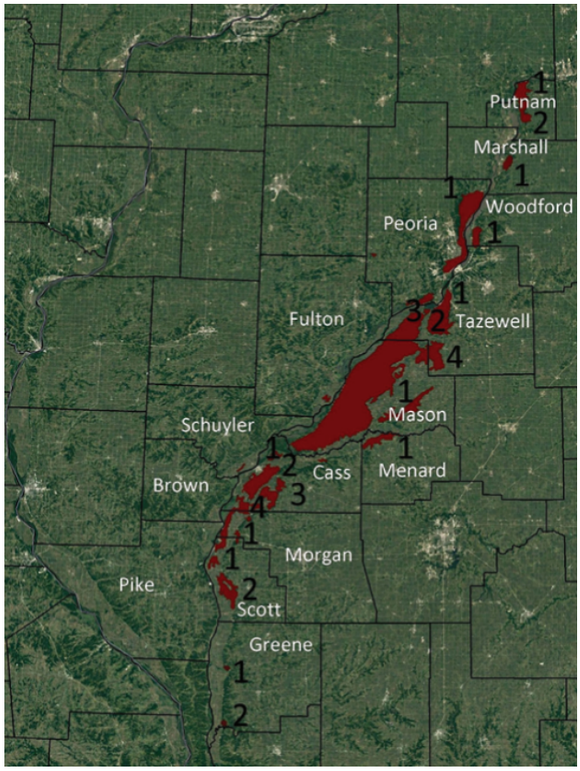

Figure 1. Map of the Illinois River valley sand deposits from the "Big Bend" in Putnam County south to the confluence with the Mississippi River in Jersey County. The numbers in the counties refer to separate sand deposits listed by county and defined in Table 1 (see left column).

Illinois River Section of the Illinois River of the Mississippi River Sand Areas Natural Division (Schwegman 1973). These studies mostly were conducted by the authors from 1999 to 2007 with a few additional observations and studies recently completed.

Materials and Methods

Vegetation Sampling

Woody Overstory Survey

Typically, a 100 m by 200 m section of study sites with a tree canopy was surveyed, mostly during midsummer, by dividing the area into contiguous quadrats 25 m on a side for a total of 2.0 ha (32 plots). Sometimes a smaller or larger area was surveyed depending on the size of the study site and the reason(s) for the study. All living and dead-standing woody individuals ≥10.0 cm dbh (diameter at breast height, considered 1.4 m above the ground) were identified and their diameters recorded. From these data, living-stem density (stems/ha), basal area (m^2/ha), relative density, relative dominance, importance value (IV of 200 possible), 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). Multiple-stemmed trees (coppices) were recorded as separate individuals.

Change in overstory cover within the Sand Ridge State Forest (Mason County, Illinois) 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 site, were interpreted and then digitized using ARC/INFO.

Woody Understory Survey

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 m intervals along randomly located transects within the study area. Four additional 0.0001 ha circular plots were located 7 m from the center points of each original plot along cardinal compass directions. In the 0.0001 ha plots, woody seedlings (≤50 cm tall) 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. The number of center points used was determined by the number of overstory plots.

Ground-Layer Vegetation

Quantitative sampling was conducted in mid- to late-summer using 1-m^2 quadrats located at 1 m intervals along one to six (depending on size and species diversity of the study site) randomly placed 25 m long transects (sometimes longer). Even-numbered quadrats were placed to the right, odd-numbered quadrats to the left of each transect. A random numbers table was used to determine the number of meters a quadrat was placed from a transect line (0 up to 9). Percent cover of each species encountered was determined using the Daubenmire (1959) cover class system as modified by Bailey and Poulton (1968): class 1 = 0-1%; class 2 = >1-5%; class 3 = >5-25%; class 4 = >25-50%; class 5 = >50-75%; class 6 = >75-95%; class 7 = >95-100%. From these data, frequency (%), mean cover (%), relative frequency, relative cover, and importance value (IV of 200 possible) were determined.

Voucher specimens

For most plant communities voucher specimens of most plant species found were collected, identified, and deposited in the herbaria of the Illinois Natural History Survey, Champaign, Illinois (ILLS), and the Stover-Ebinger Herbarium of Eastern Illinois University, Charleston, Illinois (EIU). The study sites were visited 9 to 12 times during the growing season for two consecutive years, and habitat, along with other pertinent data, recorded. Criteria for designating nonnative species followed Mohlenbrock (2002) and Gleason and Cronquist (1991), while nomenclature followed Mohlenbrock (2002). Also, we recorded the location of all threatened and endangered plant species found, but unless very common on the site, were not collected (Herkert and Ebinger 2002; IESPB 2020). For many of the studies, a species list has been published separately.

Field Evaluation

To find possible new high natural quality sites for the plant communities, we conducted a drive-through survey of all sand deposits of the Illinois River Valley from near Hennepin, Putnam County, south into Greene County (Willman and Frye 1970; Figure 1). This survey was conducted during the winter and spring of 2006 and did not include dedicated nature preserves because they had been previously examined and mostly surveyed on previous trips. To complete this survey, soil maps of the entire study area were examined and the sand deposits marked on county road maps. These areas were then examined for high-quality sand communities by traveling all roads (and many farm lanes) in these sand areas and included a great deal of hiking. The classification and community descriptions of White and Madany (1978) were used to determine the quality of prospective sites. The very few potential new sites found were visited during the summer and fall of 2006. The observations and results found during this extensive examination of the Illinois River sand areas are discussed in the Description of the Study Area in this review. Also, included are observations made while driving to and from study sites, along with other trips looking for potential study sites. Also included is the general location and habitat of endangered and threatened plant species found during the study.

Results and Discussion

Description of the study area

Wind-blown glacial sand deposits along the lower Illinois River extend as a series of small to relatively large areas of exposed sandy soil from the "Big Bend" region of the Illinois River near Hennepin, Putnam County, south into Greene County (Figure 1). These isolated deposits, mostly located on the east side of the Illinois River, are listed along with their geographic and topographic positions, size (km^2), and the county soil surveys used to determine the area of each deposit (Table 1).

In the northern counties (Putnam, Marshall, and Woodford), the sand deposits are mostly situated on gently rolling uplands (Zwicker 1992; Teater 1999; Teater and Walker 2002). These sands were deposited during the highest floods of the Kankakee Torrent when floodwaters overtopped uplands to the east of the Illinois River Valley. In Peoria, Tazewell, and Mason counties, and south, the sand deposits are common on terraces but also extend into the uplands, the result of strong westerly winds. The sand area in Peoria County is unique (Figure 1), being the only large deposit on the west side of the river (Walker 1992). In addition to the two small sand deposits in northern Tazewell County, there are two relatively large deposits in the southern part of the county that extend south in Mason County (Tazewell 3 and 4, in Figure 1; Willman and Frye 1970; Teater 1996). This large sand deposit extends across most of the western part of Mason County (Calsyn 1995) and covers an area of approximately 569.8 km^2 of Mason County, with the two extensions into Tazewell County adding another 124.3 km^2 (Table 1).

The sand deposit in Mason County, the largest in the Illinois River Valley, extends as a broad northeast-southwest band of sand 8 to 15 kms wide and about 50 kms long (Mason 1, in Figure 1). The western boundary includes the floodplain and terrace of the Illinois River, while the southern and southeastern boundaries comprise the uplands adjacent to the Sangamon River. The topography within this deposit consists of flat to gently rolling terrace and upland. Dune fields are common, including some large, steep-sided dunes that exceed 30 m in height (Willman and Frye 1970; Calsyn 1995). The Illinois endangered *Stylisma pickeringii* (Torr.) Gray var. *pattersonii* (Fern. & Schub.) Myint. (Patterson's bindweed) is located on private land at the southern tip of this extensive sand deposit about 1 km southwest of Snicarte, Illinois (SW1/4 S4 T19N R10W) (Claerbout *et al.* 2010; Phillippe *et al.* 2011).

High quality sand communities are encountered in the Mason County sand deposit in a series of nature preserves mostly purchased between 50 and 80 years ago by the State of Illinois (McFall and Karnes 1995). Also, sand communities occur in Sand Ridge State Forest located just west of Forest City, Illinois. Initial land purchases for this site began in 1939, and from the 1940's into the 1950's pine plantations were established on old pastureland, abandoned cultivated fields, and dry sand prairies that were scattered throughout this state forest. Presently, 1,012 ha of marketable pine plantations

Table 1: Illinois county and sand deposit number, geographic area, topographic position (terrace or upland), extent of the sand deposit (km^2), and the county soil surveys used to determine the extent of the sand deposits along the Illinois River valley from the "Big Bend" in Putnam County, south to the Mississippi River in Jersey County. *see Figure 1.

County and Number*	Geographic Area	Topographic Position	Area (km^2)	County Soil Survey
Putnam #1	Hennepin	upland	25.9	Zwicker (1992)
Putnam #2	Senachwine	upland	10.4	Zwicker (1992)
Marshall #1	Lacon	upland	18.1	Teater and Walker (2002)
Woodford #1	Spring Bay	upland	28.5	Teater (1999)
Peoria # 1	Chillicothe	terrace	46.6	Walker (1992)
Tazewell # 1	Pekin	terrace	10.4	Teater (1996)
Tazewell # 2	Powerton	terrace	7.8	Teater (1996)
Tazewell # 3[a]	SW extension	upland	82.9	Teater (1996)
Tazewell # 4[a]	SE Extension	upland	41.4	Teater (1996)
Mason # 1	W ½ of co.	terrace/upland	569.8	Calsyn (1995)
Menard # 1[b]	Oakford	upland	25.9	Fehrenbacher and Odell (1953)
Cass # 1	Beadstown	terrace	20.7	Calsyn (1989)
Cass # 2	Airport	terrace	59.6	Calsyn (1989)
Cass # 3	Arenzville	terrace/upland	51.8	Calsyn (1989)
Cass # 4[c]	S extension	terrace	13.0	Calsyn (1989)
Morgan # 1	Meredosia	terrace	20.7	Gotsch (1989)
Scott # 1	Naples	terrace	15.5	Gotsch (1989)
Scott # 2	dune fields	terrace/upland	33.7	Gotsch (1989)
Greene # 1	Apple River	upland	2.6	Downey *et al.* (1974)
Greene # 2	Macoupin Cr.	upland	1.0	Downey *et al.* (1974)

[a]These sand deposits are extensions of the major sand deposit of Mason County.
[b]About half of this sand deposit is in Cass County, and includes three deposits of 20.7 km^2, 3.9 km^2, and 1.3 km^2, respectively, the two smaller being completely in Menard County.
[c]This sand deposit has a north/south extent of about 14 miles and extends through Morgan and the northern part of Scott counties and totals about 49.2 km^2, 13.0 km^2 in Cass County, 20.7 km^2 in Morgan County, and 15.5 km^2 in Scott County.

occur in the state forest while most of the remainder is degraded oak and oak-hickory sand savannas and sand forest along with some dry sand prairie inclusions (McFall and Karnes 1995; Andrews 2004).

Sand deposits are also found along the lower part of the Sangamon River, a major tributary of the Illinois River, that forms the boundary between Mason, Cass, and Menard counties (Figure 1). These sand deposits, which occur in northeastern Cass and northwestern Menard counties (Menard 1, in Figure 1), were formed in post-glacial times by prevailing westerly winds that blew sand through the Sangamon River Valley (Fehrenbacher and Odell 1953; Willman and Frye 1970; Calsyn 1989). Found on the upper terrace and associated hills to the south of the Sangamon River, these deposits consist of small lenses of sand on the flanks and in the valleys of hills adjacent to the river, and most are less than a few hundred ha in size (Table 1).

To the south of the Sangamon River most of the sand deposits are on the Illinois River terrace in Cass, Morgan, Scott, and Greene counties (Figure 1, Table 1). The majority of these consist of long, narrow, relatively shallow ridges of sand having a north/south orientation (Calsyn 1989; Gotsch 1989; Downey *et al.* 1974). These low sand ridges, some with an elevation of less than a meter above the surrounding Illinois River terrace, have migrated to the east along the Illinois River terrace due to the prevailing westerly winds. Though most are on the Illinois River terrace, some sand dunes were blown onto the flanks of the hills east of the terraces, the sand sometimes extending to the ridge tops (Table 1). The largest of these ridges extends from southern Cass County through Morgan into Scott County. Around and to the north of Arenzville in Cass County (Cass 3, in Figure 1), sand deposits are in the uplands bordering the Illinois River terrace. Degraded

sand savanna and sand forests are common throughout these uplands. During our travels we found all were of poor quality due to past logging, grazing, and fire suppression. The Illinois threatened species *Astragalus distortus* Torr. & A. Gray (bent milk vetch) is known from the Sand Creek Cemetery northwest of Glasgow, Illinois. This cemetery is at the extreme southern edge of the most southern sand deposit in Scott County (McClain and Ebinger 2003; Phillippe *et al.* 2011).

Many rare taxa of the vascular flora in the Illinois River Sand Area are well documented due to the efforts of the amateur botanist, Rollo T. Rexroat (1893-1979) of Virginia, Cass County, Illinois. Mr. Rexroat operated a general store with his brother in the city of Virginia during the early part of the last century. His working hours were at the store, but evenings and weekends were spent searching the sand areas for vascular plants. He once said "I have driven 40,000 miles and walked about 50,000 more" during his survey for plants. These efforts resulted in the collection of nearly 11,000 specimens, including 14 not previously known from the state, 20 that had not been located for nearly a century, and 40 others that are infrequently observed (Dolbeare 1973). Among these is a member of the Cyperaceae, *Lipocarpha maculata* (Michx.) Torr., collected at the edge of a temporary sand pond in Cass County in the 1960s, but not seen since. Mr. Rexroat was meticulous with his collecting and specimen preparation and donated his collection to the Illinois State Museum where they continue to be a valuable data source for field research on plant diversity within the Illinois Sand Areas.

Sand Communities

The sand and some associated natural communities studied in the Illinois River Section of the Illinois River of the Mississippi River Sand Areas Natural Division (Schwegman 1973) are discussed below. The natural community names used are mostly those of White and Madany (1978) and the Illinois Natural Area Inventory directed by White (1978). Similar reports are available for two smaller sand areas in northwestern Illinois: the Mississippi River Section of the Illinois River and Mississippi River Sand Areas Natural Division (Ebinger *et al.* 2006), and the Green River Lowland Section of the Grand Prairie Natural Division (Ebinger *et al.* 2009).

Sand Pond

According to Government Land Office survey records wetlands were a common landscape feature of the sand deposits of the Illinois River Valley prior to European settlement (Rodgers and Anderson 1979). At that time the water table was close to the surface, many sand ponds were permanent or only rarely became dry in late summer or during drought years. Presently, most sand ponds of the Illinois River sand deposits are ephemeral and farmed in most years. The time between extensive flooding of these sand ponds may be 20 years or more.

Schwegman (1984) described wetlands on agricultural lands near Snicarte in Mason County during the wet year of 1974 when many emergent wetland plant species dominated flooded agricultural fields throughout the growing season. These fields were flooded from the fall of 1993 to late summer of 1995 (McClain *et al.* 1997). At that time, the authors collected 72 vascular plant species from five temporary ponds that inundated farm fields in Cass and Mason counties, Illinois. Illinois endangered and threatened plant species encountered included the state threatened *Schoenoplectus hallii* (A. Gray) S. G. Sm. (Hall's bulrush), and the state and federally threatened *Boltonia decurrens* (Torr. & Gray) Wood (decurrent false aster), the endangered *Schoenoplectus purshiana* (Fern.) M. T. Strong (Pursh's bulrush), and *Fimbristylis vahlii* (Lam.) Link (Vahl's fimbry) (IESPB 2020). The continued re-emergence of these species during wet years suggests their persistence in the soil seed bank (Van der Valk and Davis 1978; McClain *et al.* 1997; Phillippe *et al.* 2011).

At Sand Prairie-Scrub Oak Nature Preserve, 4 km west of Kilbourne in Mason County, there was a sizeable sand pond prior to the lowering of the water table, principally by the continued use of central pivot irrigation systems on land surrounding the preserve. Presently, water rarely accumulates in this stabilized blowout (McClain *et al.* 2008c). In contrast, a sand pond that commonly retains water in the spring and early summer of most years is located at Shick Shack Sand Pond Nature Preserve, located about 6 kms south of Bluff City in Cass County, Illinois (SE1/4 S9 T17N R11W). The majority of this preserve is dominated by degraded second growth upland, dry-mesic oak forest which surrounds a sand pond of about 1.5 ha (McFall and Karnes 1995). We observed that the vegetation of the pond was in three zones. The shrub zone, at the outer edge, was dominated by *Cephalanthus occidentalis* L. (buttonbush), *Salix interior* Rowlee (sandbar willow), *S. nigra* Marsh. (black willow), and *Sambucus canadensis* L. (common elderberry). The *Phalaris arundinacea* L. (reed canary grass) zone was next, with the associate *Persicaria lapathifolia* (L.) S. F. Gray (pale smartweed) being common and scattered. The center of the nearly dry pond was dominated by the mixed herbaceous zone with wetland species that commonly occur as emergents in shallow water.

Sand Seep

Seep communities occur in areas with saturated soil caused by groundwater reaching the surface in a diffuse flow (White and Madany 1978). Gates (1911) was first to describe a series of seep communities south of Havana, Illinois. The only seeps of high natural qual-

ity found during the present study, are located along White Oak Creek about 6 kms south of Havana, Mason County, Illinois (NW1/4 S23 T21N R9W). At this site numerous small seeps were located along both sides of White Oak Creek on a sandy terrace about 1500 m east of the Illinois River. The largest seep was nearly 125 m long, varied in width from 1 to 8 m, and was in an open area with nearly continuous sunlight throughout the day. The remaining seeps were smaller with the largest approximately 100 m long, 1 to 10 m wide, and shaded nearly the entire day (McClain *et al.* 2008a).

In the seep community in full sunlight, the perennial vine *Apios americana* Medic. (groundnut) was dominant [IV of 31.5 (possible 200)]. The species *Impatiens capensis* Meerb. (spotted touch-me-not), *Leersia oryzoides* (L.) Swartz (rice cut grass), *Decodon verticillatus* (L.) Ell. (swamp loosestrife), *Saururus cernuus* L. (lizard's-tail) and *Pilea pumila* (L.) Gray (clearweed) followed in importance. In the shaded seep *Symplocarpus foetidus* (L.) Nutt. (skunk cabbage) dominated (IV of 70.2), with *Impatiens capensis* and *Saururus cernuus* following in importance. The sunny seep plant community contained 23 species in the plots while only 19 were recorded for the shaded seep, with 12 common to both seeps (McClain *et al.* 2008a). Gates (1911) reported the state endangered *Mimulus glabratus* HBK. (yellow monkey-flower) and the state threatened *Veronica scutellata* L. (marsh speedwell) from this site, but neither were observed during our study (IESPB 2020).

Tall Shrub Fen

Dominated by tall shrubs, this fen community is on gently sloping ground in a lens of heavy peat soil with calcareous seepage, surrounded by sand deposits. It is located at the eastern edge of an *Acer saccharinum* L. (silver maple) wet floodplain forest of the Illinois River about 3 kms south of Spring Bay, Illinois (McFall and Karnes 1995). Presently, this tall shrub fen, located in Spring Bay Nature Preserve, Woodford County, Illinois (NW1/4 S23 T27N R4W), is the only tall shrub fen known in Illinois (Arnold 1970; Murphy et al 2009, 2021).

A few trees were growing in the fen with *Acer saccharinum* and *Fraxinus lanceolata* Borkh. (green ash), most less than 25 cm dbh. Shrubs were the dominant feature of the fen, averaging 5,975 stems/ha, the most important being *Ribes americanum* Mill. (wild black currant), *Viburnum lentago* L. (nannyberry), *Cornus sericea* L. var. *sericea* (red-osier dogwood), and *Toxicodendron vernix* (L.) Kuntze (poison sumac). The most common species in the ground layer plots were *Apios americana* (IV of 27.62) followed by *Symplocarpus foetidus, Impatiens capensis*, *Aster firmus* Nees (swamp aster), *Sagittaria latifolia* Willd. (common arrowhead), and *Ribes americanum*. Of the 53 species encountered in the plots, three were non-native: *Lysimachia vulgaris* L. (loosestrife), *L. nummularia* L. (moneywort), and *Mentha* x *piperita* L. (peppermint) (Murphy *et al.* 2021). The state endangered *Cypripedium reginae* Walt. (showy lady's-slipper), and the state threatened *Boltonia decurrens* and *Filipendula rubra* (Hill) Robins. (Queen-of-the-prairie) have been reported from this fen community (IESPB 2020; Murphy *et al.*, 2009, 2021).

Sedge Meadow

This wetland community occurs on a deep, acid soil with a dark A horizon. Rare in the Illinois River sand deposits, the only extensive example occurs at Matanzas Prairie Nature Preserve about 2 kms north of Bath, Mason County, Illinois (NE1/4 S4 T20N R9W). In this community surface water was present during the winter and spring. This community is dominated by large tussocks of *Carex stricta* Lam. (IV of 66.6) with *Calamagrostis canadensis* (Michx.) P. Beauv. (bluejoint grass), and *Rosa palustris* Marsh. (swamp rose) ranking second and third in importance (Feist *et al.* 2008). Other common species include *Boehmeria cylindrica* (L.) Sw. (false nettle), *Tracaulon sagittatum* (L.) Small (tear thumb), *Thelypteris palustris* Schott. (marsh fern), *Doellingeria umbellata* (Mill.) Nees (flat-topped aster), and *Lycopus virginicus* L. (bugleweed). Colonies of *Rosa palustris* were common throughout the sedge meadow, accounting for nearly one quarter of the entire cover. This sedge meadow is occasionally burned which causes temporary, but dramatic, shifts in species composition (Feist *et al.* 2008).

Sand Prairie

This community type is dominated by grasses and occurs on course-textured sand and sandy loam soils. A few trees may be present, but less than 10% of the area has a tree canopy (White and Madany 1978). Prairie bunchgrasses dominate, but forbs occupy open spaces between these grasses. Generally, the drier the site, the less developed the soil A horizon, being essentially non-existent on dry sites to well-developed in mesic areas. Based on the original Government General Land Office survey records, Rodgers and Anderson (1979) determined that sand prairies dominated the sand deposits of Mason County, Illinois. On these prairies, trees were rare and averaged about 0.26 trees/ha and a basal area of 0.02 m^2/ha.

-*Dry Sand Prairie*: Gleason (1910) was the first to quantify the species composition of the Mixed Consocies of the Bunch-Grass Association in Illinois which corresponds to the dry sand prairie community of White and Madany (1978). As described by Gleason (1910), this association is dominated by native bunchgrasses with the remaining species restricted to areas of bare soil (sand) between bunchgrasses. These "secondary species" were divided into ecological groups based on

their habit and structure**:** (1) large perennials and shrubs that competed with the bunchgrasses; (2) mat-plants, such as *Opuntia humifusa* (Raf.) Raf. (common prickly pear); (3) interstitial herbs that were mostly annuals and restricted to bare sand between the bunchgrasses; and (4) parasitic herbs. This community, in the absence of recurring fire, develops into a dry sand savanna community, and ultimately sand forest.

We studied five mature dry sand prairie communities in the Illinois River sand deposits, all from nature preserves and other state-owned lands in Mason County. These included Long Branch Nature Preserve (Phillippe *et al.* 2004), Henry Allan Gleason Nature Preserve (McClain *et al.* 2005), Sand Prairie-Scrub Oak Nature Preserve (McClain *et al.* 2008c), and Sand Ridge State Forest where two small dry sand prairie inclusions were surveyed, the 4 ha Burns Sand Prairie and the 2.4 ha Quiver Sand Prairie (Marcum *et al.* 2013; Phillippe *et al.* 2017).

None of the study sites showed indications of past disturbance except for a few paths, occasional tracks from off-road-vehicles, and animal borrows. All sites were dominated by *Schizachyrium scoparium* (Michx.) Nash (little bluestem). This bunchgrass commonly formed dense mats through which few other species grew, were mostly 20-60 cm across, and nearly circular in outline. Some of the larger clumps had centers that had died, and no other species were found growing in these centers. A typical example of this community type is located at Henry Allan Gleason Nature Preserve in northwestern Mason County, just southeast of the town of Goofy Ridge, Illinois. Dominated by a 20-meter-tall sand dune, commonly referred to as Devils Tower, this preserve was heavily disturbed at the time of dedication in 1970. The dune is commonly mentioned by Dr. Henry Allan Gleason in his memoirs, who made field trips to the sand region with students from the University of Illinois.

The dry sand prairie sampled is located on the east slope of Devils Tower, at the entrance to the preserve (SE1/4 S6 T22N R7W). Only 17 species were encountered in the study plots of this dry sand prairie remnant. The small size (about 1 ha), along with foot traffic and animal burrows, has resulted in some disturbances, but the prairie still contains species commonly associated with dry sand prairies (McClain *et al.* 2005). *Schizachyrium scoparium* (IV of 84.6) was the leading dominant, while *Tephrosia virginiana* (L.) Pers. (goat's-rue), *Opuntia humifusa, Ambrosia psilostachya* DC. (western ragweed) and *Dichanthelium villosissimum* (Nash) Frechm. (hairy panic grass) followed in importance. On this small prairie Fulk and Ebinger (1999) and Tucker *et al.* (2014) recorded the plant species encountered on the numerous small animal mounds created by foraging plains pocket gophers (*Geomys bursarius*) and badgers (*Taxidea taxus*). The few plants encountered on these mounds were small annuals, though seedings of a few perennials were also present, and a few perennials had growth through these mounds.

-*Late Successional Dry Sand Prairie:* Based on aerial photographs from 1939 and later years, it was possible to determine when many agricultural fields were abandoned in the nature preserves of the Illinois River sand deposits. At Sand Prairie-Scrub Oak Nature Preserve, a 60-year-old successional field, abandoned in the early 1940's, was surveyed in 2000 by McClain *et al.* (2008c) (SE1/4 S14 T20N R9W). A total of 20 native herbaceous species were encountered in the study plots. *Eragrostis trichodes* (Nutt.) Wood (thread love grass) dominated (IV of 51.2) but was absent in mature sand prairies on this preserve. This field contained many taxa commonly associated with mature sand prairies. Four of the top five species in importance by rank (*Schizachyrium scoparium, Ambrosia psilostachya, Dichanthelium villosissimum*, and *Opuntia humifusa*) are common components of mature dry sand prairies. Also, a disturbed dry sand prairie of unknown age, located on Devils Tower at Henry Allan Gleason Nature Preserve, surveyed in 2000 (McClain *et al.* 2005), has a very similar floristic composition (SE1/4 S6 T22N R7W).

-*Early Successional Dry Sand Prairie:* Successional fields 30 to 40 years of age are relatively common in the Illinois River sand deposits. At Sand Prairie-Scrub Oak Nature Preserve a 30-year-old successional field was surveyed in 2000 (McClain *et al.* 2008c) (NE1/4 NE1/4 S14 T20N R9W). This field, taken-out of cultivation when the preserve was purchased in 1969, was dominated by *Eragrostis trichodes* (IV of 97.4), followed in importance by *Strophostyles helvula* (L.) Ell. (wild bean), *Monarda punctata* L. (horsemint), *Eragrostis spectabilis* (Pursh) Steud. (tumble-grass), and *Paspalum bushii* Nash (hairy bead grass). Three dominants associated with mature dry sand prairie, *Schizachyrium scoparium*, *Ambrosia psilostachya,* and *Tephrosia virginiana* were not encountered while *Dichanthelium villosissimum* and *Opuntia humifusa* were rare.

-*Blow-Out Community:* Early studies suggested that blow-out communities were extremely common because of over-grazing and farming practices (Hart and Gleason 1907; Gleason 1910; Vestal 1913). Since the establishment of nature preserves in the Illinois sand deposits during the 1970's, most blow-outs became stabilized with successional vegetation. One large blow-out at Henry Allan Gleason Nature Preserve on the west flank of Devils Tower was surveyed (SE1/4 S6 T22N R7W) (McClain *et al.* 2005). In this community the vegetation was widely scattered, and bare ground and litter averaged 83.75% of the area. Only 12 species were encountered, with 8 species in the plots: *Aristida tuber-*

culosa Nutt. (needle grass) was the dominant species (IV of 95.5), followed by *Cyperus grayoides* Mohlenbr. (sand prairie flatsedge) and *Diodia teres* Walt. (rough buttonweed).

The Illinois threatened species *Cyperus grayoides* is a common associate of dry sand prairie blow-out communities at Long Branch Nature Preserve, Sand Prairie-Scrub Oak Nature Preserve, and Burns Sand Prairie at Sand Ridge State Forest (Phillippe *et al.* 2011). Also, in and around blow-outs on Devils Tower at Henry Allan Gleason Nature Preserve, the Illinois endangered *Lesquerella ludoviciana* (Nutt.) S. Wats. (silvery bladderpod) [now *Physaria ludoviciana* (Nutt.) O'Kane & Al-Shehbaz] is common. This western species occurs at its most easterly location here (Claerbout *et al.* 2007; Phillippe *et al.* 2011; Grant et al 2012). Presently, three populations of silvery bladderpod are known to occur in the preserve (McClain *et al.* 2005).

-*Wet-Mesic Sand Prairie*: This community occurs on a deep, acid, sandy soil with a dark A horizon. Water is present for short periods, particularly in winter and early spring (White and Madany 1978). Wet-mesic sand prairies are rare in the Illinois River sand deposits, the only example known to us is at Matanzas Prairie Nature Preserve about 2 kms north of Bath, Mason County, Illinois (NE1/4 S4 T20N R9W), and is not of high-quality. In a 1999 survey by Feist *et al.* (2008) this wet-mesic sand prairie was dominated by S*olidago canadensis* L. (Canada goldenrod, IV of 34.2), followed by *Andropogon gerardii* Vitman (big bluestem), *Carex stricta*, and the non-native grass *Poa pratensis* L. (Kentucky bluegrass) that was found throughout much of the prairie with a frequency of 68%. Other common species included *Euthamia graminifolia* (L.) Nutt. (grass-leaved goldenrod), *Fragaria virginiana* Duchesne (wild strawberry), *Rubus flagellaris* Willd. (common dewberry), *Vernonia missurica* Raf. (Missouri ironweed), *Potentilla simplex* Michx. (common cinquefoil), and *Sorghastrum nutans* (L.) Nash (Indian grass). A total of 92 taxa were found within the boundary of the wet-mesic sand prairie. In this prairie woody invasion is common with *Cornus drummondii* C.A. Mey. (rough-leaved dogwood), *C. obliqua* Raf. (pale dogwood), *Rosa palustris*, and *Salix discolor* Muhl. (pussy willow), along with the remnants of a 2-ha thicket dominated by *Betula nigra* L. (river birch), which has been greatly decreased in size by occasional prescribed burns (Uhlarik *et al.* 1990).

Dry Gravel Prairie

Located within the Illinois River sand deposits, this community, found on gravel soils with little organic material, is now rare in the Illinois River sand deposits. The only good quality example is located at Manito Prairie Nature Preserve about 12 kms southwest of Pekin, Tazewell County, Illinois (SW1/4 S15 T24N R6W) (McFall 1984; McClain *et al.* 2004). Gravel prairies were more common in pre-settlement times on the slopes of gravel terraces along the Illinois River, particularly north of present-day Peoria, Illinois. Most have been destroyed by excessive grazing, cultivation, and surface mining for gravel.

In a 2002 survey by McClain *et al.* (2004), this gravel prairie was dominated by the bunchgrass *Schizachyrium scoparium* (IV of 61.8) that was more than four times as abundant as the next most important species, *Dichanthelium oligosanthes* (Schult.) Gould (panic grass) with an IV of 12.3. Other native grasses included *Sorghastrum nutans, Sporobolus clandestinus* (Biehler) Hitchc. (dropseed), and *Bouteloua curtipendula* (Michx.) Torr. (side-oats grama), along with a small amount of *B. hirsuta* Lag. (grama grass). Common forbs included *Dalea purpurea* Vent. (purple prairie clover) followed by *Echinacea pallida* (Nutt.) Nutt. (pale coneflower), *Ambrosia psilostachya, Opuntia humifusa, Lespedeza capitata* Michx. (round-headed bush clover), *Chrysopsis camporum* Greene (prairie golden aster), and *Senecio plattensis* Nutt. (prairie groundsel).

The state threatened *Besseya bullii* (Eat.) Rydb. (kitten tails), the state endangered *Astragalus tennesseensis* Gray (Tennessee milk vetch), and the federally threatened, *Tetraneuris herbacea* Greene (lakeside daisy) (IESPB 2020) were found on the preserve. Lakeside daisy disappeared from Manito Prairie in early 1960s but was reintroduced at three location in 1988 (McClain and Ebinger 2008; Phillippe *et al.* 2011). We located one flowering and 63 non-flowering individuals at one of the reintroduction sites in 2003. Long-term survival of this species at Manito Prairie Nature Preserve appeared unlikely as it has not been found at this preserve since our report in 2004 (IDNR, Michelle Simone, personal communication). Presently, the only known location for *Astragalus tennesseensis* in Illinois is at Manito Prairie Nature Preserve (McClain and Ebinger 2003).

Sand Savanna

Common in pre-settlement times, sand savannas are usually associated with dune and swale topography and other natural fire breaks throughout the Illinois River sand deposits. These fire breaks limit the frequency and severity of fires, allowing the establishment of fire-resistant, thick-barked tree species (Anderson 1991). These two-layered communities have a nearly continuous ground layer composed mostly of prairie bunchgrasses and forbs along with scattered prairie shrubs. The tree canopy has a cover of 10% to 40% composed of broad-canopied trees usually with low branches that may extend to near ground level, depending on fire frequency and intensity. Based on original Government General Land Office Survey records, Rodgers and Anderson (1979) estimated that in the 1820s, 67.7% of Mason County was sand prairie, 14.4% sand savanna,

4.3% open sand forest, 9.0% closed sand forest, and 4.6% lakes and swamps.

Two sand savanna community types existed in presettlement times in the Illinois River sand deposits, the result of moisture requirements: dry sand savanna and dry-mesic sand savanna (White and Madany 1978). In dry sand savannas, *Quercus velutina* Lam. (black oak) was commonly the only tree species found in the canopy, and the soil lacked, or had a poorly developed A horizon. Dry-mesic sand savannas, in contrast, though usually dominated by *Q. velutina*, contain some *Q. alba* L. (white oak) and/or other tree species reaching the canopy, and the soil A horizon was better developed being darker and thicker. Also, the topographic position of these two savanna types differed; dry sand savannas were usually on the upper slopes and ridges of sand dunes; while dry-mesic sand savannas were mostly restricted to the lower dune slopes and sandy terraces of rivers and large streams which afford some protection from prairie fires. At the present time, both dry and dry-mesic sand savannas are essentially absent from the Illinois River sand deposits mostly due to fire suppression since early settlement-times (Rodgers and Anderson 1979). These two communities, over time, grew into closed forests, and in the process lost the characteristic open canopy structure and prairie understory, with soil tending to develop a deeper and darker A horizon.

-*Dry Sand Savanna*: Remnants of dry sand savannas are common in the Illinois River sand deposits. All, however, have been degraded by logging, grazing, fire suppression, and invasion by woody shrubs and non-native species (Anderson and Brown 1986; Anderson 1991; Abrams 1992; McClain and Elzinga 1994). The prairie bunchgrasses of the ground layer are mostly gone, as are most of the prairie forbs, being replaced by shade-tolerant herbaceous species associated with closed-canopy forests. These species thrive with less light and more moisture and add to the litter layer that is not regularly removed by fire. Also, the canopy is multi-layered, more younger trees are growing taller and straighter, their lower branches self-pruning, and underneath the canopy is a subcanopy composed of small trees and tall shrubs. The forest is becoming filled! It will become a thicket in the subcanopy layers, with the lack of fire and/or grazing (McClain *et al.* 2021).

Four dry sand savanna communities that, over time, developed into closed dry sand forests, have been studied in the Illinois River sand deposits, all located on state-owned lands in Mason County. All have closed canopies with large black oaks dominating the overstory, a developed subcanopy, and a ground layer lacking most prairie grasses and forbs. These include: Bishops Woods at the southern part of Sand Ridge State Forest (Jenkins *et al.* 1991), Barkhausen Woods Conservation Area (Coates *et al.* 1992), Sand Prairie-Scrub Oak Nature Preserve (McClain *et al.* 2002), and an area near the central part of Sand Ridge State Forest (Phillippe *et al.* 2013).

In these closed forests, *Quercus velutina* is the dominant tree species and the only taxon that has individuals in the larger diameter classes. Many larger individuals are missing their lower branches, and dead snags and branch scars are obvious, an indication of their previous open-grown structure. The black oaks in the lower diameter classes are tall and straight, with a narrower canopy and trunks that lack lower branches. Also present are scattered individuals of more mesic species such as *Prunus serotina* Ehrh. (wild black cherry), *Carya tomentosa* (Poir.) Nutt. (mockernut hickory), *Diospyros virginiana* L. (persimmon), *Ulmus americana* L. (American elm), and *Tilia americana* L. (basswood) along with an occasional non-native tree species [*Catalpa speciosa* Warder (catalpa) and *Morus alba* L. (white mulberry)].

Degraded dry sand savannas that are presently forests due to fire suppression are the dominant community of ridges and upper slopes on the large, stabilized dunes at Sand Ridge State Forest, Mason County (Phillippe *et al*. 2013). Based on an analysis of 1939 aerial photographs, approximately 50.18% of the present area of Sand Ridge State Forest was covered by trees and large shrubs. In the absence of fire, canopy cover increased dramatically in the 1957 aerial photographs to 68.96%, in 1969 to 78.66%, in 1988 to 88.08%, while in 1998 canopy cover was 89.50%. As a result of fire suppression, in about 70 years the sand savanna, covering most of Sand Ridge State Forest, became a closed forest (Phillippe *et al.* 2013).

In the dry sand savanna community surveyed in 2004 at Sand Ridge State Forest, 11 tree species were encountered (Ebinger *et al.* 2007; Phillippe *et al.* 2013)**.** *Quercus velutina* dominate all diameter classes, accounting for 65% of the stems/ha, and is the only species with trunks 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) (IV of 34.7) ranked second in importance, followed by the adventive *Pinus strobus* L. (white pine), and *Carya texana* Buckl. (black hickory). The woody understory averaged 15,200 seedlings/ha, 1,775 small saplings/ha, and 295 large saplings/ha. Because of the relatively few saplings, the woody understory was fairly open. Few prairie grasses were encountered though many prairie forbs were present in low numbers (Maier 1976; Marcum *et al.* 2013).

-*Dry-mesic Sand Savanna*: Sand savannas associated with lower dunes slopes, ravines, and sandy river terraces are more mesic than dry sand savannas (White and Madany 1978). In these savannas *Quercus velutina*

was present, but more mesic tree species, particularly *Quercus alba,* were canopy members. Other species were present in low numbers, including *Celtis occidentalis* L. (hackberry), *Juglans nigra* L. (black walnut), Sassafras *albidum* (Nutt.) Nees (sassafras), and *Ulmus americana*. Due to the lower topographic position, there was usually some development of a soil A horizon; some mesic ground layer prairie species were present; and some prairie grasses commonly exceeded 1 m in height. Due to lack of fires and non-native species encroachment good quality examples of dry-mesic sand savannas no longer exist in the Illinois River sand deposits.

One former degraded dry-mesic sand savanna that presently is a dry-mesic sand forest was studied in 2004 (McClain *et al.* 2008b). Located in the Speckman-Stelter Woods Land and Water Reserve, this woodlot is about 6 kms south of Havana (NW1/4 S23 T21N R9W) (Ebinger 2005; Ebinger *et al.* 2007; McClain *et al.* 2008b). About 2 ha in size, this woodlot is located on a sandy terrace about 1500 m east of the Illinois River. *Quercus alba* dominates the larger diameter classes with an IV of 144.2, and an average diameter of 53.4 cm. Most of the larger *Q. alba* had open-grown canopies with large branches or branch scars within 4 m of the ground. *Quercus velutina*, also restricted to the larger diameter classes, was second in IV (12.7) and had an average diameter of 71.3 cm. The remaining species, mostly in the 10-29 cm diameter classes, were recent encroachments, three being non-native. The density of tree seedlings, shrubs, and woody vines was high, totaling 19,000 individuals/ha, small saplings averaged 2,250 stems/ha, and large saplings totaled 1,370 stems/ha. *Sassafras albidum* dominated the seedling and sapling categories with 4300 seedlings/ha, 1600 small saplings/ha, and 545 large saplings/ha while *Celtis occidentalis* was second with 1700 seedlings/ha, but few saplings. Oak seedlings were next, being fairly common, but no oak saplings were recorded, and no oaks were found in the 10-39 cm diameter classes.

According to Lerczak (2000), Ms. Stelter, the owner of the property, recalled her great grandfather saying that it was possible to drive a wagon through the woods in the 1840s, an indication of its openness. Also mentioned was the presence of many oak grubs. Grubs are usually associated with the nearly annual prairie fires that burned extensive tracts of grassland, top-killing many of the smaller oak and hickory trees. These plants, despite the prairie fires, developed large, gnarled root systems that were often many years old despite their small stature. The cessation of prairie fires allowed these "grubs" to quickly develop into small trees. The present appearance of White Oak Creek Woods, compared to 150 years ago, is probably due to a reduced fire frequency followed by a total absence of fire in recent decades (Taft 1997; McClain *et al.* 2021).

Dry Sand Forest

Forests are generally defined as communities dominated by trees and have nearly closed overstories with more than 80% canopy cover (Nuzzo 1986; White and Madany 1978). The soil commonly has a dark A horizon from accumulated leaf litter, the ground cover may have some prairie species, but native shade-tolerant forest species are common. Dry sand forests are associated with dune and swale topography and other natural fire breaks that greatly limited the frequency and severity of fires. Post-European settlement fire exclusion in the Illinois River sand deposits has increased the acreage of sand forest at the expense of sand savannas and open sand forests (Anderson and Brown 1986; Anderson 1991; McClain *et al.* 2021).

According to Rodgers and Anderson (1979) presettlement closed sand forests were relatively common in Mason County and accounted for about 9.0% of the vegetation. They estimated that tree density averaged 263 stems/ha in these forests, while basal area averaged 29 m^2/ha. Using Government Land Office survey records they found that these sand forests were mostly restricted to areas along the Illinois River and areas of extensive dunes in the northern and central parts of the county. Present-day dry sand forests (80-100% canopy cover), that in presettlement times were probably sand savannas (10 to 40% canopy cover) or open sand forest (40 to 80% canopy cover), have been studied in Mason County: Bishop's Woods Natural Area (Jenkins *et al.* 1991), Barkhausen Woods Natural Area (Coates *et al.* 1992), and Tomlin Timber Nature Preserve (Phillippe *et al.* 2009).

Tomlin Timber Nature Preserve is located about 2 kms southwest of Easton, Mason County, Illinois (SW1/4 S11 T20N R7W). When surveyed by the Illinois Natural Areas Inventory (White 1978), the owner indicated that the woods had been selectively logged 50 to 60 years ago, but never grazed. Don McFall (Illinois Department of Natural Resources, personal communication) mentions that he first walked through the woods in the early 1980s, and there was a fairly dense woody understory and a number of large dead black oaks. The preserve was dedicated as a Nature Preserve in 1987 (McFall and Karnes 1995).

Surveyed in 2003, 19 tree species were present in the overstory of Tomlin Timber. *Sassafras albidum* dominated with an importance value of 54.9 (possible 200), an average dbh of 24.4 cm, with most individuals in the 10-39 cm diameter classes (Phillippe *et al.* 2009). *Quercus velutina* (IV of 38.5), with an average dbh of 62.7 cm, dominated the 50+ cm diameter classes. Other common species included *Carya texana*, *Celtis occidentalis*, *Prunus serotina*, *Ulmus americana*, *Carya tomentosa*, *Ulmus rubra* Muhl. (slippery elm), and *Asimina triloba* (L.) Dunal (pawpaw). The woody understory was dense with 18,639 woody seedlings/ha, 4,862

small saplings/ha, and 1,222 large saplings/ha. Extensive colonies of *Asimina triloba* occurred throughout the preserve, averaging 4,028 seedlings/ha, 2,986 small saplings/ha, 854 large saplings/ha, along with 14.9 stems/ha that exceeded 10 cm dbh. The herbaceous understory was composed mostly of shade-tolerant forest species, 113 taxa being encountered including 24 non-native species. Tomlin Timber is another example of oaks being replaced by more mesic, thin-barked tree species due to a reduced fire frequency (Ebinger and McClain 1991; Taft 1997).

Tomlin Timber was part of an extensive dry open sand forest in pre-settlement times. Canopy closure and increased importance of mesic trees, resulting from fire suppression, has altered its structure. With canopy closure, shade-intolerant *Quercus velutina* could not effectively recruit. *Sassafras albidum*, a fire-sensitive but relatively shade-tolerant species, became the dominant understory species, entered the canopy, and now has the highest importance value. Though the growth of *Sassafras albidum* is not rapid, this species can reproduce by root suckers, probably the reason for the relatively rapid increase of this species since European settlement.

Conclusions

This review documents many of the changes that have occurred within some of the plant communities of the sand deposits in the Illinois River Valley since early European settlement. Grasslands have a long and dynamic history in North America since the Miocene, and fire is now considered the primary reason for their modern origin and in the persistence of the Midwestern Tallgrass Prairie (McClain *et al.* 2021). A reduction in the extent and frequency of wild fires, with the increase in European settlement in the 1800s, resulted in the increase of forest at the expense of prairie. This decrease in fire frequency and extent resulted in the woody invasion of prairie and savanna with the resulting dominance of forest through the Midwestern Tallgrass Prairie. Also, more subtle changes have occurred during the past 150 years, like the lowering of the water table, which has eliminated many sand ponds and wetlands, and the more recent invasion of nonnative species that decreased habitat availability for native species.

Plant communities are always in a state of flux and change with the passage of time. Human activities, over time, accelerated these changes, by preventing prairie fires, draining wetlands, cultivating, and home steading. This is now obvious with the change in structure and composition of the sand prairies and sand savannas that once covered most of the study area. These plant communities can rarely be found at the present time, and we looked very hard! Other than the few we have studied, other examples are relatively rare in the Illinois River Valley, and as far as we can tell, are mostly restricted to dedicated nature preserves. The few remaining outside of dedicated nature preserves are degraded remnants that are small with low species diversity. The tree part of these communities is still present, but usually with a greater density compared to the average in the 1800s. Parks, in and around small towns, and some large yards, still contain the tree component of large black and white oaks, including some with lower branches suggesting a former open community. The prairie understory, however, has been replaced by Kentucky bluegrass, crabgrass, fescue, and dandelions. To maintain these savanna and forest communities requires fire on a fairly regular basis. However, by studying the few remaining plant communities, we can usually infer their floristic composition and structure before European settlement.

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