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Development of a Recovery Strategy For Endangered Plant Species Through Habitat Recovery, Preservation, and Management

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INTRODUCTION

Most of the endangered and threatened species of Illinois are restricted to one or a few natural divisions of Illinois, and have growth requirements based on climate and habitat specificity found in these natural divisions. These natural divisions are distinguished on the basis of topography, glacial history, bedrock, soil, climate, and the distribution of native plants and animals (Schwegman 1973). Generally many of these endangered and threatened species have a consistent list of associated species, and mostly occur in only one, or a few, natural communities within a natural division. These natural communities are outlined in White and Madany (1978), and are based on vegetation structure (forest, prairie, savanna, etc.), topographic position, soil texture and structure, and moisture (xeric, mesic, wet). Any management strategies used to preserve endangered and threatened plants must focus on these natural divisions and the natural communities (habitat types) in which these species normally occur.

Planning for protection, conservation, and recovery for each of the more than 260 plant species presently on the Illinois endangered and threatened plant list would require an excessive expenditure of time and energy. Many of these species, however, are habitat specific, and most are commonly associated with other endangered and threatened species in a particular natural community. By developing recovery plans that focus on specific habitats with groups of endangered and threatened species, instead of individual species, it may be possible to protect and conserve these groups of species. Many of these same species are also associated with disturbances in and around the natural community in which they commonly grow. By providing more insight into which habitats contain the greatest concentration of rare species, we can best invest our efforts to preserve communities that will have a maximum effect on preserving these rare taxa of Illinois.

The present study was undertaken to determine the habitat requirement of a group of endangered and threatened plant species that are mostly restricted to the sand deposits of Illinois. Presently more than 70 species of endangered and threatened plant species are known to grow in these deposits in habitats ranging from sand prairies, sand forests, sand savannas, to various wetland communities. During the present study, 46 species that are commonly associated with these sand deposits were studied, and their habitat fidelity and natural community type(s) determined. Also presented are management strategies that should be used for some of these habitats types.

ORIGIN OF ILLINOIS SAND DEPOSITS

At the time of settlement, aeolian (wind-blown) sand deposits covered approximately 3.4% (497,248 ha) of the total land area of Illinois (Lineback 1979,

Fehrenbacher et al.1984). The majority of these deposits (>85%) occur in the northern one-half of the state, and most are on glacial outwash plains resulting from erosional events associated with Wisconsin glaciation (Willman and Frye 1970, King 1981). The most extensive are the Kankakee sand deposits of northeastern Illinois, the Illinois River sand deposits in the central part of the state, and the Green River Lowlands in northwestern Illinois (Gleason 1910, Schwegman 1973). Other sand deposits are associated with the floodplain of the Mississippi River in northwestern Illinois, and the Chicago Lake Plain and beaches along Lake Michigan in northeastern Illinois (Schwegman 1973, Willman and Frye 1970).

The extensive sand deposits occurring in the Kankakee area were deposited approximately 14,000 to 16,000 years ago by glacial melt-waters flowing from the retreating Laurentide ice sheet (Wisconsin glaciation), which in some instances resulted in catastrophic floodwater events (e.g., Kankakee Torrent) (Frankie et al. 1996, Wiggers 1997, Killey 1998b). Large amounts of sandy materials were deposited by these melt-waters in various areas within this region, including previously formed glacial lakes (Lake Wauponsee, Lake Watseka), outwash plains, and stream channels (Willman and Frye 1970, Lineback 1979, Frankie et al. 1996). After the waters receded from episodes of glacial floodwater activity, many of the sand deposits were later sorted and reworked into dunes and sheet-like formations by strong winds (Willman and Frye 1970, Frankie et al. 1996. Additionally, floods subsequent to deposition events sometimes completely removed many of these deposits from the landscape and re-deposited them elsewhere in the state, and in turn deposited new materials for which the physical processes of weathering, sorting, and transporting would begin again (Willman and Frye 1970). These deposits are the materials on which the sand plant communities within the Kankakee Sand Area Section of the Grand Prairie Natural Division would later develop (Schwegman 1973).

Melt-waters associated with the Kankakee area were discharged into the Kankakee River Valley, mostly during major flooding events (e.g., Kankakee Torrent) (Willman and Frye 1970). The Kankakee Valley could not accommodate these extensive floods, and at peak flow the water spread-out over the surrounding uplands. During these flooding events large quantities of sand were removed from the Kankakee area and transported by the Kankakee River into the Illinois River. Much of the Illinois River sand deposits were formed during the Kankakee Torrent. The outlet channel for the Kankakee Torrent was along the Illinois River Valley and the Torrent, which was entrenched in bedrock, moving rapidly and scouring broad areas of the bedrock. Below the Big Bend at present day Hennepin, Illinois, however, the Kankakee Torrent entered a wider and more easily eroded section of the Illinois River Valley. In this wider valley the Kankakee Torrent slowed and much of the gravels and sands being carried were deposited, particularly below present day Peoria. The broad terraces presently along the Illinois River Valley from Hennepin to Beadstown are mostly erosional surfaces of the Kankakee Torrent and many are presently covered with sand and gravel deposits. These deposits in the southern half of Tazewell County, nearly all of Mason County, and small parts of Cass, Marshall, Morgan, Peoria, Putnam, Scott, and Woodford counties, are the Illinois

River Section of the Illinois River and Mississippi River Sand Areas Natural Division (Schwegman 1973)

Another large sand deposit occurs in the Green River Lowland Section of the Grand Prairie Natural Division (Schwegman 1973). These sand deposits cover the southern half of Whiteside County, most of the northern half of Henry County, and small parts of Bureau and Lee counties in northwestern Illinois. Located just to the west of the terminal moraine of Wisconsin glaciation, extensive amounts of sand and gravel were deposited over the existing Illinoian till during intermittent warm periods of the Wisconsin Episode (Killey 1998a). These sands were reworked by wind creating numerous small sand dunes (Willman and Frye 1970). Except for local "blowouts," these dunes were formed soon after the sand was exposed to wind action and most have long been stabilized in their present position by vegetation.

Many smaller sand deposits are scattered throughout the lowlands of the Mississippi River and its tributaries. Referred to as the Mississippi River Section of the Illinois River and Mississippi River Sand Areas Natural Division, these scattered deposits occur from Jo Daviess County south to Hancock County (Schwegman 1973). Some of these deposits were formed when the glacial Lake Milan and Lake Cordova in Carroll, Henry, Rock Island, and Whiteside counties drained. Others were deposited during flood events during the retreat of the Wisconsin Glacier when moraines and ice dams were breached when the glacial lakes to the north of Illinois drained.

In northeast Illinois, the sand deposits are mostly associated with the Lake Michigan Dunes Section and the Chicago Lake Plain Section of the Northeastern Morainal Division (Schwegman 1973). This area is the most recently glaciated part of Illinois. The soils of the Chicago Lake Plain Section were derived from lakebed sediments deposited by glacial Lake Chicago, which had an elevation about 4.6 meters higher than present Lake Michigan (Willman and Frye 1970).

Most of these sand deposits, commonly referred to as Parkland Sand or the Parkland Formation, consist of windblown sand in dunes and in sheet-like deposits between and bordering the dunes (Willman and Frye 1970). The dunes are usually found on terraces along major river valleys in the northern half of Illinois, and consist of medium-grained sands that are sorted by wind from the underlying glacial outwash. These sands were reworked by wind, forming the dune and swale topography characteristic of these deposits. Dunes 6 to 12 meters high are common, with occasional dunes to 30 m high. In the Mississippi River valley in northwestern Illinois the dunes have migrated onto the bluffs and uplands to the east of the terraces. Dunes were also common features on the beaches of glacial Lake Chicago.

Dry habitats are characteristic of sand deposits, and the associated species are those adapted to xeric conditions. Some of these open sands are desert-like with cactus being common. However, wet areas are also found, particularly where the water table is at or near the soil surface. Plant communities of sand deposits are diverse and include sand ponds (McClain et al. 1997), marshes and sedge meadows (Handel et al. 2003, Feist

et al. 2006), prairies (Handel et al. 2003, McClain et al. 2003. 2004a), savannas and woodlands (McDowell et al. 1983, Johnson and Ebinger 1992, 1995, McClain et al. 2002), closed forests (Jenkins et al. 1991, Coates et al. 1992), and flatwoods (McDowell et al. 1983).

Some of the most comprehensive early research completed on the vegetation of Illinois sand deposits was undertaken in the early 1900s by Henry Allan Gleason, an ecologists and plant geographer at the Illinois Natural History Survey, and by Arthur G. Vestal, a botanist at the University of Illinois (Hart and Gleason 1907, Gleason 1910, Vestal 1913). These authors described the dominant plant communities of the sand deposits and discussed the animals associated with these deposits, particularly the insects. In these early studies species composition and structure of many plant communities of sand deposits were discussed in detail. These early studies were completed at a time when much of the sand deposits had not been extensively modified. In particular, large sections of land in the sand deposits had not been subjected to disturbances such as cultivation, grazing and fire suppression.

METHODS

Plant community types, associated species, moisture requirement, and other data concerning each of the species studied was determined by reviewing the pertinent literature, examining information in the Illinois Department of Natural Resources Natural Heritage Database (IDNR2005), examining herbarium specimens in most of the state herbaria, and examining many populations of the species being studied.

Most of the pertinent literature concerning the flora of Illinois is available in the herbarium of the Illinois Natural History Survey (ILLS). Much of the remaining literature is available in the libraries of the University of Illinois and the Illinois Natural History Survey, Champaign and Urbana, Illinois. From this literature the data concerning the habitat, taxonomy, and ecology of the species was obtained.

The Illinois Department of Natural Resources Natural Heritage Database (IDNR2005) was used to determine the present population status of many endangered and threatened plant species at various localities throughout the state. Biologists from the Illinois Department of Natural Resources are consistently updating site information on many of the rare and listed species. Commonly, this information includes recent sightings of rare species, habitat information, extent and size of populations, as well as management activities at these sites.

The herbaria listed below were visited and all label information present on each herbarium specimen of each species was recorded. Also, the identification of each specimen was verified. The data commonly found on labels included scientific name of the specimen along with ecological data, locality, date collected, and collector. This data is listed in Table 1 for each herbarium specimen found.

Location of the herbaria where specimens were examined:

Chicago Botanical Garden, Glencoe, Illinois (CHIC)

Eastern Illinois University, Charleston, Illinois (EIU)
Field Museum of Natural History, Chicago, Illinois (F)
Illinois Natural History Survey, Champaign, Illinois (ILLS)
Illinois State Museum, Springfield, Illinois (ISM)
Illinois State University, Normal, Illinois (ISU)
Knox College, Galesburg, Illinois (KNOX)
Missouri Botanical Garden, St. Louis, Missouri (MO)
Northern Illinois University, DeKalb, Illinois (DEK)
Natural Land Institute, Rockford, Illinois (NLI)
Rockford College, Rockford, Illinois (RCH)
Southern Illinois University, Carbondale, Illinois (SIU)
The Morton Arboretum, Lisle, Illinois (MOR)
University of Illinois, Urbana, Illinois (ILL)
Western Illinois University, Macomb, Illinois (MWI)

During the past ten years, the authors have been studying the vegetation of the Illinois sand deposits. Throughout the course of these studies, most of the nature preserves, state parks, and listed natural areas in the sand regions were visited. While analyzing the vegetation of these areas, the authors observed many of the endangered and threatened species that have been incorporated into this present study. The habitats of many of these species have been statistically evaluated, and much of this data published.

RESULTS AND DISCUSSION

Many of the 46 species examined, during the present study, can be placed into distinct plant communities. These communities are discrete units that conform to the natural community classification system developed by White and Madany (1978). Listed and described below are these plant communities, the endangered and threatened plant species commonly associated with these habitats, and management practices commonly used to maintain these communities that will potentially increase the number of individuals and populations of these species.

A. Lake Michigan Beach Communities: The beach and fore dunes of Lake Michigan in Cook and Lake counties contain a number of rare plant species. Some species are found only in this part of Illinois, and even here, some are only rarely encountered. Many of these species have been listed as threatened or endangered in Illinois (Herkert and Ebinger 2002). Several species have not been seen for many years and are probably extirpated.

Only the endangered and threatened plant species of the beach and fore dunes of the Lake Michigan shoreline are discussed in the present study. Many other endangered and threatened species occur in this part of the state, mostly in specialized habitats such as bogs, pannes, and fens. In the shoreline communities, such as beaches and fore dunes, blowing sand is common and exposed sand is the dominant feature of these communities. Species diversity, however, is relatively high with many of the rare species being clumped and locally common.

On the middle beach the growing conditions are very harsh, and the resulting vegetation is composed of species that are in some way adapted to xeric conditions. On the middle beach, *Cakile edentula* is sometimes the only component and at other locations this taxon is dominant, with the following potential associates: *Argentina anserina*, *Artemisia campestris*, *Chamaesyce polygonifolia*, *Cirsium pitcheri*, *Corispermum hyssopifolium*, *Cycloloma atriplicifolium*, *Lathyrus maritimus*, *Populus deltoides*, *Salix syrticola*, *Salsola tragus*, and *Xanthium strumarium* (Cowles 1899, Gates 1912, Fuller 1925).

Higher, on the upper beach or fore-dune, where *Ammophila breviligulata* and *Artemisia campestris* are often the dominants, *Cakile edentula* is a secondary component along with the following potential associates: *Arabis lyrata*, *Argentina anserina*, *Asclepias syriaca*, *Calamovilfa longifolia*, *Chamaesyce polygonifolia*, *Cirsium pitcheri*, *Corispermum hyssopifolium*, *Cycloloma atriplicifolium*, *Dalea purpurea*, *Elymus canadensis*, *Equisetum hyemale*, *Lathyrus maritimus*, *Lithospermum croceum*, *Minuartia michauxii*, *Oenothera biennis*, *Oenothera clelandii*, *Oligoneuron rigidum*, *Orobanche fasciculata*, *Prunus susquehanae*, *Salix glaucophylloides*, *Salix syrticola*, and *Strophostyles helvula* (Cowles 1899, Gates 1912, Fuller 1925, Swink 1969, Swink and Wilhelm 1979, 1994, Bowles et al. 1993).

On the early successional upper beach, Bowles et al. (1993) recorded frequencies of occurrence for the following taxa: *Ammophila breviligulata* (60%), *Chamaesyce polygonifolia* (40%), *Cakile edentula* (27%), *Equisetum hyemale* (5%), and *Salix* sp. (5%). On the windward slopes of active dunes, dominated by *Populus deltoides*, *Cakile edentula* is an occasional component, with the following potential associates: *Ammophila breviligulata*, *Argentina anserina*, *Artemisia campestris*, *Asclepias syriaca*, *Calamovilfa longifolia*, *Celastrus scandens*, *Chamaesyce polygonifolia*, *Cirsium pitcheri*, *Corispermum hyssopifolium*, *Cycloloma atriplicifolium*, *Elymus canadensis*, *Equisetum hyemale*, *Lathyrus maritimus*, *Oligoneuron rigidum*, *Orobanche fasciculata*, *Physalis subglabrata*, *Physalis virginiana*, *Populus balsamifera*, *Prunus susquehanae*, *Salix humilis*, *Salix glaucophylloides*, *Salix interior*, *Salix syrticola*, *Salsola tragus*, *Strophostyles helvula*, *Toxicodendron radicans*, and *Xanthium strumarium* (Cowles, 1899, Gates 1912, Fuller 1925).

In the low dune fields along the lakeshore, sand prairies exist (Bowles et al. 1993). On these sites, some humus is present in the soil and *Juniperus horizontalis* is a consistent and obvious component (Ross 1963). Other common associates include: *Arctostaphylos uva-ursi*, *Ceanothus herbaceus*, *Comandra umbellata*, *Hypericum kalmianum*, *Juniperus communis*, *Pentaphylloides floribunda*, *Prunus susquehanae*, *Calamovilfa longifolia*, *Koeleria macrantha*, *Panicum virgatum*, *Schizachyrium scoparium*, *Anemone cylindrica*, *Artemisia campestris*, *Asclepias viridiflora*, *Coreopsis lanceolata*, *Dalea purpurea*, *Helianthus occidentalis*, *Liatris aspera*, *Liatris cylindricea*, *Lithospermum croceum*, *Minuartia michauxii*, *Oenothera biennis*, *Oligoneuron album*, and *Opuntia humifusa* (Swink 1969, Swink and Wilhelm 1979, 1994).

Bowles et al. (1993) also listed the common and associated species of two sand prairies on the fore dunes along Lake Michigan. At these sites *Arctostaphylos uva-ursi, Calamovilfa longifolia, Koeleria macrantha, Liatris aspera, Schizachyrium scoparium,* and *Solidago nemoralis* all have frequencies of 50% or higher in at least one of the sand prairies. Other associates, with frequencies ≥10 and < 50%, included *Prunus susquehanae, Artemisia campestris, Dalea purpurea, Euphorbia corollata, Minuartia michauxii,* and *Poa compressa.* In the shrub zone of some of the older dune fields, where the ground cover was >75% sand, Bowles et al. (1993) reported *Juniperus horizontalis* and *Schizachyrium scoparium* with frequencies of 72% and 56%, respectively. Other associates include *Calamovilfa longifolia, Dalea purpurea, Euphorbia corollata, Liatris aspera, Opuntia humifusa, Rosa carolina,* and *Solidago nemoralis.*

Illinois endangered and threatened plant species associated with the Lake Michigan beach that were evaluated during the present study:

Ammophila breviligulata (Appendix 1) -- Beach grass is a characteristic species along the Lake Michigan shoreline in Cook and Lake counties. In the upper beach or fore dunes it is the first perennial plant necessary for dune formation.

Arctostaphylos uva-ursi Appendix 2) -- Common bearberry is presently limited in Illinois to the Lake Michigan shoreline. It is common in the fore dunes and older dunes where there is a ground cover of >75% sand. Bearberry occurs in the shrub zone dominated by *Juniperus horizontalis.*

Cakile edentula (Appendix 8) -- Sea rocket is a characteristic species of the Lake Michigan shoreline, where it is often a pioneer on the middle sandy or gravelly beach (storm beach), a secondary component of the fore dunes, and an occasional associate on the windward slopes of active dunes.

Chamaesyce polygonifolia (Appendix 12) – Seaside spurge is a characteristic species of the Lake Michigan shoreline, where it is often a pioneer on the middle sandy or gravelly beach (storm beach), a secondary component of the fore dunes, and an occasional associate on the windward slopes of active dunes.

Cirsium pitcheri (Appendix 13) – Pitcher's dune thistle is a characteristic species of the Lake Michigan shoreline where it is a pioneer on the middle sandy or gravelly beach (storm beach) and fore dunes. This species is believed extirpated from Illinois.

Hypericum kalmianum (Appendix 21) -- Kalm's St. John's-wort is mostly a shoreline species of open dunes, sandy ridges, marshes, sand prairies, inter-dune swales, and moist sandy depressions on Lake Michigan beaches. This species has also been reported from shrub sand prairies, mesic sand prairies, sedge meadows, pannes, and disturbed sandy areas along the Lake Michigan shoreline.

Juniperus communis (Appendix 23) -- Ground juniper is mostly a species of the Lake Michigan shore in northeastern Illinois where individuals are scattered along the fore dunes and on stable portions of the eroded lakeshore bluffs.

Juniperus horizontalis (Appendix 24) -- Natural populations of trailing juniper are limited in Illinois to the Lake Michigan shoreline. It is a common species in the fore dunes and older dunes. Trailing juniper is an important component of the shrub zone.

Lathyrus maritimus (Appendix 25) – Beach pea is a species of the Lake Michigan beach, often a pioneer of the middle sandy or gravelly beach (storm beach), a secondary component of the fore dunes, and an occasional associate on the windward slopes of active dunes. It is very possible that this species has been extirpated from Illinois.

Salix syrticola (Appendix 37) -- In Illinois, the sand-dune willow is restricted to open sand dunes, sand ridges, and sandy beaches of Lake Michigan. The majority of the recently collected specimens are from Illinois Beach State Park in Lake County.

Recommendations: Very little of Lake Michigan shoreline is available for preservation. Considering the human population density along the Lake Michigan shoreline in Cook and Lake counties it is surprising that any natural plant communities still exist, much less the few good quality preserves that are still there. It is doubtful that there will be a significant increase in the extent of nature preserves along the Lake Michigan shoreline. Two major threats to the rare plant species of this region are human impact and shoreline erosion, both of which must be solved to prevent the loss of more populations and individuals of the endangered and threatened species listed above.

B. Mature Dry to Dry-mesic Sand Prairie Communities: Dry and dry-mesic sand prairies are common plant communities in all Illinois sand deposits. In presettlement time, dry sand prairies dominated the ridges and upper slopes of sand dunes and commonly continued into the edge of sand savannas and black oak sand forests. During the past ten years, the authors have examined dry and dry-mesic sand prairies in many of the nature preserves from throughout the sand deposits of Illinois.

In a mature, dry sand prairie at Ayers Sand Prairie Nature Preserve in the Mississippi River sand deposits of Carroll County, *Schizachyrium scoparium* was the leading dominant with an IV of 47.6 (200 possible) and a mean cover of 27.17%. *Ambrosia psilostachya* was second with an IV of 27.3, followed by *Selaginella rupestris* (IV of 11.5), and *Koeleria macranta* (IV of 11.0). Bare ground and litter had a mean cover of 28%. The remaining 40 species encountered in the plots mostly had low frequencies and low mean covers. Grasses formed extensive clumps while most other species grew in spaces between clumps. *Selaginella rupestris*, which was rare in most of the sand prairies, was very common, in some places covering most of the space between the bunch grasses. The exotic *Poa pratensis* was common with an IV of 4.1 but had a clumped distribution, while the exotic *Achillea millefolium* was rare (Ebinger et al. 2006b).

At Big River Natural Area in Henderson County, another site in the Mississippi River sand deposits, the leading dominant of the mature sand prairie was *Schizachyrium scoparium* with an IV of 39.9 and a mean cover of 29%. This species formed extensive clumps, many more than 40 cm across, while most other species grew in spaces between

these clumps. *Solidago nemoralis* was second with an IV of 20.5, followed by *Ambrosia psilostachya* (IV of 19.3), and *Opuntia macrorhiza* (IV of 18.6). *Lespedeza capitata*, *Stylisma pickeringii*, and *Monarda punctata* had IV's exceeding 10, while *Dichanthelium villosissimum*, *Cyperus lupulinus*, and *Commelina erecta* had frequencies greater than 50%. Of the remaining species encountered in the plots, all had frequencies of less than 50% and IV's lower than 5.0. The only exotic species in the plots, *Poa pratensis* and *Chenopodium album*, were rare, having an IV of 0.8 or less (Ebinger et al. 2006b). Bare ground and litter had a mean cover of 11%.

In the Green River sand deposits, dry and dry-mesic sand prairies were encountered at Green River State Wildlife Area in Lee County. In dry sand prairies the dominant grasses, which did not exceed 1 m in height, were *Schizachyrium scoparium* (IV of 47.4), *Leptoloma cognatum* (IV of 8.5), and *Dichanthelium villosissimum* (IV of 4.9). *Ambrosia psilostachya* (IV of 51.1) and *Solidago nemoralis* (IV of 13.7) were the dominant forbs, while *Amorpha canescens* and *Rosa carolina* were the only native woody species encountered in the plots. Bare ground and litter had a mean cover of 21%. A total of 34 taxa were found in the plots, while 94 species were observed on the prairie, 14 being non-native. Of these, *Rumex acetosella* and *Achillea millefolium*, with IV's of 8.5 and 3.8, respectively, were encountered in the plots (Ebinger et al. 2006a). The dry sand prairie at Foley Sand Prairie Nature Preserve, also in Green River sand deposits, is similar to those found in the Green River State Wildlife Area (McClain et al. 2003).

In dry-mesic sand prairies at Green River State Wildlife Area, vegetation was relatively sparse as indicated by the cover for bare ground and litter (57%). On two ridges the important grasses were *Sorghastrum nutans* (IV of 23.0), *Andropogon gerardii* (IV of 10.6), and *Dichanthelium villosissimum* (IV of 10.3), the first two grass species averaged between 0.9 and 1.3 m tall. *Liatris aspera* (IV of 31.0) was the dominant forb on both sites while other common forbs included *Antennaria plantaginifolia*, *Euphorbia corollata*, and *Euthamia gymnospermoides*. *Antennaria plantaginifolia* sometimes covered small areas in a near monoculture. Bare ground and litter had a mean cover of 57%. The exotic species *Rumex acetosella* and *Achillea millefolium* were common, being ninth and tenth in importance, respectively. Both species consistently had high frequencies but a low number of individuals were present. Overall, 49 species were encountered in the plots while 102 species were observed on the sites, nine being non-native species (Ebinger et al. 2006a).

Mature to nearly mature dry sand prairie are also relatively common in the Illinois River sand deposits. Sections of nearly all nature preserves and listed natural areas in this sand deposit contain dry sand prairies that have minimal disturbance, some exceeding 100 ha. At Long Branch Sand Prairie Nature Preserve, dry sand prairie was dominated by *Schizachyrium scoparium* having a frequency of 93%, an average cover of 26%, and an IV of 55.7. Also common, *Ambrosia psilostachya* was second with an IV of 28.5, while *Opuntia humifusa* was third with an IV of 19.0 (Phillippe, et al. 2004). Prairie grasses completed the top six species and included *Leptoloma cognatum*, *Calamovilfa longifolia*, and *Dichanthelium villosissimum*. Overall, five native prairie species, that are typical components of dry sand prairies, had IV's greater than 10. All would be expected in good

quality dry sand prairie communities in Illinois. Forty-five native prairie species were encountered in the plots. No exotic species were encountered in the plots, and none were observed in the general area. Similar results were recorded for the dry sand prairies at Henry Allan Gleason Nature Preserve and Sand Prairie-Scrub Oak Nature Preserve. Some forest openings at Sand Ridge State Forest also contained excellent quality dry sand prairies.

Illinois endangered and threatened plant species associated with mature dry and dry-mesic sand prairies that were evaluated during the present study:

Bouteloua gracilis (Appendix 7) -- Blue grama is rarely collected in Illinois and most of the collections probably represent adventive or planted individuals. Possibly the only indigenous population is in a dry sand prairie at Lost Mound, Jo Daviess County, in the Mississippi River sand deposits.

Carex inops subsp. *heliophila* (Appendix 10) -- Plains sedge is an uncommon and rarely observed species that is restricted to dry sand prairies in a few of the northern counties of Illinois. The most recent collection was made in 1985 from Jo Daviess County, in a dry sandy hill prairie in the Mississippi River sand deposits. This species has also been collected from sand and gravel prairies in the Winnebago Driftless Section of the Northeastern Morainal Natural Division.

Ceanothus herbaceus (Appendix 11) -- Prairie red root occurs in sandy or gravel prairies and savannas across northern Illinois and forms large colonies in grazed dry-mesic sand prairie. Most collections of this species are from both mature and disturbed dry sand prairies, as well as beaches, dunes, and gravel prairies.

Comptonia peregrina (Appendix 14) -- Sweet-fern is restricted in Illinois to dry-mesic sand prairies and savannas from the Northeastern Morainal Natural Division, open sandy woods in the Green River Lowlands, and in the Kankakee River sand deposits where it grows in open sandy soil, sandy wooded hillsides, dry-mesic sand prairies, sand savannas, and sand flatwoods.

Opuntia fragilis (Appendix 27) -- The little prickly pear is restricted in Illinois to disturbed and mature dry sand prairies in Jo Daviess County, at Lost Mound in the Mississippi River sand deposits.

Orobanche fasciculata (Appendix 28) -- The habitat for clustered broomrape is dry soil of prairies and plains where it is most commonly found in dry to dry-mesic sand prairies and on sand dunes. Early Illinois collections are mostly from Cook and Lake counties, on Lake Michigan beaches, but this taxon is also known from the Mississippi and Illinois River sand deposits.

Orobanche ludoviciana (Appendix 29) -- The habitat for prairie broomrape is blowouts. dry sand prairies, dry-mesic sand prairies, degraded dry sand prairies, and sand dunes. This species is scattered throughout Illinois with many collections from river sand

deposits. Prairie broomrape has been collected from wind-blown sands in the Green, Illinois, and Mississippi River sand deposits where its habitat is mostly disturbed dry sand prairies.

Penstemon grandiflorus (Appendix 30) -- Populations of the large-flowered beardstongue are known from dry sand prairies in both Henderson and Whiteside counties in the Mississippi River sand deposits, and from a dry gravel prairie in Winnebago County.

Stylisma pickeringii (Appendix 43) -- Patterson bindweed is known from the Mississippi River and Illinois River sand deposits. It grows in blowouts, areas of open, blowing sand, and dry sand prairies. This species is one of the dominant species in a dry sand prairie at Big River Natural Area in the Mississippi River sand deposits.

Recommendations: The structure and species composition of the mature dry and dry-mesic sand prairies should be maintained, mostly through the use of management fires at a regular interval. The endangered and threatened species of this natural community are not dominant members of the communities, generally occurring in low numbers between the dominant bunch grasses. Seeds or transplants of the endangered and threatened species may be introduced into these communities using local seed. If possible, introduced seeds and transplants should only be planted in natural areas that are from the same natural division from which the seeds were harvested.

C. Disturbed Dry to Dry-mesic Sand Prairie Communities: Degraded dry and dry-mesic sand prairies are found in many nature preserves and natural areas where mature high quality sand prairies are found. This community type varies from prairies with relatively minor disturbances to those that have been nearly destroyed. Usually non-native species are common, and may dominate sections of the disturbed sand prairie. Non-native cool-season grasses are commonly the dominant invading non-native herbaceous species. On these sites, woody invasion is usually pronounced, fire suppression being one of the major reasons for the degraded condition of the prairie. Exposed sand caused by burrowing animals and other natural disturbances, as well as some human disturbances, may be important in maintaining the habitat for some of these endangered and threatened species.

Illinois endangered and threatened plant species associated with disturbed dry and dry-mesic sand prairies that were evaluated during the present study:

Astragalus distortus (Appendix 3) -- Most collections of bent milk vetch are from disturbed dry to dry-mesic sand prairies, sandy roadsides, and open sandy woods, though there are a few collections from rocky ledges and bluffs in Adams and Pike counties, and from a sandy hill prairie in Scott County. This species is mostly limited to the Illinois River sand deposits.

Baptisia tinctoria (Appendix 5) – Presently, yellow wild indigo is known only from the Kankakee River sand deposits where two populations have recently been found, one from

a dry-mesic sand savanna and the other from a sandy disturbed field containing dry sand prairie species.

Botrychium matricariifolium (Appendix 6) – Daisy-leaved moonwort was recently collected from the edge of a dry-mesic sand prairie under a clump of woody plants at the Green River State Wildlife Area in the Green River sand deposits. Rare in Illinois, this species has only been recorded from disturbed habitats and should probably be considered adventive in the state.

Hymenopappus scabiosaeus (Appendix 19) -- The natural habitat of the old plainsman in Illinois appears to be sand barrens, open sandy oak woods, and dry sand prairies. Presently this species is restricted to disturbed sandy habitats in the Kankakee and Illinois River sand deposits. In black oak savannas and dry sand prairies, old plaintsman is rarely encountered in small disturbances such as old animal burrows.

Orobanche ludoviciana (Appendix 29) -- The habitat for prairie broomrape is blowouts, dry sand prairies, dry-mesic sand prairies, degraded dry sand prairies, and sand dunes. This species is scattered throughout Illinois with many collections from river sand deposits. Prairie broomrape has been collected from wind-blown sands in the Green, Illinois, and Mississippi River sand deposits where its habitat is mostly from disturbed dry sand prairies.

Recommendations: The structure and species composition of the disturbed dry and dry-mesic sand prairies should be maintained, mostly through the use of occasional management fires. The endangered and threatened species of this natural community are mostly not dominant members of the communities, but generally occur as clumps of individuals associated with disturbances. It is important to maintain areas of disturbance, and also to keep excessive overstory from developing. Seeds or transplants of the endangered and threatened species may be introduced into these communities using local seed. If possible, introduced seeds and transplants should only be planted in natural areas that are from the same natural division from which the seeds were harvested.

D. Mature Wet-mesic to Wet Sand Prairie Communities: Wet-mesic and wet sand prairies are encountered throughout all of the sand deposits of Illinois. In presettlement times, these sand prairies dominated the lower slopes of dunes and some of the low areas between dunes. During the past ten years, the authors have examined some mesic, wet-mesic, and wet sand prairies, and the transition to sedge meadows, in nature preserves and natural areas in most of the sand deposits of northern Illinois.

A high quality mesic to wet-mesic sand prairie exists on Green River State Wildlife Area in the Green River sand deposits of Lee County. This extensive area, consisting of 34 ha, has high natural quality, few exotic species, and high species diversity. Topographic differences are responsible for the mosaic of sand communities that existed here, varying from dry to dry-mesic sand prairies on the dune ridges to sedge meadows and sand ponds at the lower elevations. Mesic sand prairie vegetation occurs on the lower slopes of dunes while the wet-mesic prairies are on the lower ground between

the dunes. In the wet-mesic sand prairie *Sorghastrum nutans* dominated (IV of 48.7 out of 200) while other common grasses included *Andropogon gerardii* (IV of 6.9), and *Dichanthelium villosissimum* (IV of 5.9). Native forbs with high IV's, included *Euthamia gymnospermoides, Solidago nemoralis, Parthenium integrifolium, Liatris aspera,* and *Euphorbia corollata.* A total of 38 taxa were encountered in the plots while 124 taxa were observed during the survey. Eight non-native taxa were found, with *Rumex acetosella* (IV of 4.8), *Poa pratensis* (IV of 4.1) and *Achillea millefolium* (IV of 1.4) being encountered in the plots

Wet sand prairies were also examined at the Green River State Wildlife Area. One wet sand prairie, about 5 ha in size, was transitional between a sedge meadow and a wet-mesic sand prairie. Here, slight changes in species composition occurred depending upon slight differences in elevation. *Spartina pectinata* was the dominant grass (IV of 18.6), while *Carex stricta* was the common sedge (IV of 11.6). Numerous forbs were common components of this prairie with *Helianthus grosseserratus, Solidago canadensis, Galium obtusum, Hypericum sphaerocarpum,* and *Silpium integrifolium* all having IV's of 8.0 or greater. Within this wet prairie, 68 species were encountered in the plots.

Both wet and wet-mesic sand prairies are found at the Richardson Wildlife Foundation, also in Lee County (Handel et al. 2003). *Sorghastrum nutans* and *Andropogon gerardii* were the dominant tall grasses while *Euthamia graminifolia,* (or *E. gymnospermoides*) was an important forb on some of the small wet-mesic prairie remnants at the Richardson Wildlife Foundation as well as at Green River State Wildlife Area. At both sites, species diversity was high with more than 120 species observed. Except for dominant tall grasses, however, there was almost no similarity in species composition between Green River State Wildlife Area and Richardson Wildlife Foundation. Past disturbances and small size of remnants at the Richardson Wildlife Foundation are probably responsible for these differences.

A few small wet-mesic sand prairies are located in the Iroquois County Conservation Area in the Kankakee River sand deposits. These sites, all designated "grade C" by the Illinois Natural Areas Inventory, are located adjacent to the extensive sedge meadow community that dominates the area. All of the wet-mesic prairies examined show indications of disturbance, but species diversity was relatively high, with 42 taxa occurring in the plots. Eight species had IV's exceeding 10.0: *Rubus hispidus* (IV of 20.1), *Euthamia graminifolia* (IV of 18.3), *Potentilla simplex* (IV of 18.2), and *Sorghastrum nutans* (IV of 18.1), being the most important.

Wet-mesic sand prairie was also found at Matanzas Prairie Nature Preserve in the Illinois River sand deposits of Mason County. At this sand prairie, surface water was present for short periods even during the growing season and the soil had a dark A horizon. *Solidago canadensis* (IV of 34.2) dominated this community followed by *Andropogon gerardii* (IV of 25.9) and *Carex* spp. (IV of 21.9), most of which was *Carex stricta.* Fourth in dominance, the exotic species *Poa pratensis* was found throughout much of the prairie. Numerous species were encountered, 52 occurring in the plots with many other taxa being observed (Feist et al. 2006).

Illinois endangered and threatened plant species associated with mature wet-mesic to wet sand prairies that were evaluated during the present study:

Carex cumulata (Appendix 9) -- Crowded oval sedge is known in Illinois only from the Kankakee River sand deposits in Iroquois and Kankakee counties. Most recent collections are from moist oak woods and depressions in pin oak flatwoods. Some collections are from wet sand prairies, from the edge of oak woods, and occasionally from disturbed ground in former crop fields.

Drosera intermedia (Appendix 16) -- The narrow-leaved sundew is common in bogs in extreme northeastern Illinois. In the Kankakee River sand deposits this species occurs in shallow, depressions of wet sand prairies, and in pin oak flatwoods. In some years narrow-leaved sundews nearly cover the ground in these flatwoods.

Hypericum adpressum (Appendix 20) -- In Illinois, shore St. John's-wort is mostly restricted to the Kankakee River sand deposits were it commonly grows in moist, open sand deposits, including wet sand prairies, usually in full sunlight. Some collections are from drainage ditches and wet, sandy old fields.

Platanthera ciliaris (Appendix 32) -- Orange fringed orchid is known from the Lake Michigan sand deposits of Cook County were its habitat is mesic to wet-mesic sand prairie, often in sites exhibiting past disturbances. In the Kankakee River sand deposits, this taxon is found in a mesic sand savanna and adjacent successional field.

Platanthera flava var. *herbiola* (Appendix 33) -- Tubercled orchid is associated with the major sand deposits in central and northern Illinois where it grows in wet-mesic sand prairies, sand thickets, and beaches of Lake Michigan. The habitats reported for this species include sandy shrub prairies, sedge meadows, sand flatwoods, swales, wet sand prairies, wet-mesic sand prairies, and marsh.

Polygonum careyi (Appendix 36) -- Carey's heartsease is mostly restricted to wet sand prairies and sand flatwoods of the Kankakee River sand deposits in Grundy, Iroquois, and Kankakee counties. Some of the specimens were collected from disturbed habitats such as ditches and roadsides.

Sisyrinchium atlanticum (Appendix 42) -- In Illinois, eastern blue-eyed grass is only known from the Kankakee River sand deposits where it is found in wet, sandy depressions, wet to mesic sand prairies, wet shrub prairies, and sand flatwoods, though a few collections are from roadsides and other disturbed habitats.

Viola primulifolia (Appendix 46) – In Illinois, the primrose violet is restricted to the Kankakee River sand deposits in Iroquois and Kankakee counties. Its habitat is highly variable, ranging from successional fields, edge of ditches, and disturbed areas in sand prairies and savannas, but sometimes from wet to wet-mesic sand prairies, mesic sand savannas, and sand flatwoods.

Recommendations: The structure and species composition of the disturbed wet-mesic to wet sand prairies should be maintained, mostly through the use of occasional management fires to control native and exotic shrub invasion. Also, cutting of shrubs and trees should probably be undertaken when the areas are too wet for burning. Endangered and threatened species of this natural community are mostly not dominant members of the communities, generally occurring as isolated individuals, or small clumps of individuals scattered throughout the prairie. Seeds or transplants of the endangered and threatened species could possibly be introduced into these communities using local seed. If possible, introduced seeds and transplants should only be planted in natural areas that are from the same natural division from which the seeds were harvested.

E. Disturbed Wet-mesic to Wet Sand Prairie Communities: Degraded wet-mesic to wet sand prairies are found in many nature preserves and natural areas where mature high quality sand prairies are found. This community type varies from prairies with relatively minor disturbances to those that have been nearly destroyed. Usually, non-native species are common, and may dominate sections of disturbed sand prairie. Non-native cool-season grasses are often the dominant invading, herbaceous species. On these sites, woody invasion, particularly native shrubs, is excessive, fire suppression being one of the major reasons for the degraded condition of the prairie. Exposed sand due to burrowing animals and other natural disturbances, as well as some human disturbances, may be important in maintaining the habitat for some of these endangered and threatened species. Many of the endangered and threatened species that occur in these habitats are found near the edge of the prairie in areas of heavy human disturbances, particularly spoil from drainage ditches, in drainage ditches, and on roadsides.

Illinois endangered and threatened plant species associated with disturbed wet-mesic to wet sand prairies that were evaluated during the present study:

Carex cumulata (Appendix 9) -- Crowded oval sedge is known in Illinois only from the Kankakee River sand deposits in Iroquois and Kankakee counties. Most recent collections are from moist oak woods and depression in pin oak flatwoods. Some collections are from wet sand prairies, from the edge of oak woods, and occasionally from disturbed ground in former crop fields.

Hypericum adpressum (Appendix 20) -- In Illinois, shore St. John's-wort is mostly restricted to the Kankakee River sand deposits were it commonly grows in moist, open sand deposits, including wet sand prairies, usually in full sunlight. Some collections are from drainage ditches and wet sandy old fields.

Polygonum careyi (Appendix 36) -- Carey's heartsease is mostly restricted to wet sand prairies and sand flatwoods of the Kankakee River sand deposits in Grundy, Iroquois, and Kankakee counties. Some of the specimens were collected from disturbed habitats such as ditches and roadsides.

Scleria muhlenbergii (Appendix 41) -- Naturally occurring populations of this species are known from Lee County in the Green River Lowland sand deposits. In these sand

deposits, this species was found at the border of an interdunal pond near Amboy in 1959, and again in 1990. Muhlenberg's nut sedge is also known from a disturbed wet-mesic sand prairie in the Kankakee River sand deposits.

Sisyrinchium atlanticum (Appendix 42) -- In Illinois, eastern blue-eyed grass is only known from the Kankakee River sand deposits where it is found in wet, sandy depressions, wet to mesic sand prairies, wet shrub prairies, and sand flatwoods, though a few collections are from roadsides and other disturbed habitats.

Viola primulifolia (Appendix 46) – In Illinois, the primrose violet is restricted to the Kankakee River sand deposits in Iroquois and Kankakee counties. Its habitat is highly variable, ranging from successional fields, edge of ditches, and disturbed areas in sand prairies and savannas, but sometimes from wet to wet-mesic sand prairies, mesic sand savannas, and sand flatwoods.

Recommendations: The structure and species composition of the disturbed wet-mesic to wet sand prairies should be maintained, mostly through the use of occasional management fires to control native and exotic shrub invasion. The endangered and threatened species of this natural community are mostly not dominant members of the communities but generally occur as clumps of individuals associated with disturbances. It is important to maintain areas of disturbance, and also to keep excessive shrubby overstory from developing. Seeds or transplants of the endangered and threatened species may be introduced into these communities using local seed. If possible, introduced seeds and transplants should only be planted in natural areas that are from the same natural division from which the seeds were harvested.

F. Blowing Sand and Blowout Communities: Areas of blowing sand are generally associated with dune ridges. These treeless areas, with low vegetation cover, are the result of past disturbances, particularly off-road vehicle use, but also excessive grazing. Gleason (1910) reported the formation of a blowout from a hole excavated after the removal of sand for building purposes. Any disturbance that opens the dry ridge to wind creates the potential for the development of a blowing sand community, and may cause the formation of a blowout. According to Gleason (1910) blowouts probably occurred in every large sand region of the state where forests were not present. These blowouts can become very large, and frequently are a prominent feature of the landscape. Presently blowouts, some of which are extremely large and cover up to one ha, are found in all the major sand deposits of Illinois. Blowouts are probably most abundant, and usually largest, in the Mississippi River sand deposits.

Blowing sand communities on dune ridges are relatively abundant in the nature preserves and natural areas of the Mississippi River sand deposits of northwestern Illinois. On the few dune ridges examined, *Hudsonia tomentosa* formed extensive low mounds and dominated the blowing sand area with a mean cover of 20% and an IV of 41.0 (possible 200). *Tephrosia virginiana*, *Dichanthelium villosissimum*, *Ambrosia psilostachya*, and *Andropogon gerardii* followed in IV. Most other species found in the plots were common sand prairie species. The non-native *Rumex acetosella* was common,

ranking eighth in IV, and found in about 50% of the plots. The non-native cool-season *Poa pratensis* was rarely encountered (Ebinger et al. 2006b). In one transect (50 m^2 plots), 34 species were encountered and bare ground and litter had a mean averaged cover of 40%.

Blowouts in the Mississippi River sand deposits occur in nearly all of the dedicated natural areas and at Lost Mound (Savanna Army Depot) in Jo Daviess and Carroll counties. A few blowout communities are also found in the sand deposits of the Green River lowlands, while most of the nature preserves in the Illinois River sand deposits contain blowouts. A few blowouts are also found in the Kankakee sand deposits, but are generally rare as most of the nature preserves and natural areas are dominated by savanna vegetation.

All blowouts examined had sparse vegetation cover and relatively low species diversity. In one community surveyed, 23 species were encountered in the study plots. Seven native species dominated, all with high mean covers (2 to 6%) and IV's (18.3 to 25.7 out of a possible 200.0). Five of these species, *Carex muhlenbergii*, *Dichanthelium villosissimum*, *Aristida tuberculosa*, *Cyperus schweinitzii*, and *Panicum virgatum* were grasses and sedges, whereas *Croton glandulosus* and *Ambrosia psilostachya* were the dominant forbs. The 16 remaining species were mostly native dry prairie components that were common in surrounding plant communities. The only non-native species observed was *Mollugo verticillata* (carpetweed) with an IV of 0.8. Bare ground and litter had a mean cover of 63%. The endangered or threatened *Hudsonia tomentosa*, *Cyperus grayoides*, and *Polanisia jamesii* were found in the blowing sand and blowout communities (Ebinger et al. 2006b).

Illinois endangered and threatened plant species associated with blowing sand and blowout communities that were evaluated during the present study:

Cyperus grayoides (Appendix 15) -- Throughout its range, the habitat for sand prairie flatsedge is blowouts associated with dry sand prairies or dry sand savannas, and occasionally disturbed areas such as roads or fallow fields, always in dry, sandy soil. It is common in the Mississippi and Illinois River sand deposits, but has not been reported from the Kankakee River sand deposit.

Hudsonia tomentosa (Appendix 18) -- The habitat requirements for beach heather in Illinois are open sand of natural blowouts in dry-mesic and dry sand savanna, and in dry-mesic and dry sand prairie. This species occurs in both the Mississippi and Green River sand deposits.

Lesquerella ludoviciana (Appendix 26) -- In Illinois, the silver bladderpod is restricted to a few small populations associated with partially stabilized blowouts at the Henry Allan Gleason Nature Preserve, in the Illinois River sand deposits of Mason County.

Polanisia jamesii (Appendix 35) -- James' clammyweed is reported from both the Illinois and the Mississippi River sand deposits in Tazewell and Jo Daviess counties where it is limited to open sand dunes and active blowouts.

Stylisma pickeringii (Appendix 43) -- Patterson bindweed is known from the Mississippi River and Illinois River sand deposits. It grows in blowouts, areas of open, blowing sand, and dry sand prairies. This species is occasionally associated with fallow, sandy fields, and has been reported from a pine plantation in a disturbed sand prairie.

Recommendations: Blowouts are common in most of the nature preserves and listed natural area in the Mississippi, Green, and Illinois River sand deposits. Many of these blowouts have *Cyperus grayoides* as a relatively common component, and this species may now be too common to list as a threatened species. The remaining three species are uncommon or often absent on many of the blowouts and dry wind blown ridges. The introduction of seed, or possibly plants, into some of these blowouts is probably the only method available to increase population numbers.

G. Sand Flatwood Community: Sand flatwoods are rarely encountered in Illinois, being restricted to the Kankakee River sand deposits and the Chicago Lake Plain. These flatwoods occur in depressions between dunes where the water table is at or near the surface of the ground for extended periods of time in winter and spring. Sometimes water is present until mid-summer. The peaty soils are acidic and consist of fine sandy loams with high concentrations of organic material.

Quercus palustris is consistently the dominant species of sand flatwood forests, usually accounting for 60 to 95 percent of the importance value. *Quercus alba* and *Nyssa sylvatica* are commonly present in low numbers, usually occurring on slightly raised areas. A large flatwood located at Hooper Branch Nature Preserve in Iroquois County has tree densities averaging 302 stems/ha with a basal area of 25.7 m^2/ha. *Quercus palustris* dominated, accounting for nearly 95 percent of the IV (188.6 of a possible 200). The only other overstory species present were *Nyssa sylvatica* and *Quercus alba.* The woody understory was open, only 35 saplings/ha were encountered. Woody seedlings, however, were common and averaged 41,800 stems/ha, most being *Quercus palustris* along with scattered individuals of *Sassafras albidum, Ilex verticillata, Vaccinium angustifolium*, and various *Rubus* spp. The ground layer vegetation was sparse. Common ground layer species were *Carex stricta* and *Calamagrostis canadensis* (McDowell et al. 1983).

Sand flatwood forests also occur on the sandy plains of the glacial Lake Chicago at the Jurgensen Nature Preserve and Thornton-Lansing Road Nature Preserve in Cook County. *Quercus palustris* is the dominant canopy species, with *Nyssa sylvatica* also common. Other tree species encountered are *Quercus ellipsoidalis*, *Acer saccharinum*, *Ulmus americana*, and *Quercus bicolor*. These sand flatwoods are fairly large, up to 25 ha, with the soil being a mixture of peat and sandy loam. About one meter below the sand is an impervious layer of lake bottom clay (McFall and Karnes 1995).

These sand flatwoods, which are commonly called pin oak flatwoods, have an interesting and unique flora. The acid soil and dense shade create a habitat that is rare in Illinois. *Vaccinium angustifolium* is sometimes common, along with occasional scattered clumps of all three Illinois members of the fern genus *Osmunda: Osmunda cinnamomea*, *Osmunda claytoniana*, and *Osmunda regalis*. Also, the carnivorous plant species *Drosera intermedia* is sometimes present.

Illinois endangered and threatened plant species associated with sand flatwood communities that were evaluated during the present study:

Carex cumulata (Appendix 9) -- Crowded oval sedge is known in Illinois only from the Kankakee River sand deposits in Iroquois and Kankakee counties. Most recent collections are from moist oak woods and depressions in pin oak flatwoods. Some collections are from wet sand prairies, from the edge of oak woods, and occasionally from disturbed ground in a former crop field.

Comptonia peregrina (Appendix 14) -- Sweet-fern is restricted in Illinois to dry-mesic sand prairies and savannas from the Northeastern Morainal Natural Division, open sandy woods in the Green River Lowlands, and in the Kankakee River sand deposits, it grows in open sandy soil, sandy wooded hillsides, dry-mesic sand prairies, sand savannas, and sand flatwoods.

Drosera intermedia (Appendix 16) -- The narrow-leaved sundew is common in bogs in extreme northeastern Illinois. In the Kankakee River sand deposits this species occurs in shallow, wet depressions of wet sand prairies, and in pin oak flatwoods. In some years narrow-leaved sundews nearly completely cover the ground in these flatwoods.

Polygonum careyi (Appendix 36) – Carey's heartsease is mostly restricted to wet sand prairies and sand flatwoods of the Kankakee River sand deposits in Grundy, Iroquois, and Kankakee counties. Some of the specimens were collected from disturbed habitats such as ditches and edge of roads.

Viola primulifolia (Appendix 46) – In Illinois the primrose violet is restricted to the Kankakee River sand deposits in Iroquois and Kankakee counties. Its habitat is highly variable, ranging from successional fields, edge of ditches, and disturbed areas in sand prairies and savannas, but sometimes from wet to wet-mesic sand prairies, mesic sand savannas, and sand flatwoods.

Recommendations: Sand flatwoods are very rare plant communities in Illinois. The few flatwoods that exist are mostly degraded by past cutting, and in dry years, fire kills some of the trees. The biggest threat to this community, however, is the loss of available moisture due to the lowering of the water table. In much of the sand deposits, central pivot irrigation systems are becoming common and in dry years these flatwood depressions may be dry in winter and early spring. Seeds or transplants of the endangered and threatened species may be introduced into these communities using local seed. If

possible, introduced seeds and transplants should only be planted in natural areas that are from the same natural division from which the seeds were harvested.

H. Permanent and Temporary Sand Pond Communities: Wetlands were a major landscape feature of the Illinois River sand deposits prior to European settlement (Rodgers and Anderson 1978). The present day permanent and temporary sand ponds are just some of the vestiges of these nearly extirpated plant communities. The temporary sand ponds are presently transient communities. Many of the species commonly associated with these ponds persist within the soil seed bank. During most years the areas where these ponds existed is intensively farmed. During these dry years the species associated with these ponds do not grow, only to reappear during times of high precipitation (Schwegman 1984). These shallow ponds, most of which become dry at least in some years, have long been known for rare vascular plant species.

In Illinois, temporary sand ponds are common in parts of Cass and Mason counties in the Illinois River Section of the Illinois River and Mississippi River Sand Areas Natural Division (Schwegman 1973). These shallow depressions, some less than a meter deep and extending for many ha, are common in the lowlands between the widely spaced dunes. All except one, a shallow depression at the Sand Prairie-Scrub Oak Nature Preserve, are in fields commonly cultivated, and except in extremely wet years are planted to corn and soybeans.

The early successional stages in these temporary wetlands, particularly areas that are farmed in most years, generally consist of many annual and a few perennial plant species. Some of the species have propagules that remain in the seed bank for extended periods, while others are transported into the area by wind and water birds (Robinson 1995). The resulting plant community depends on the life histories of the species involved plus their propagule longevity and establishment requirements (van der Valk 1981). In the temporary sand ponds, the time between flooding may be fairly extensive (20 years or more), and propagule longevity may be a critical factor in determining plant community composition. Before extensive modification of the landscape by modern man, the flooding regime may have been more regular and with fewer years separating each cycle. Extensive water table fluctuations and levies in our modern environment have greatly modified the flooding cycle.

The unusually high rainfall of 1993 brought unprecedented flooding along the Mississippi and Illinois rivers (Wahl et al. 1993). Within the Illinois River sand deposits this high rainfall resulted in an elevated water table, causing the pooling of water in low-lying area. The precipitation of the next few years was sufficient to maintain water in many of these sand ponds, resulting in the development of wetland plant communities in fields that had been in row crop agriculture in 1992 (McClain et al. 1997). During years characterized by unusually high precipitation, such as 1974 and 1993, a phenomenon known as ground water flooding occurs when the level of the aquifer reaches exceptionally high levels (Visocky 1995). This elevated water table results in the formation of many groundwater lakes (temporary sand ponds). In October of 1993 it was estimated that water covered 3,672 ha of normally dry farm fields in Mason and Cass counties (McClain et al 1997).

During the growing season of 1994 and 1995, the vascular flora of five temporary sand ponds was examined by McClain et al. (1997). During this study, 72 species of vascular plants were encountered, 22 being graminoid species (Poaceae, Cyperaceae, Juncaceae) with the Cyperaceae accounting for 13 species. Although annuals were the most common, 29 perennial species were present. Some of these, such as *Typha latifolia*, *Typha angustifolia*, *Schoenoplectus tabernaemontani*, and *Persicaria amphibium* formed large, dense stands. Some annuals were also common, with *Schoenoplectus hallii*, *Ammannia coccinea*, and various species of *Persicaria* and *Polygonum* producing large colonies.

Illinois endangered and threatened plant species associated with sand pond communities that were evaluated during the present study:

Fimbristylis vahlii (Appendix 17) -- Naturally occurring populations of this species are known from the Illinois River sand deposits in Cass County in moist, peaty, sandy soil at the margins of sand ponds, and rarely temporary sand ponds. It is doubtful that seeds of this annual species persist in the seed bank for extended periods, the seeds probably being introduced by water birds.

Schoenoplectus hallii (Appendix 38) -- The majority of the reports for this species were from temporary sand ponds located in fallow, flooded farm fields. Most observations were made during the summers of 1993 through 1996. Seeds of this annual species persist in the seed bank for many years. This species is rarely adventive but in wet years is found in fallow and/or rarely cultivated fields, mostly in sand deposits.

Schenoplectus purshiana (Appendix 39) -- Naturally occurring populations of this species are from the Illinois River sand deposits of Cass and Mason counties. Pursh's bulrush is most commonly encountered at the margins of sand ponds as an emergent species, and persists in these ponds as they become dry in mid and late summer. During wet years, this annual species is found as an emergent in temporary sand ponds. It is doubtful that the seeds of this species persist in the seed bank for extended periods, the seeds probably being introduced by water birds. This species is adventive in some localities where it occurs around farm ponds, and not associated with sand deposits.

Scleria muhlenbergii (Appendix 41) -- Naturally occurring population of this species are known from Lee County in the Green River Lowland sand deposits. In these sand deposits, this species was found at the border of an interdunal pond near Amboy in 1959 and again in 1990. Muhlenberg's nut sedge is also known from disturbed wet-mesic sand prairies in the Kankakee River sand deposits.

Illinois endangered and threatened plant species associated with sand pond communities that were not evaluated during the present study: In addition to the species listed above, a few other endangered and threatened species have also been found associated with temporary and permanent sand ponds. These species were not included in the present study but would probably benefit from any

management practices used to increase the abundance of the species listed above.

Boltonia decurrens (Torr. & Gray) Wood. (decurrent false aster)
Echinodorus tenellus (Mart.) Buchenau (small burhead)
Lipocarpus maculata (Michx.) Torr. (lipocarpha) This species was listed as endangered in 1981, but was de-listed in 1994 when it was determined that it was extirpated from the state.

Recommendations: Presently, only a few permanent and temporary sand ponds are in public ownership in Illinois. Some permanent sand ponds exist that could be purchased, but all have been heavily disturbed (mostly by cattle), and generally lack any of the natural vegetation that was originally associated with sand ponds. None are known that are surrounded by high quality sand prairie. Also, only one temporary sand pond is surrounded by sand prairie vegetation. This pond is at Sand Prairie-Scrub Oak Nature Preserve, and in years of heavy precipitation, contains at least one rare plant species. One possible solution to increase the potential sites for this rare community would be to obtain conservation easements on some of the few remaining permanent sand pond. Also, easement should be obtained on some areas where temporary sand ponds were found in 1993 through 1996, in Mason and Cass counties. The purpose of the easement is to prevent building on the site, not necessarily to prevent farming, since normal farm operations generally do not destroy the seed bank.

I. Gravel Prairie Community: Gravel prairies are associated with valley train deposits along a few rivers and streams in central and northern Illinois. Occurring on kames and eskers mostly in the Northeastern Morainal Division, and on the slopes of gravel terraces along major rivers, few of these gravel prairies have been studied. Presently, dry gravel prairie are rare in Illinois, most having been destroyed by mining operations.

Very little information is available concerning the flora of gravel prairies in Illinois. Along the Rock River in Winnebago County, Fell and Fell (1956) listed the consistent grasses on the gravel prairie crest as *Schizachyrium scoparium, Sporobolus heterolepis,* and *Bouteloua curtipendula. Andropogon gerardii* and *Sorghastrum nutans* were restricted to draws and damp spots, while *Panicum virgatum* and *Heterostipa spartea* were even more limited in distribution. Post et al. (1985) studied three gravel prairies along Wea Creek, a tributary of the Wabash River in north-central Indiana. These prairies, all in Harrison County, Indiana, had the visual aspect of a mid-grass prairie. Here the common grasses were *Bouteloua curtipendula, Schizachyrium scoparium,* and *Heterostipa spartea*, with *Andropogon gerardii, Sporobolus heterolepis,* and *Sorghastrum nutans* present in more mesic areas.

The only detailed study of the composition and structure of a gravel prairie was at Manito Prairie Nature Preserve on the slopes of the Illinois River valley in Tazewell County (McClain et al. 2004b). Located on the west- and southwest-facing slopes of the preserve, the prairie was, in many places, overgrown with numerous woody species that formed dense thickets. Between the thickets and toward the crests of the steep hillside were dry gravel prairie remnants of high quality. *Schizachyrium scoparium* was the

dominant species with an IV of 61.8, being more than four times as abundant as the next most important species, *Dichanthelium oligosanthes,* with an IV of 12.3. Other common grasses included *Sorghastrum nutans*, *Sprorobolus clandestinus*, and *Bouteloua curtipendula.* Common forbs included *Dalea purpurea*, *Echinacea pallida, Ambrosia psilostachya,* and *Opuntia humifusa*. Forty-one taxa were found in the plots, of which four were non-native species, while two were native woody invaders. Bare ground and litter accounted for about 25% of the cover. Some state endangered and threatened species occurred here, including *Astragalus tennesseensis* and *Besseya bullii*, along with *Tetraneuris herbacea* that was planted and still persists (Herkert and Ebinger 2002).

Illinois endangered and threatened plant species associated with gravel prairie communities that were evaluated during the present study:

Astragalus tennesseensis (Appendix 4) -- The only known extant population of the Tennessee milk vetch in Illinois is at Manito Prairie Nature Preserve on a gravel hill prairie. Most collections of this species in Illinois are from the late 1800s to the very early 1900s, and include such habitats as along railroads, edges of rivers, gravel banks, and dry banks in limestone soil. It has been eliminated from early sites by overgrazing, farming, and gravel mining.

Ceanothus herbaceus (Appendix 11) -- Prairie red root occurs in sandy or gravel prairies and savannas across northern Illinois and forms large colonies in grazed dry-mesic sand prairie. Most collections of this species are from mature and disturbed dry sand prairies, as well as beaches, dunes, and gravel prairies.

Penstemon grandiflorus (Appendix 30) -- Populations of the large-flowered beardstongue are known from dry sand prairies in both Henderson and Whiteside counties in the Mississippi River sand deposits, and from a dry gravel prairie in Winnebago County.

Tetraneuris herbacea (Appendix 44) -- The habitat for this species is dry-prairies associated with post-glacial surface exposures of dolomite, limestone, or gravel terraces of major river valleys. There are no known extant natural lakeside daisy populations in Illinois.

Recommendations: The few remaining gravel prairies in Illinois should be managed to preserve high quality dry prairie communities. The major problem on these prairies is brush encroachment. Management fires at regular intervals should be used to maintain the prairie community in the few nature preserves in which this prairie type occurs.

J. Species Not Included in the Analysis: A few of the species for which data was collected during this study could not be placed into any of the plant communities listed above. These species are associated with particular natural communities, but we did not have a sufficient number of species to adequately describe and define the habitat type. These species are listed below.

Juncus alpinoarticulatus (Appendix 22) -- Alpine rush reaches its southern range limit in northeastern Illinois where it is occasionally found in fens, wet sand prairies, interdunal swales, moist sandy depressions, and marshes near Lake Michigan. This species is mostly associated with plant communities that are not being studied in this report.

Pinus banksiana (Appendix 31) -- It is generally believed that in Illinois, Jack pine was originally found only on sand ridges bordering Lake Michigan in Cook and Lake counties and on sandstone outcrops in Ogle County. Presently there is some doubt that this species was ever native to the Lake Michigan shore in Illinois.

Platanthera psycodes (Appendix 34) -- Purple fringed orchid has a very restricted range in Illinois. All herbarium specimens found are from the four sections of the Northeastern Morainal Natural Division in Cook, Lake, and Winnebago counties. Very little information is available concerning the habitat requirements for this species in Illinois. The only data mentioned on the herbarium labels are low sand prairies, moist open woods, rich moist woods, wet ground, low ground, and most recently, a sedge marsh. We know very little about this species and do not have enough information to determine the habitat requirements.

Scirpus microcarpus (Appendix 40) -- The small-fruited bulrush has a very limited distribution in Illinois, only one small population is presently known in the state. This population was found in 1999 in a wet sandy swale at Illinois Beach State Park on the Lake Michigan shore, in Lake County. This is probably an adventive population. We suggest that this species be removed from the endangered species list.

Triglochin maritima (Appendix 45) -- The common arrow-grass is known from the Lake Michigan sand deposits where it was associated with graminoid fens, pannes, low calcareous marshes, calcareous seeps, and sedge meadows in Kane, Lake, and McHenry counties. This species is mostly associated with plant communities that are not studied in this report.

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