Floristic inventory, ecosystem assessment and herbicide effects at Sand Prairie Park, Iowa City, Iowa

Final Report to:

Johnson County Conservation

F.W. Kent Pk

Oxford, IA 52322

Submitted by:

Thomas Rosburg, PhD

Professor of Biology

Drake University

Botanical and Ecological Consulting

73448 260th Street

Colo, IA 50056

February 10, 2026

Introduction and Objectives

The conservation and protection of semi-natural landscapes and native biodiversity is at a critical stage. In a 2023 report, it was found that **34%** of **plants** and **40%** of **animals** are at risk of extinction in the United States, and **41%** of **ecosystems** are at risk of range-wide collapse (NatureServe 2023). Biocentrism tells us that all living things, from bacteria to blue whales, have a right to exist and thrive. For that to happen, they need to have a place to live. Indigenous cultures, as opposed to modern culture, exhibited a reverence for Nature that is akin to that expressed in Deep Ecology, that Nature has value independent of its usefulness to humans. Respect for Nature should be altruistic. Nonetheless, and if given the opportunity, Nature provides ecosystem services for all of human society. Protection of water, air and soil, mitigation of climate change, production of food, nutrient cycling, a safeguard from floods and pathogens, spiritual enrichment and intellectual development are some of the ways Nature makes life for humans better.

The job of protecting Nature and its native biodiversity becomes more challenging every year due to increasing threats and decreasing resources. It is important to be proactive and establish a baseline of understanding for the landscapes we live on and manage. Therein is the goal of the research completed at Sand Prairie Park in Iowa City and reported here. Field research was done to accomplish these two overall goals:

1) conduct a quantitative, ecosystem-based, floristic inventory and assessment of Sand Prairie Park
2) determine to the extent possible the effects of a grass herbicide application made in mid-April on about 30% of the park

Conservation and protection of native ecosystems require a fundamental understanding about the organisms and communities that are present. An ecosystem-based floristic survey furnishes vital information about the plant populations and vegetation that is necessary for the preparation of a well-written ecosystem management plan. The specific tasks to achieve the first research goal include:

1. Conduct botanical field surveys of the park to accomplish these floristic components:
   a) delineate, map and identity the extant ecosystems and their respective plant communities
   b) obtain a quantitative measure of the vascular plant species composition for each community
   c) collect measurements to characterize the age/size structure of the woody species
   d) map locations of imperiled and highly conservative plant species (species of management focus)
   e) utilize nomenclature of Eilers and Roosa (1994), with synonymy to the Flora of North America (1993+)
2. Provide an ecosystem evaluation and assessment using floristic quality variables
3. Build a multi-layered GIS project for the site, including layers for plant communities, plant species, soils, topography, historic native vegetation, and land use history

Description of the Study Site

Sand Prairie Park is located near the southern edge of Iowa City, in Johnson County (Figure 1). It occurs on an upland landscape along the eastern edge of the Iowa River valley; its western boundary is 930 feet from the Iowa River. Because it is on an upland, it is located on the Southern Iowa Drift Plain. But it is adjacent to the Mississippi-Iowa-Cedar Alluvial Plain (Figure 1). The park's 37 acres can be accessed on the west from South Gilbert Street, where parking is available in the Napolean Lane parking lot (Figure 2). It can also be accessed on the east end from Covered Wagon Drive. The physiognomy of the extant vegetation is herbaceous graminoids and forbs (67%) and wooded with trees and shrubs (33%) (Figure 2).

The climate of southeast Iowa, like all of Iowa, is continental, meaning that it is influenced by the interior of a large land mass and does not receive the buffering effect of a large nearby body of water. Large temperature fluctuations occur seasonally and extreme weather events are likely. Most precipitation and higher humidity occur in the warmer months. In Iowa City, the average monthly low temperatures range from 14°F in January to 65°F in July (Figure 3). Average monthly high temperatures range from 32°F in January to 87°F in July. The highest and lowest temperatures observed at Iowa City are 109°F on July 14, 1936 and -34°F on February 3, 1996 (Plantmaps). The average annual precipitation at Iowa City is 37.6 inches. The highest annual precipitation recorded is 61.6 inches in 1993, while the lowest annual precipitation is 20.5 inches in 1999 (Extreme Weather Watch). Months

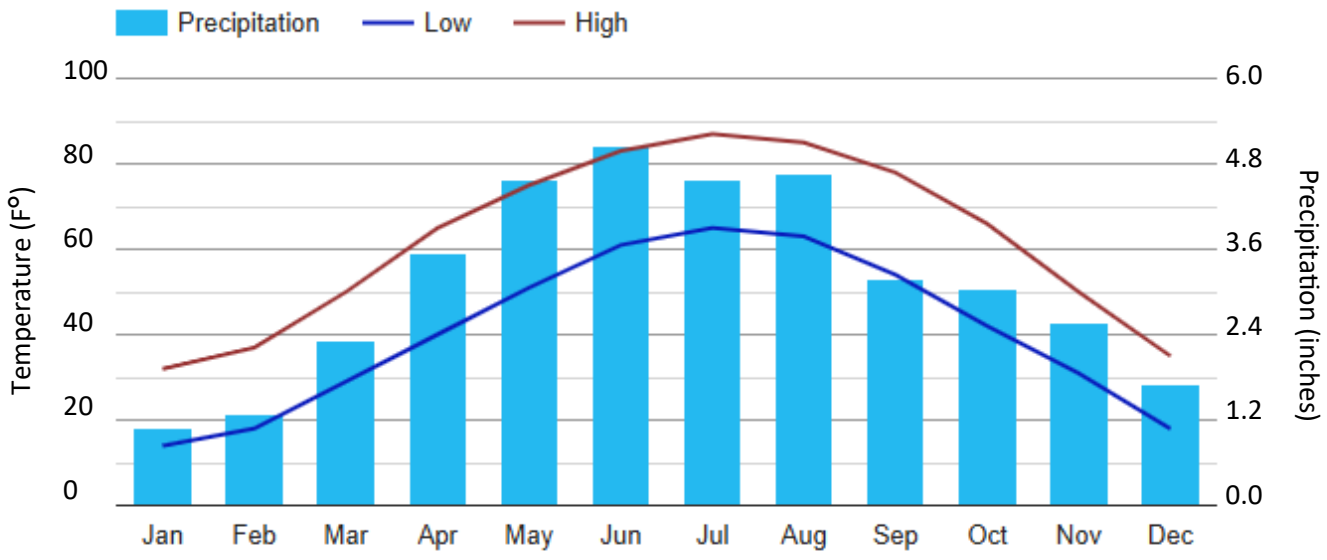
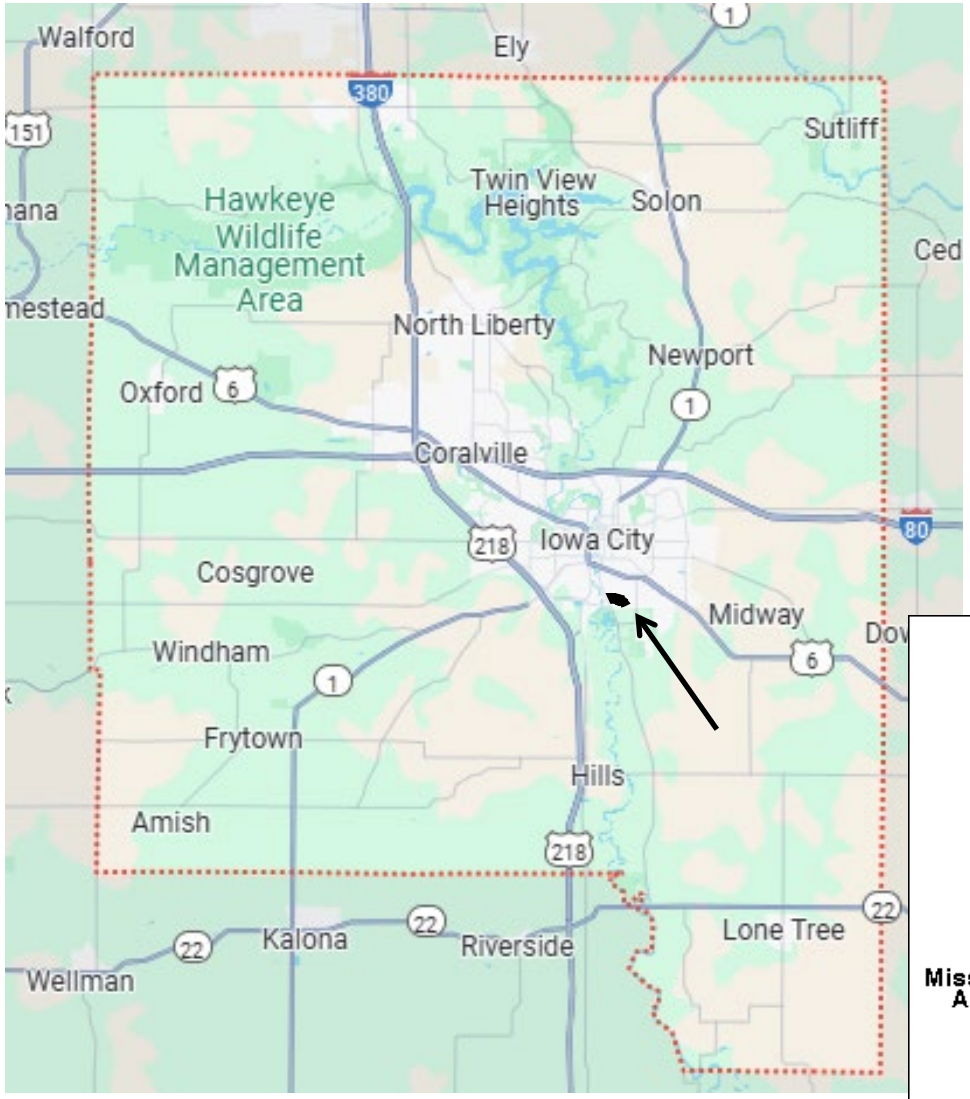
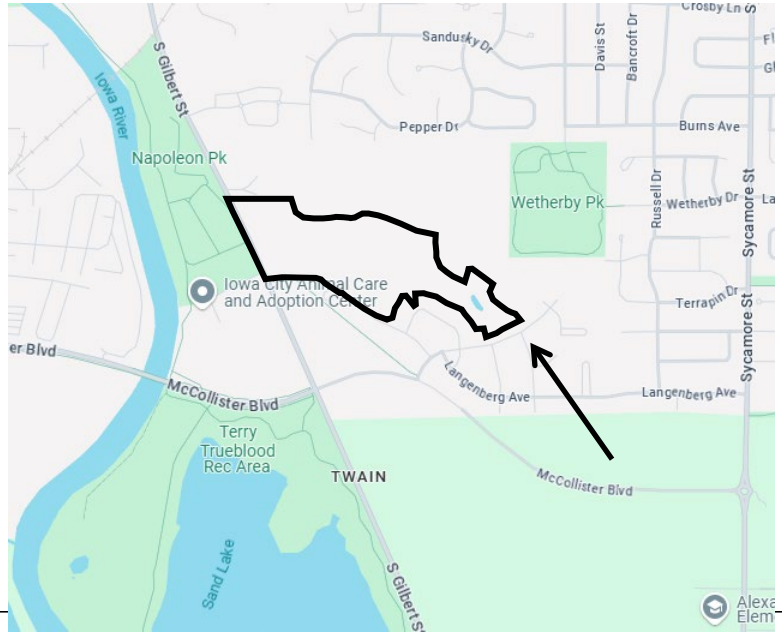


Figure 3. Mean monthly low and high temperatures and mean monthly precipitator at Iowa City, Iowa. Data are based on records from 1981 to 2010. U.S. Climate Data.





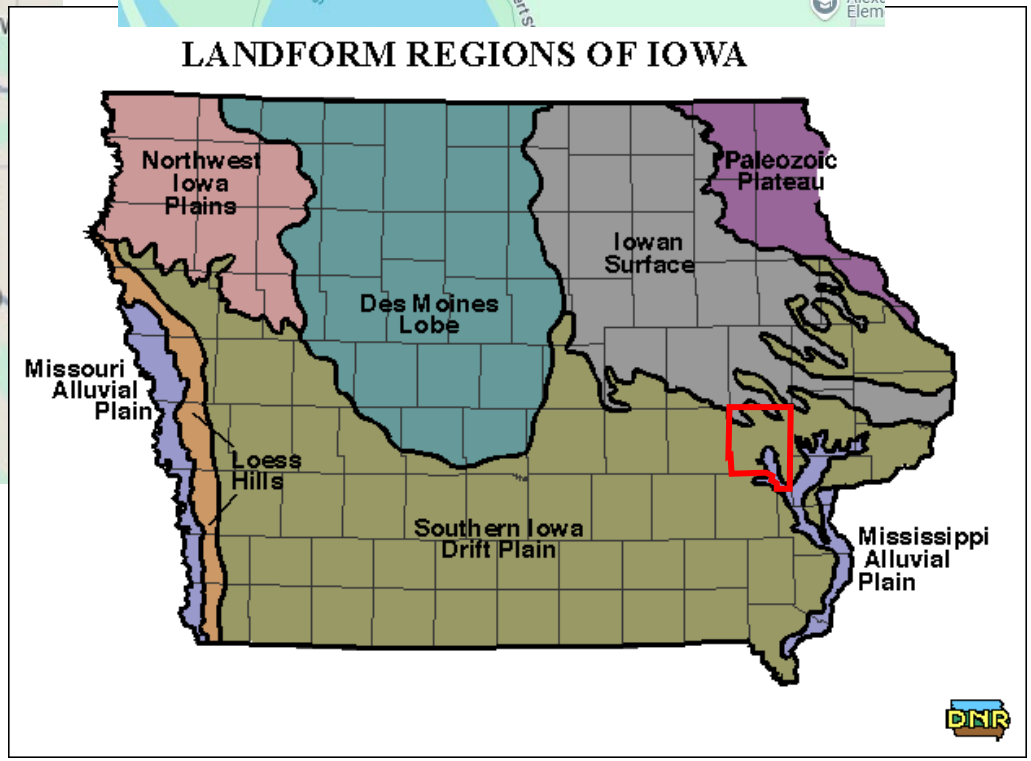


Figure 1. Location of Johnson County (red) on a map of Iowa Landforms (map on right) and Sand Prairie Park (black) in Johnson County and in Iowa City (above and above right on Google maps).

Figure 2. Sand Prairie Park (blue) on a 2023 natural color aerial photo (Iowa Geographic Map Server). The red arrow indicates an area of unprotected sand prairie.

with the highest precipitation are May through August (4.6 to 5.1 inches/month), months with the least precipitation are January and February (1.1 to 1.3 inches/month). Strong seasonality in the growth of vegetation and the occurrence of lightning in summer storms is supportive of a fire environment.

The lowest elevation in the park is 654 feet in the southwest corner (Figure 4). This is only a few feet above the elevation of the adjacent floodplain. The highest elevation is 726 feet in the north central portion of the park. Topographical variation occurs across most of the park and is maximized (72 feet) in the western two-thirds of the park.

There are six soil series present on Sand Prairie Park (Figure 5, Table 1). Parent materials, which are the geological material (i.e., deposit) the soil forms in, are either aeolian sand (68.6%), loess (14.9%), or alluvium (1.1%) (Table 2). Some of the park area (15.4%) has soil that is unidentifiable due to human disturbance caused by a quarry operation (Map Unit 5040). The Sparta soil occupies the most area (16.1 acres, 43.7%), followed by Dickinson (6.7 acres, 18.0%), Anthroportic Udorthents (5.7 acres, 15.4%) and Tama-Dickinson complex (5.2 acres, 14.0%). These four soils comprise over 90% of the park (Table 1). Much of the park (78%) is occupied by soils that have a depth to the water table of over 120 cm (Table 2). The Sperry soil is the only one that is a hydric soil. The combination of topographical variation and the dissimilarity in soils due to parent material results in extant ecosystems that can range from either very wet to very dry, thereby encompassing a very broad environmental gradient.

Table 1. The soil series present at Sand Prairie Park.

Map Unit Symbol	Map Unit Name (Soil)	Acres	Percentage
7	Wiota silt loam, 0 to 2 percent slopes, rarely flooded	0.3	0.8%
41	Sparta loamy sand, 0 to 2 percent slopes	1.1	3.1%
41C	Sparta loamy sand, 5 to 9 percent slopes	2.6	7.1%
41D	Sparta loamy fine sand, 9 to 18 percent slopes	12.4	33.5%
121B	Tama silt loam, 2 to 5 percent slopes	0.5	1.4%
122	Sperry silt loam, depressional, 0 to 1 percent slopes	2.4	6.6%
175B	Dickinson fine sandy loam, 2 to 5 percent slopes	6.7	18.0%
175C	Dickinson fine sandy loam, 5 to 9 percent slopes	0	0.0%
442D2	Tama-Dickinson complex, 9 to 14 percent slopes, moderately eroded	5.2	14.0%
520	Coppock silt loam, 0 to 2 percent slopes, occasionally flooded	0.1	0.2%
5040	Anthroportic Udorthents, 2 to 9 percent slopes	5.4	14.6%
W	Water	0.3	0.7%
	Totals	37	100.0%

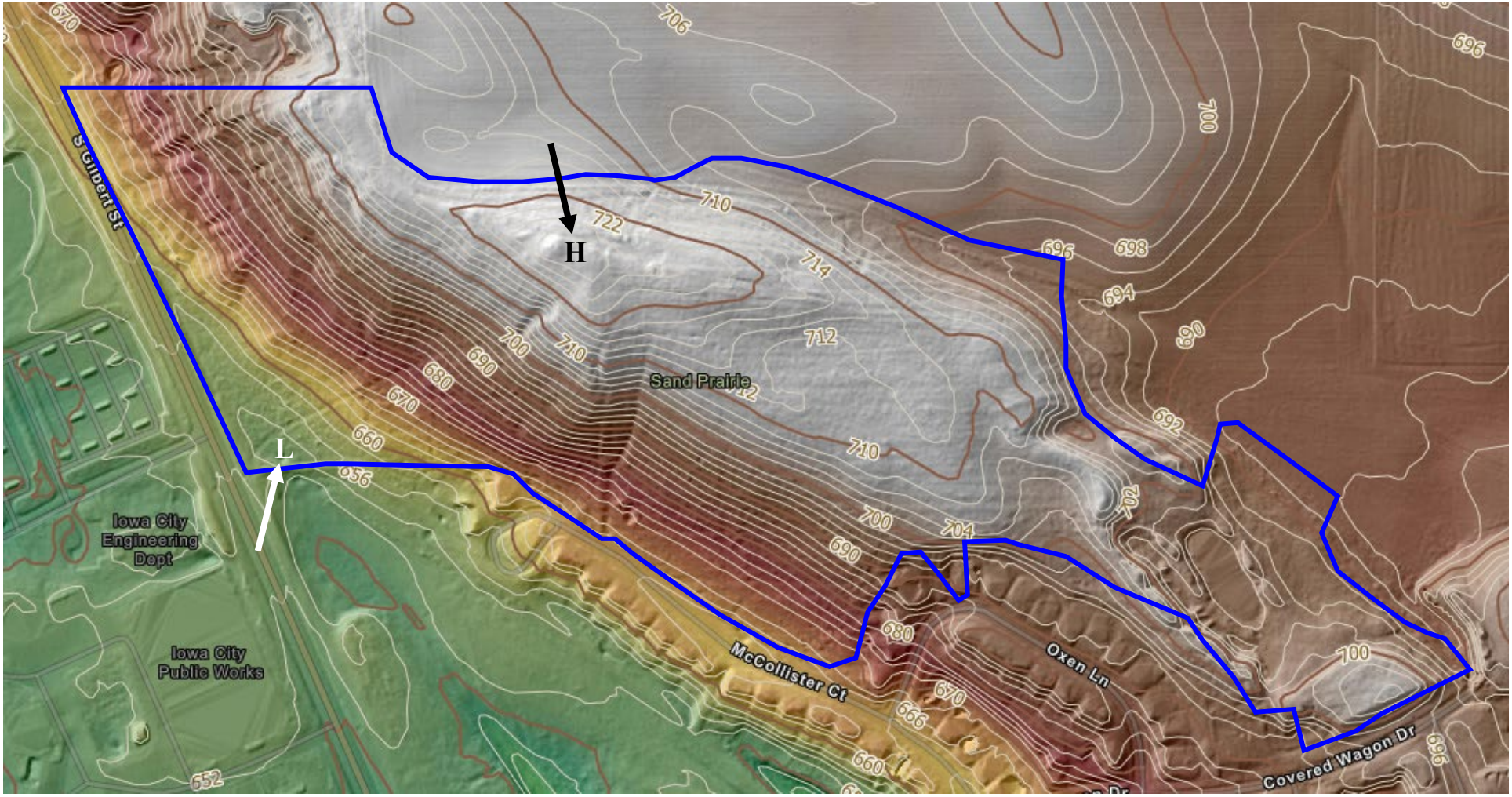
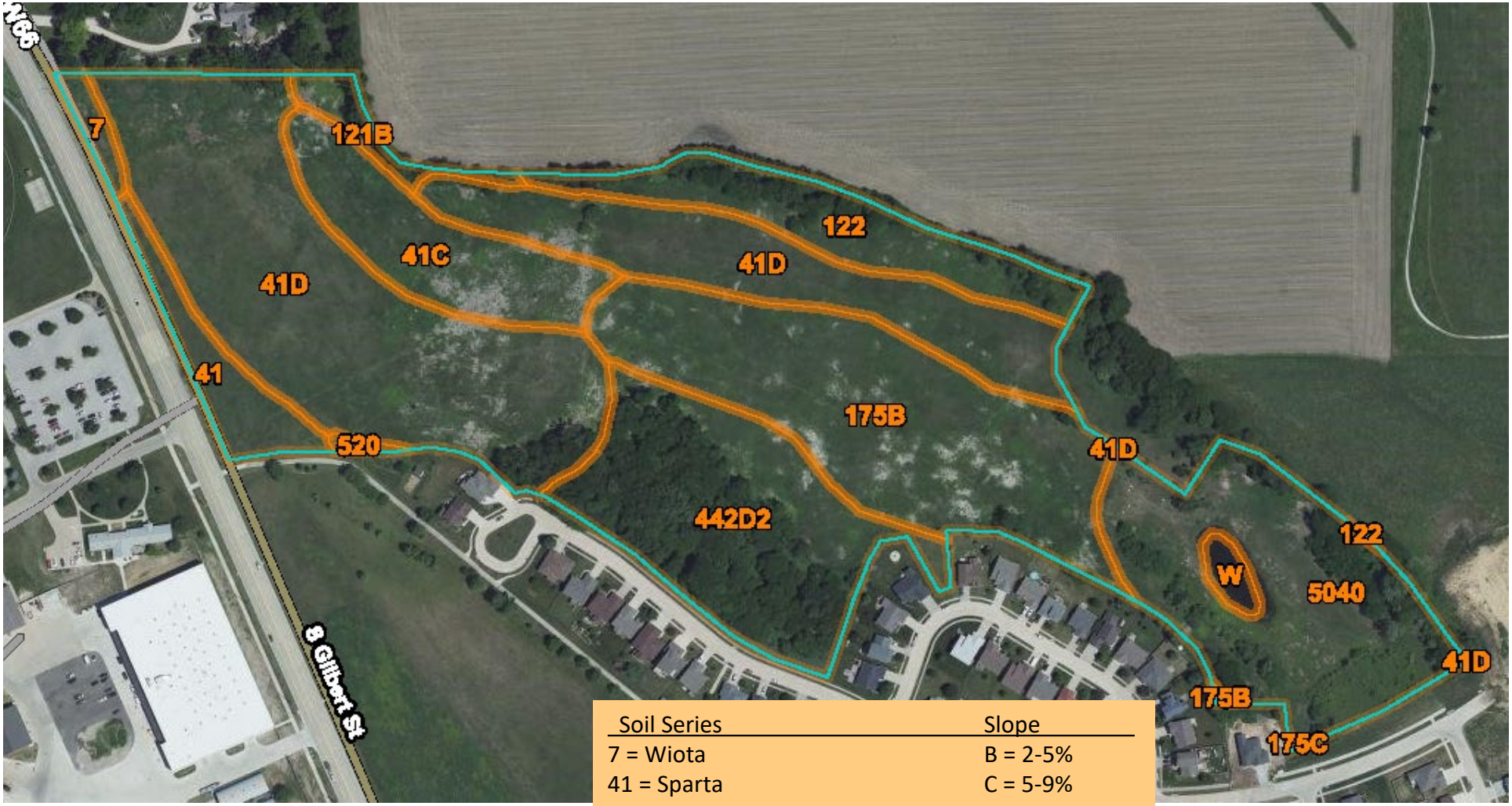


Figure 4. Sand Prairie Park (blue) on a 2020 LiDAR Color Hillshade image showing topography (Iowa Geographic Map Server). Elevation ranges from 654 feet (lowest point, L) to 726 feet (highest point, H), a difference of 72 feet.



Soil Series	Slope
7 = Wiota	B = 2-5%
41 = Sparta	C = 5-9%
121 = Tama	D = 9-18%
122 = Sperry	
175 = Dickinson	Erosion
442 = Tama-Dickinson complex	2 = moderate
520 = Coppock	
5040 = Anthroportic Udorthents	
W = Water	

Figure 5. Soil map for Sand Prairie Park (Web Soil Survey).

Because the vegetation present during soil genesis is one of the five principal soil-forming factors, insight on the native vegetation is given by the soils (Table 2). By considering the drainage and hydrology associated with the soil, a reasonably good impression can be developed for the native ecosystems present during the formation of the soils. Three ecosystems are prominent on the native landscape of Sand Prairie Park – dry prairie/oak savanna, mesic tallgrass prairie, and dry-mesic tallgrass prairie (Table 3). Together they account for 52.8% of the landscape (Table 3). The total percentage in Table 3 does not include the Anthroportic Udorthents and water (15.4%) since the native vegetation cannot be known for those areas.

The history recorded and told by the soil provides the best-informed picture of the vegetation on the native landscape. Because soils are mapped at scales less than 1 acre in area, a soil map provides the highest resolution available for mapping the native vegetation. Soil texture, slope azimuth and angle, relative elevation and drainage can all be used to classify the native vegetation more finely by considering their effects on the soil moisture regime. Two limitations of using soil as a window to the native vegetation are 1) the accuracy and resolution in soil mapping, and 2) it relies on interpretation and inference rather than direct observation. Another picture of the native vegetation, one derived from direct observation, is given by the notes of land surveyors who established the township and range grid used to construct the legal descriptions of land parcels. The General Land Office (GLO) surveys, circa 1832-1859, are manuscript maps of Iowa townships, providing a detailed record of the landscape in its earliest stages of transformation by Euro-American settlement. The maps depict the distribution of rivers, forests, prairies, wetlands and springs. They also include such features as Native American villages and fields, the first farmsteads, towns and fields established by settlers, and the location of trails.

Table 3. Native ecosystems formerly present at Sand Prairie Park based on the soils.

Presumed Native Ecosystem	Acres	Percentage (%)
Dry Prairie/Oak Savanna	16.1	18.5
Dry-mesic Tallgrass Prairie	6.7	18.1
Mesic Tallgrass Prairie	6.0	16.2
Shallow Marsh	2.4	6.5
Lowland/Alluvial Forest	0.1	0.3
Total	31.3	84.6

Table 2. Edaphic characteristics of soils present at Sand Prairie Park. Percentage clay and sand are shown for soil horizons in the solum. An (*) indicates a hydric (wetland) soil. Depth to water table is for its most shallow occurrence, when precipitation is highest.

Soil	Geomorphology	Parent Material	Depth of A Horizon	Clay	Sand	Drainage	Depth to Water Table	Native Vegetation
Coppock	treads and risers on stream terraces, foot slopes, and alluvial fans; slopes 0 to 5%	silty alluvium	20 cm	A: 15-25% E: 15-25% B: 18-38%	A: 5-15% E: 5-15% B: 2-15%	poorly drained	0 cm	Lowland/ Alluvial Forest
Dickinson	interfluves on dissected till plains and on stream terraces in river valleys; slopes 0 to 30%	glacial or alluvial sediments reworked by wind	30-50 cm	A: 7-18% B: 4-18%	A: 45-80% B: 45-95%	well drained	> 180 cm	Dry-Mesic Tallgrass Prairie
Sparta	treads and risers on stream terraces in river valleys, outwash terraces, outwash plains, and dune fields; slopes 0 to 40%	sandy outwash reworked by wind	17-45 cm	A: 1-10% B: 1-8%	A: 70-98% B: 80-95%	excessively drained	> 180 cm	Dry Oak Savanna
Sperry *	slight depressions on broad upland divides and on treads of loess covered stream terraces; slopes 0 to 2%	loess	25-31 cm	A: 18-30% E: 18-30% B: 32-48%	A: < 5% E: < 5% B: < 5%	very poorly and poorly drained	0 cm	Shallow Marsh
Tama	interfluves and side slopes on uplands and on treads and risers on stream terraces in river valleys; slopes 0 to 20%	loess	36 cm	A: 22-30% B: 24-35%	A: < 10% B: < 5%	well drained	> 180 cm	Mesic Tallgrass Prairie
Wiota	treads and risers on stream terraces; slopes 0 to 5%	alluvium	50-61 cm	A: 20-32% B: 30-35%	A: < 15% B: < 15%	moderately well drained	120 cm rarely flooded	Mesic Tallgrass Prairie

This first-hand picture of Iowa's native landscape compiled by 20 or more land surveyors, is accessible to the public in a visual format (Anderson 1997).

The GLO maps are most useful for obtaining a general picture of the native landscape at the scale of many square miles. Because of the method used to describe and map the vegetation, the resolution and detail are much less than can be obtained with soil maps. Still the importance of direct visual observation should not be understated. The GLO data indicate that land surveyors described the landscape where Sand Prairie Park now occurs as prairie (Figure 6). To the west in the Iowa River valley the vegetation was described as oak barrens, which was interpreted by Anderson (1997) as scattered trees and prairie (i.e., savanna).

Another historic picture of the native landscape is available and helpful. The "Illustrated Historical Atlas of the State of Iowa," published by A.T. Andreas in 1875, is a comprehensive historical document that presents detailed county maps, city plat maps, bird's eye views of towns, biographical sketches of prominent citizens, and historical information about Iowa. The county maps show section lines, roads, railroad tracks, ferries, streams and rivers, towns, rural school houses, wetlands and the occurrence of forest and woodland vegetation. It appears the mapping was done with more resolution than in the GLO data, which would be expected since the landscape was more accessible. Although prairie is not identified, the presence of forest/woodland ecosystems is illustrated. Therefore the absence of forest/woodland implies the presence of prairie or fields. It furnishes a first-hand account of the amount and location of forest/woodland in the decade prior to 1875. The Atlas indicates that the Sand Prairie Park was treeless (Figure 7).

The availability of water, light and nutrients are the most important abiotic factors affecting the plant species composition of natural communities. Disturbance and perturbation by animals are a part of the biotic environment that increases heterogeneity in the vegetation. However, in most Midwestern landscapes it is historical land use that is often the most relevant factor affecting the extant vegetation and ecosystems. While history cannot be changed, the negative effects of history can be corrected. It is a worthy endeavor to examine land use history to gain any insight that is possible about its role in the management of conservation areas. Figures 8 to 16 span a period of time from 1937 to 2016. None of the aerial photos, particularly the ones prior to 2000, suggest that tillage ever occurred on the park. It appears that land use during the last 70 years of the 20th century probably centered on grazing. The quarry operation that operated on the east end of the park is evident in the 1937 aerial photo (Figure 8),

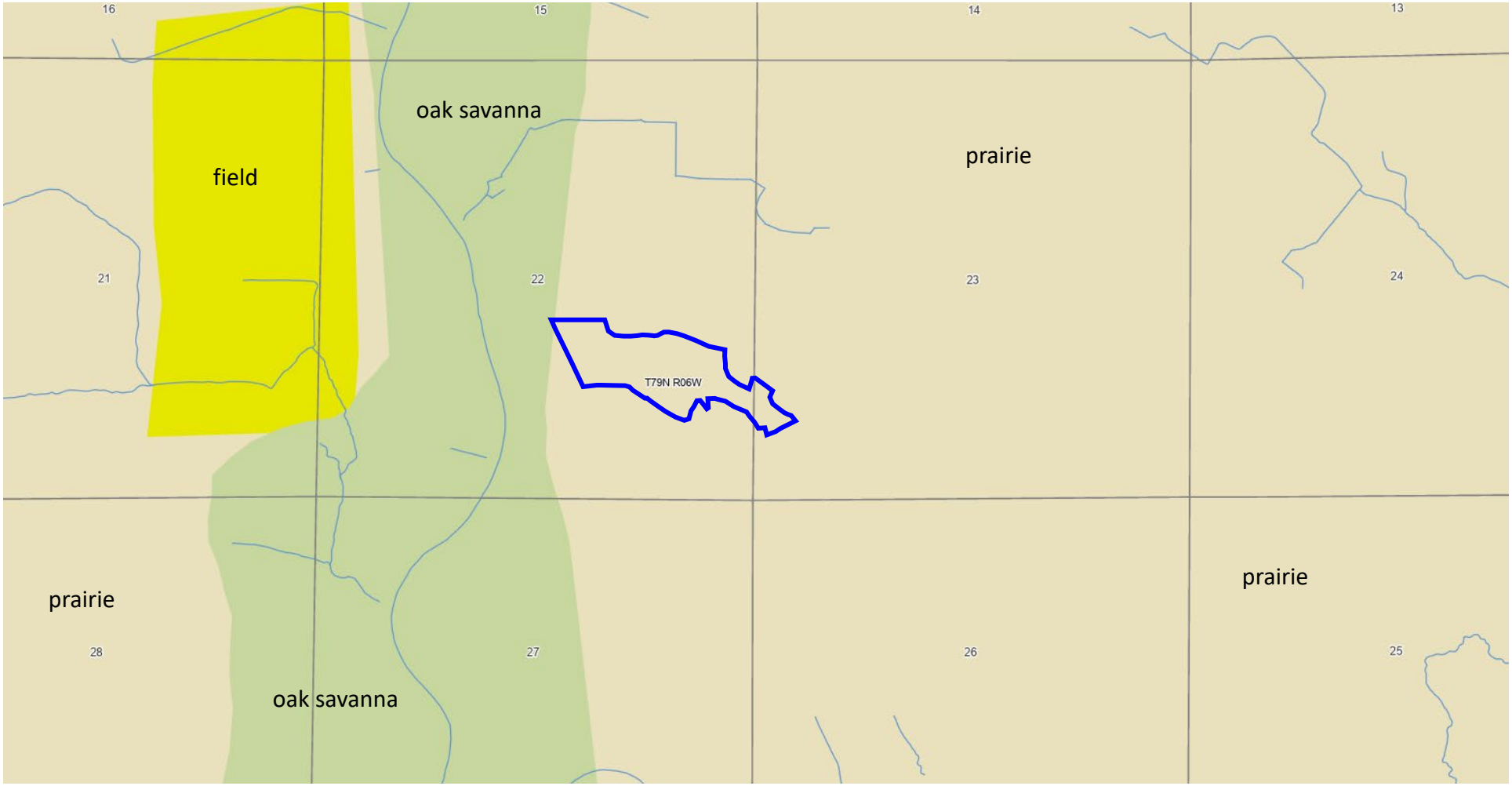


Figure 6. Sand Prairie Park (blue) on a GLO map of the historical vegetation. Section lines and numbers are shown

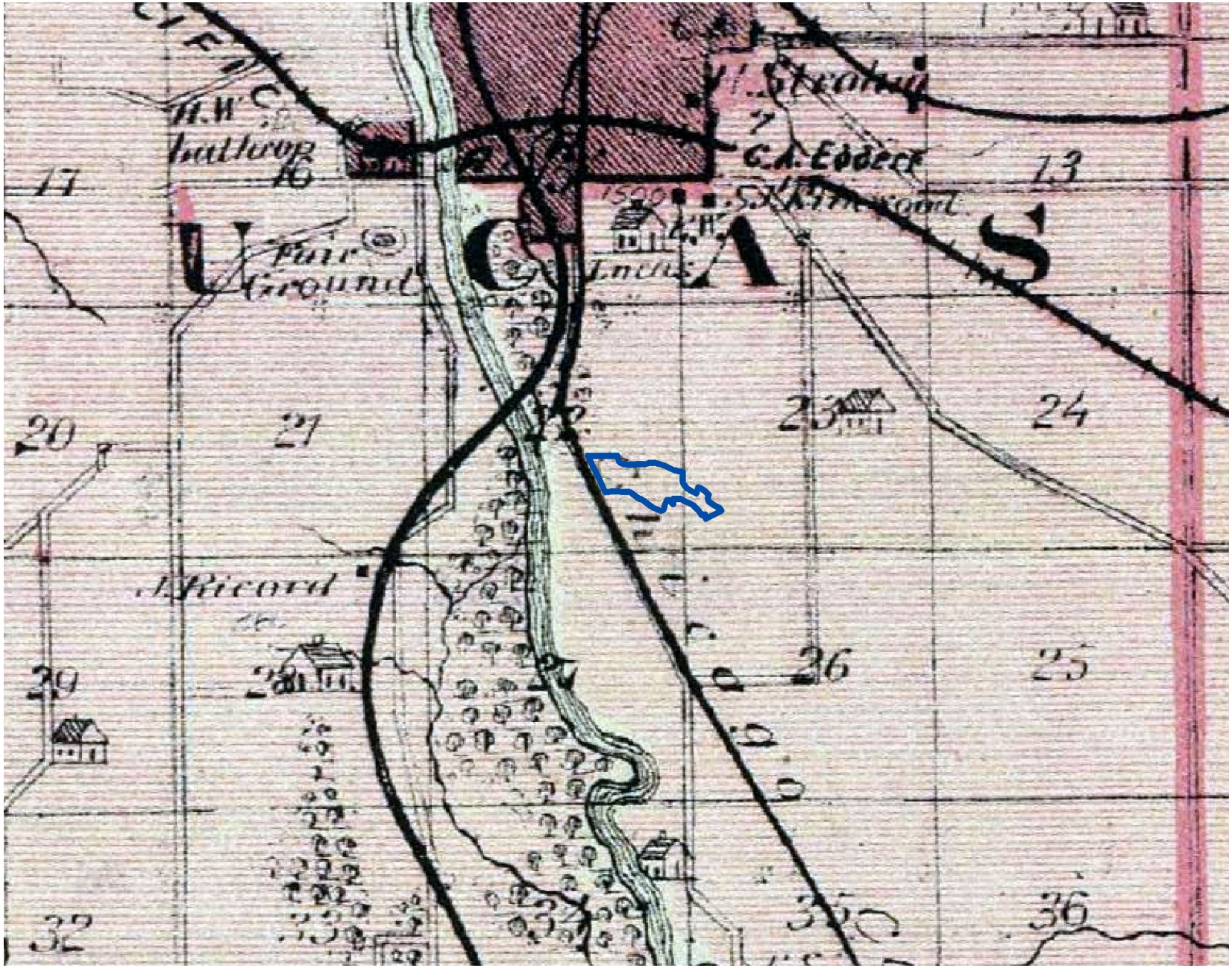


Figure 7. Sand Prairie Park (blue) on a map of Johnson County from the Andreas Atlas (1875).

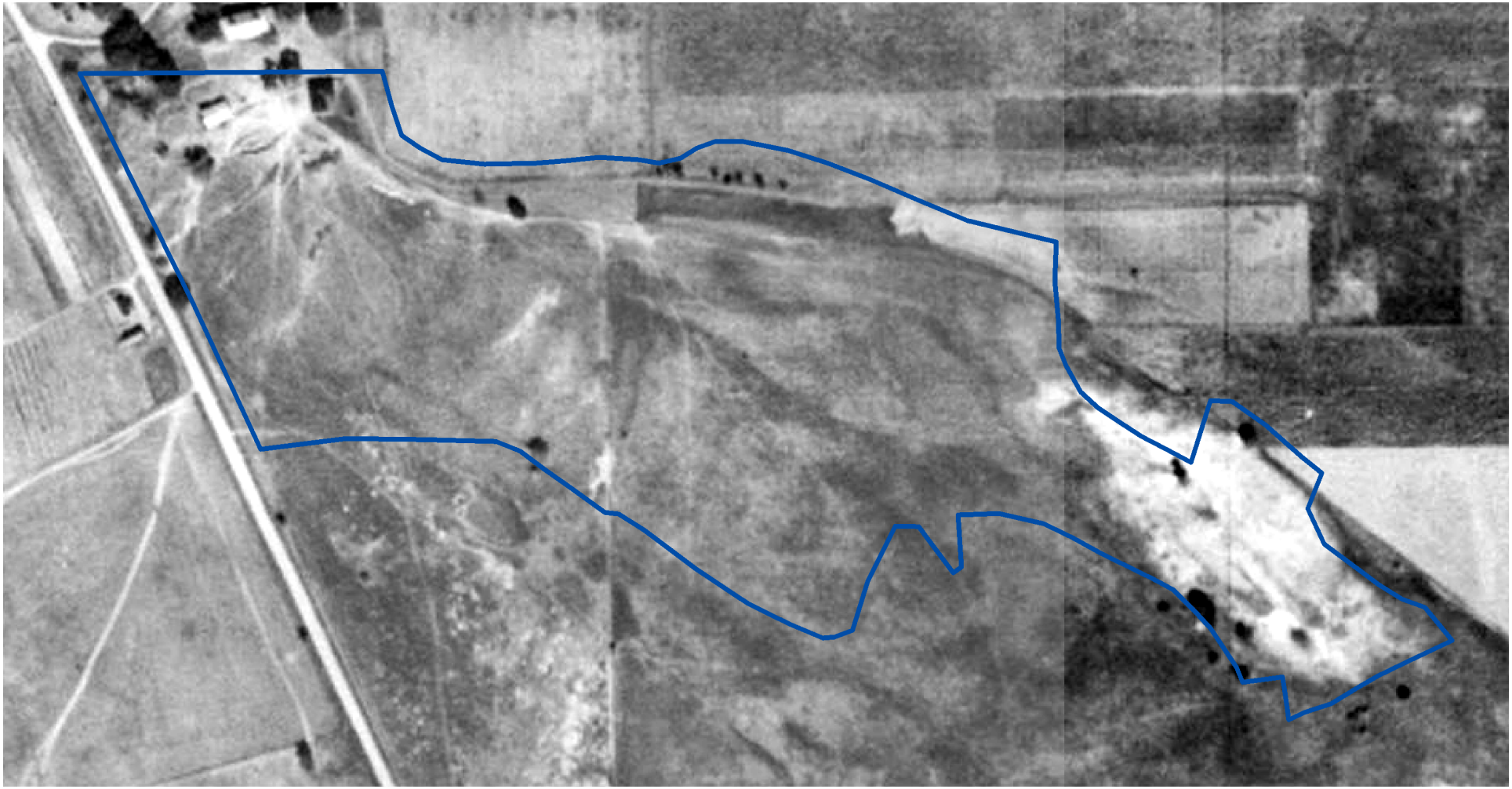


Figure 8. Sand Prairie Park (blue) on a black & white aerial photo taken on September 26, 1937 (Iowa Geographic Map Server).

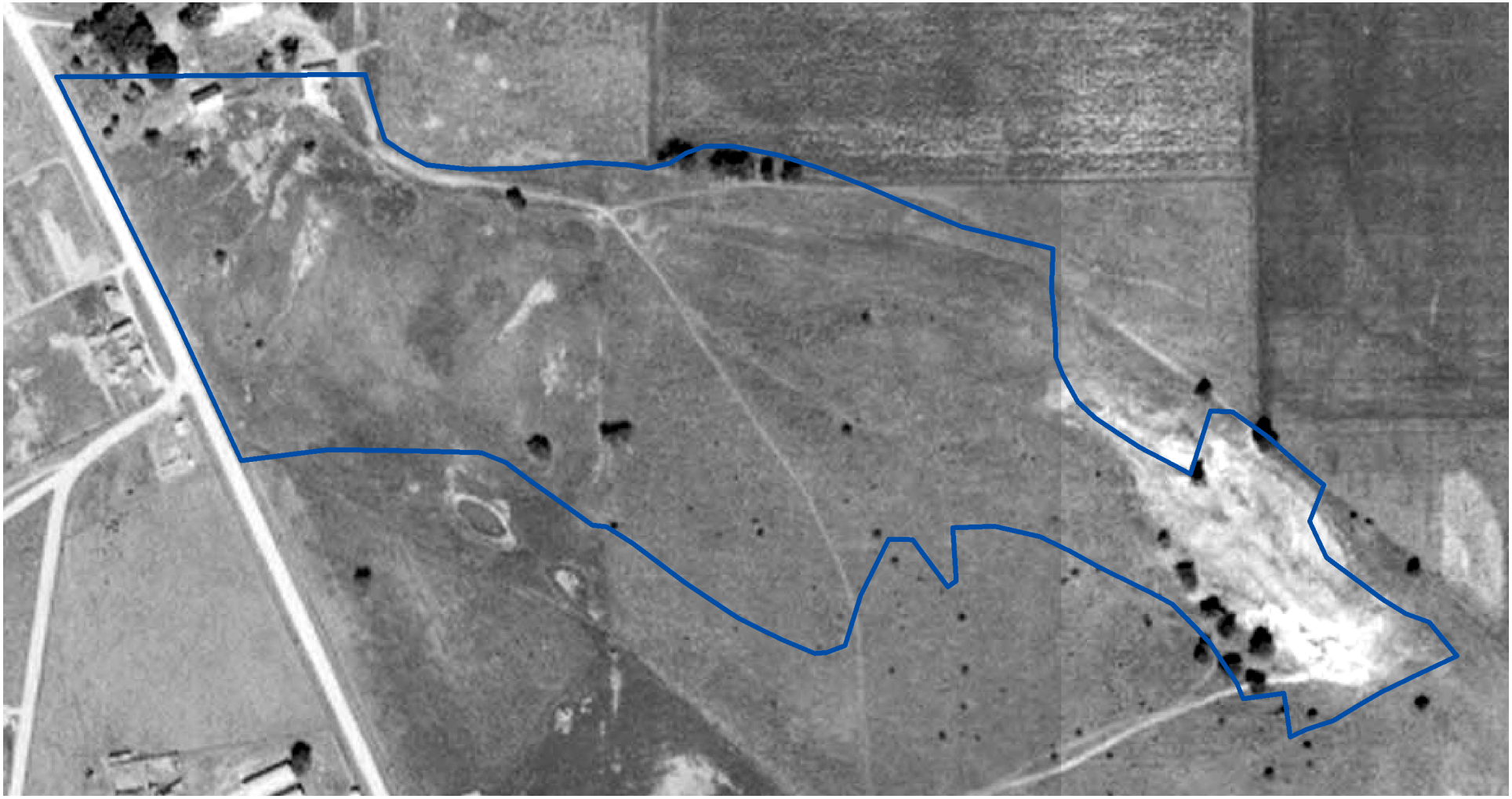


Figure 9. Sand Prairie Park (blue) on a black & white aerial photo taken on September 13, 1951 (Iowa Geographic Map Server).

Figure 10. Sand Prairie Park (blue) on a black & white aerial photo taken on July 11, 1963 (Iowa Geographic Map Server).

the earliest available aerial imagery for the site. But the extant wetland that occurs in that area (Figure 2) does not appear until the 1970 aerial photo (Figure 11). The wetland is an artifact of the quarry operation. Lon Drake (Professor Emeritus in Geology at the University of Iowa) suggested that sand removal in this area could have started as early as 1880 to provide fine, clean, dry sand to the Iowa City Flint Glass Company, which was located at Kirkwood Avenue and Maiden Lane, 1.4 miles north of the quarry area on the park. Continued excavation of sand eventually exposed the water table, perhaps with the intent of supplying livestock with water.

The color infrared aerial photo on April 24, 1983 (Figure 12) shows a water body that is larger than the extant wetland. It also shows the first evidence of substantial woody encroachment, mostly in the area that is currently forest. Additional insight revealed by the color infrared image is the amount and dominance of non-native grasses. Color infrared (CIR) images provide the ability to distinguish prairie remnants from non-native pasture grasses, especially if they are made in the spring. Green actively-growing vegetation strongly reflects infrared light, which is rendered with red color in CIR images. Plant litter, dormant plants, or less vigorous growth in vegetation is less reflective of infrared light, and will appear as muted shades of gray, white, pink, tan or light green. Cool-season, non-native pasture grasses green up in April, a month ahead of the native, warm-season grasses. Thus an image obtained in April can distinguish between vegetation dominated by non-native grasses (vibrant red) and prairie vegetation (white to grayish with minor touches of pink or light red). The 1983 CIR image (Figure 12) shows the site had a strong and dominating presence of cool-season pasture grasses (probably mostly smooth brome and Kentucky bluegrass). A decent prairie signature can be seen in some areas, mostly among the encroaching trees and shrubs. In the 1990 black and white aerial photo (Figure 13), it appears that some woody control and removal occurred in the south-central area (relative to 1983). A color infrared aerial photo on March 22, 2002 (Figure 14) shows the site 2 years before it became city property. The March date is too early to see good separation of non-native cool-season grass and native grasses. Nonetheless a uniform presence of non-native cool-season grass is shown across the entire property.

The land that is Sand Prairie Park was obtained by the City in 2004. The plant communities delineated in this study (Figure 17) are overlain on the 2002 image (Figure 14) to facilitate a comparison between its condition at the time of acquisition and now after 22 years of management by the City. About 40% of the south forest was more open with grassland (pasture-prairie) present in 2002. The west shrubland was already established. Portions of the west grassland and central grassland have less woody encroachment

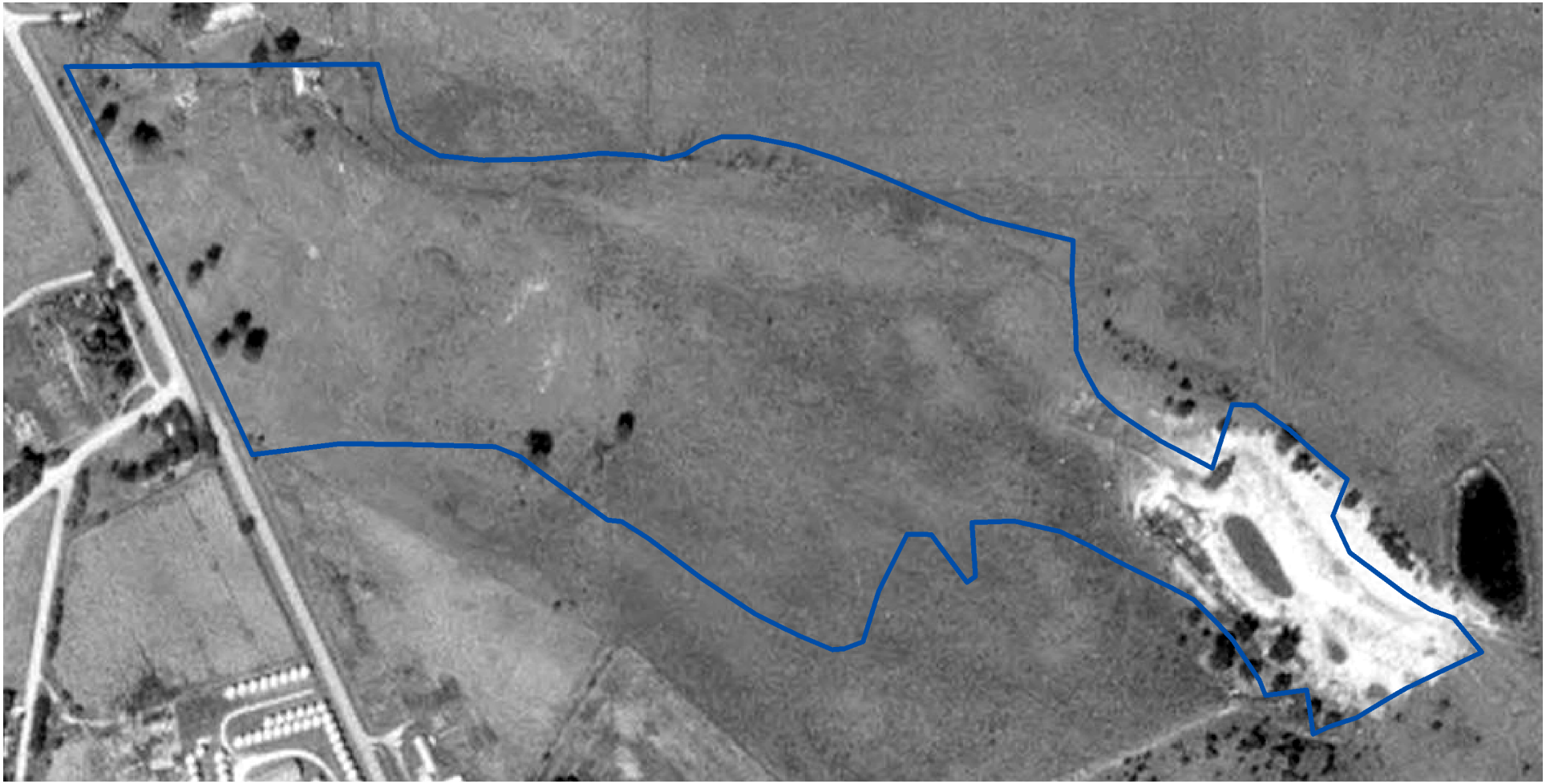


Figure 11. Sand Prairie Park (blue) on a black & white aerial photo taken on September 11, 1970 (Iowa Geographic Map Server).

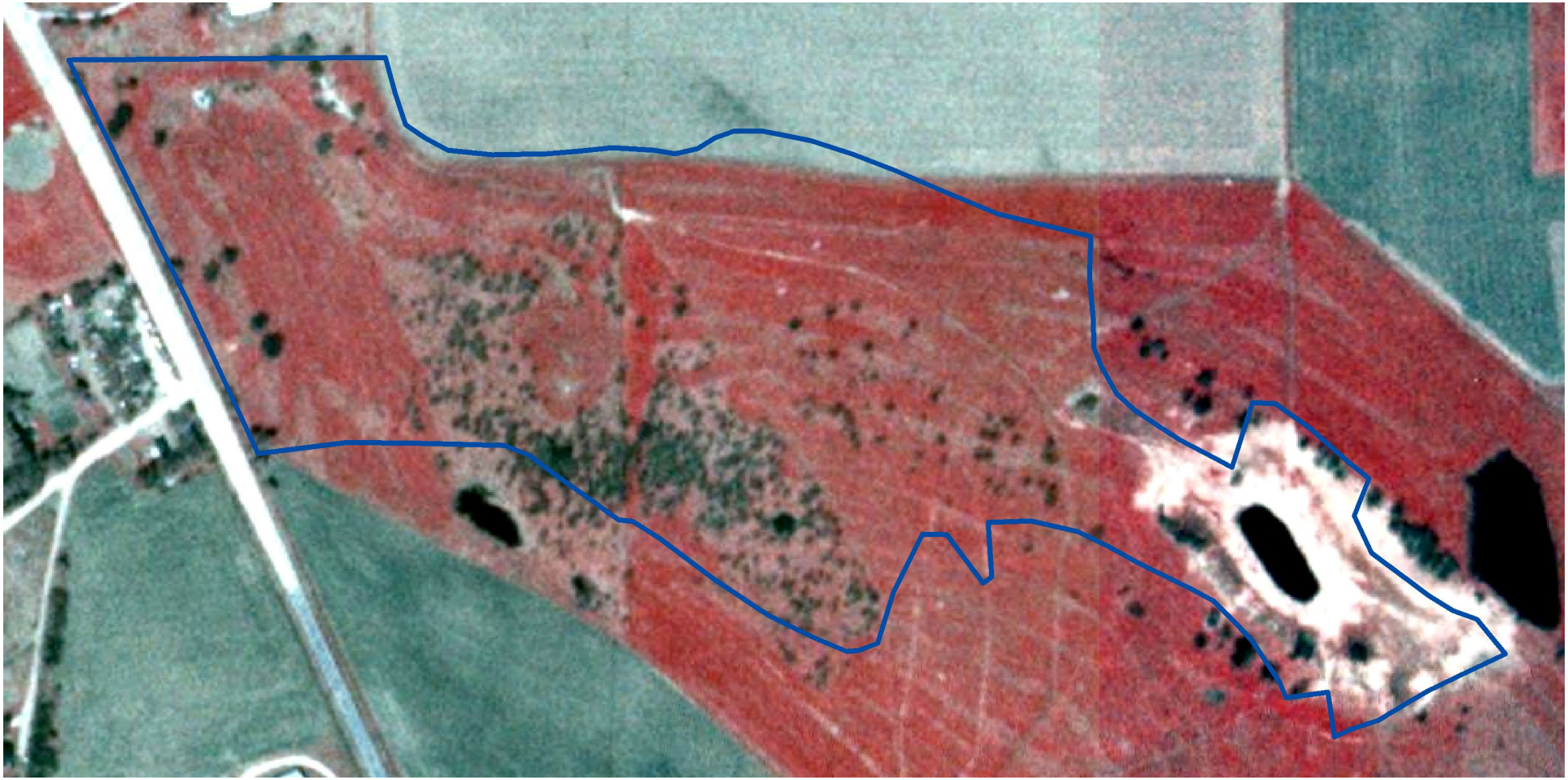


Figure 12. Sand Prairie Park (blue) on a color infrared aerial photo taken on April 24, 1983 (Iowa Geographic Map Server).

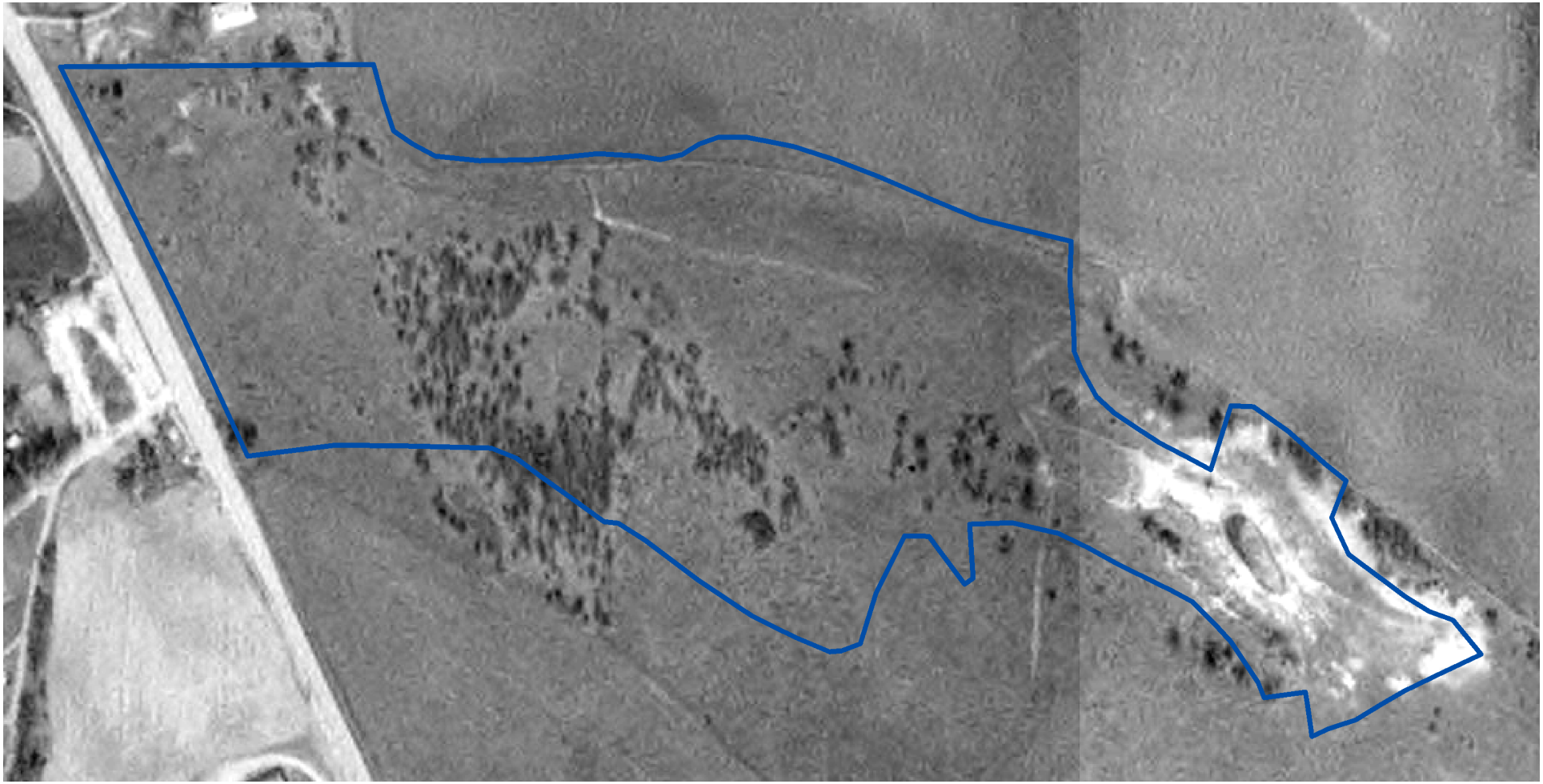


Figure 13. Sand Prairie Park (blue) on a black & white aerial photo taken on April 7, 1990 (Iowa Geographic Map Server).

Figure 14. Sand Prairie Park and extant community boundaries (yellow) on a color infrared aerial photo taken on March 22, 2002 (Iowa Geographic Map Server).

now than in 2002. The effort to protect this landscape and its biodiversity goes back at least 10 years prior to its acquisition by the City to the mid-1990s. A local group of conservation activists were aware of its remnant character and documented their observations of flora and fauna. Others were active in letter-writing to City officials. The group included Richard Rhodes, Judy Felder, Diana Horton, Lon Drake, Tim Thompson and Connie Mutel. Handwritten and typed pages, dated 1994, 2001 and 2002, identify the area as the Showers/McCollister tract and relate the observations of ornate box turtles and their burrows. Plant species observed include the grasses hairy grama, side-oats grama, sand dropseed, beadgrass, three-awn grass, little bluestem and a panic grass species. Also noted were the prairie species lead plant, prairie sage, sand puccoon, false boneset, wild hairy petunia, sweet everlasting, starry campion, narrow leaf mountain mint, bracted plantain, field pussytoes, western rock jasmine, woolly croton and western ragweed. Several in the group commented on the grazed (or overgrazed) condition of the site and that it appeared to have never been tilled. The pasture-prairie was 75 acres in 2002 (Figure 18). Only half of it was protected by the establishment of Sand Prairie Park.

A color infrared aerial photo taken on April 14, 2010 (Figure 15) highlights the heavy presence of non-native cool-season grasses throughout the entire park. The south forest has continued to fill in with trees. On a positive note, the west shrubland, clearly established in 2002, and the prairie units seem to be relatively free from woody encroachment. Six years later (Figure 16), an increase in woody encroachment is evident. However the area now occupied by the east woodland is more open and presumably supporting some prairie species.

A management plan for the Iowa City Sand Prairie was produced by Driftless Land Stewardship in 2005 or 2006 (there is no date on the report, but a plant list is dated May and June of 2005). The 38-page report mainly provides a description of the park, discusses its significance and probable native state, and identifies management threats. A significant part of the document covers management methods, including a management timeline. Several management options are proposed, including removal of tree and brush species, the use of herbicides, supplemental seeding, invasive species control, prescribed fire and timber harvest. Field work was done in 2005 that produced a plant list that includes 79 vascular plant species, of which 52 (65.8%) are native and 27 (34.2%) are non-native species.

In 2018, Applied Ecological Services from Prior Lake Minnesota submitted a document to the City of Iowa City entitled “Natural Areas Inventory and Management Plan.” Its 577 pages are an inclusive and wide-ranging narrative that addresses 42 parks and approximately 1,500 acres of conservation land. Key

Figure 15. Sand Prairie Park (blue) on a color infrared aerial photo taken on April 14, 2010 (Iowa Geographic Map Server).

Figure 16. Sand Prairie Park (blue) on a color infrared aerial taken on April 3, 2016 photo (Iowa Geographic Map Server).

components of the plan include 1) discussion of the principles of conservation biology, 2) an overview of ecological restoration and management, 3) high-resolution, multi-spectral aerial imagery, 4) natural areas inventory, including a field assessment of each park, 5) a Geographic Information System database, 6) review of STAR Community Goals, 7) review of related City policies and ordinances, and 8) short (less than 10 pages) 10-year management plans for 42 City-owned natural areas. Their vascular plant list identifies 89 species, including 56 (62.9%) native species and 33 (37.1%) non-native species.

Field Methods

Field research in 2024 was completed on April 11 and 21, May 10, June 15, July 5, August 5 and 12, September 3, and October 2. A total of 90 hours was invested in field surveys. Those surveys produced a total of 980 observations of plant species occurrence and abundance in a plant community. Another 14 hours were utilized to key and verify the identity of 192 plant specimens collected during field work. There were 9 plant communities delineated (Figure 17) that represent 8 different plant associations. An inventory of the vascular plants was completed for each plant association (i.e., a species list was compiled of all the vascular plants observed and an estimate of their abundance was made). Each plant community was inventoried multiple times over the growing season. The number of inventories per plant community ranged from 2 to 5, depending mostly on the size and complexity of the plant community. There were two Whittaker Plots established for intensive quantitative measurement of the plant species composition. These data provide insight on the effects of an herbicide application in April. They also provide a baseline measurement of the extant vegetation for future monitoring.

Floristic data were collected by hiking a wondering route to map the extant plant communities and observe vegetation. All vascular plants observed in the plant communities were recorded with a subjective estimate of the species' absolute frequency using these basic levels – sparse (< 10%), occasional (11-30%), frequent (31-60%) and very common (>60%) (Table 4). Frequency is a measure that is based on the spatial occurrence of individuals in the community; it is an index of a plant's population size. It was envisioned as the percentage of 100 50x50 cm quadrats randomly-located in the community that would contain one or more individuals of the species. Combinations of the basic levels were often used when the frequency of a species in the community varied spatially, for example occasional on half the area and frequent on the other half. The use of "locally" occurred when the frequency of a species was spatially variable but not in a symmetrical manner. Occasional to locally frequent means a species is occasional on most of the area, at least 75%, but is frequent in the rest of the area. The locally classes are often used when a species exhibits patches of clonal growth that result in

Figure 17. Nine ecosystem and plant survey units (yellow) representing 8 plant associations and two permanent plots (white) at Sand Prairie Park on a 2023 natural color aerial photo (Iowa Geographic Map Server). Ecosystem labels EWood = East Woodland and EWet = East Wetland. The red arrow indicates an area of unprotected sand prairie.

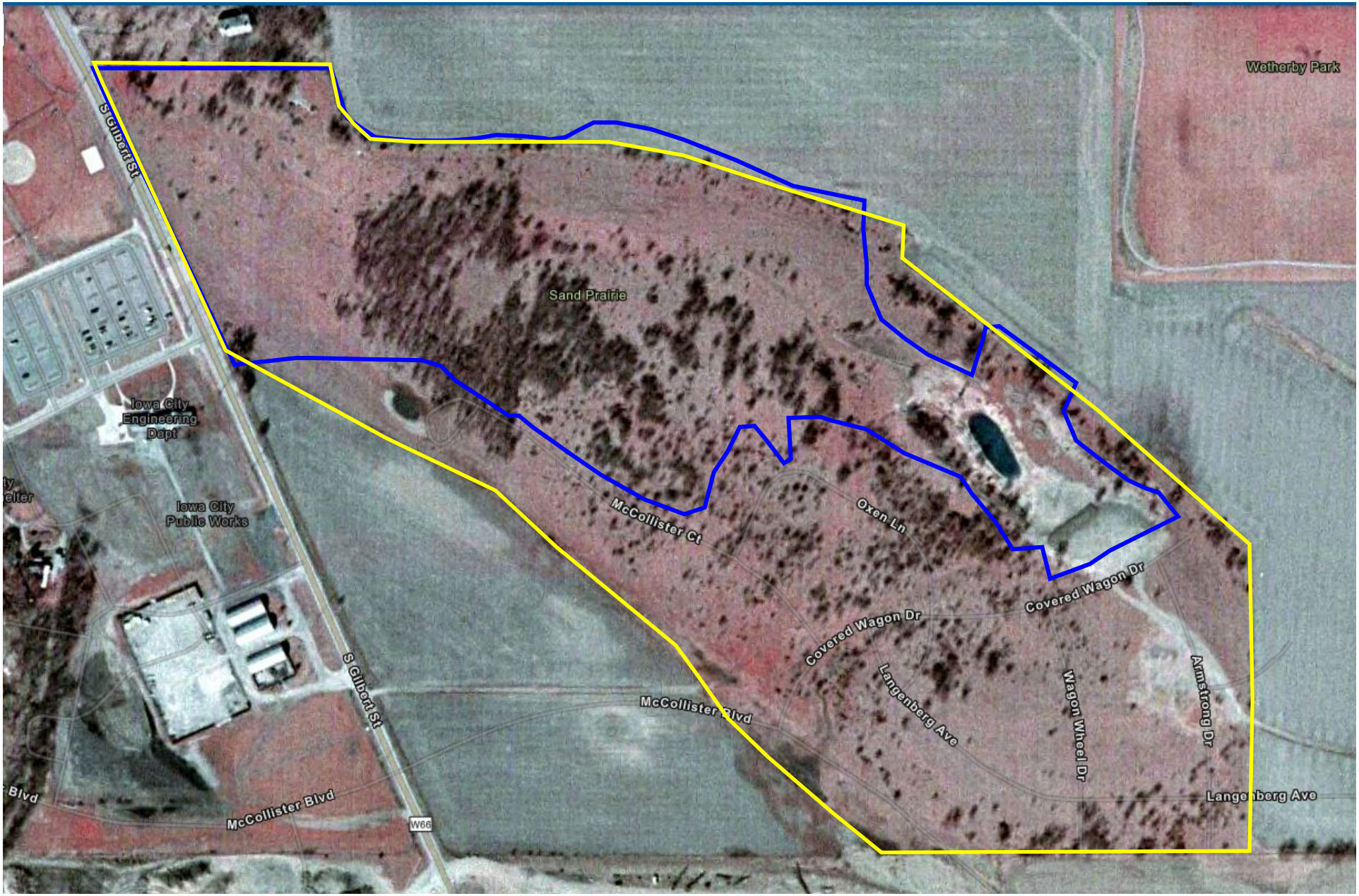


Figure 18. Sand Prairie Park (blue) and the pasture-prairie known as the Showers/McCollister tract (yellow) overlain on a color infrared aerial photo taken on March 22, 2002 (Iowa Geographic Map Server). The city streets present in 2025 are visible. About half of the pasture's 75 acres was protected by the establishment of the park.

Table 4. Numerical values of absolute frequency used for species abundance.

Frequency assigned in the field	Numerical absolute frequency %
Sparse (1-10%)	**5**
Sparse to Locally Occasional	10
Sparse/Occasional	13
Sparse to Locally Frequent	17
Occasional (11-30%)	**20**
Sparse/Occasional/Frequent	23
Sparse/Frequent	25
Sparse to Locally Very Common	28
Occasional to Locally Frequent	28
Occasional/Frequent	33
Sparse/Occasional/Very Common	35
Occasional to Locally Very Common	38
Sparse/Frequent/Very Common	43
Sparse/Very Common	43
Frequent (31-60%)	**45**
Occasional/Frequent/Very Common	48
Occasional/Very Common	50
Frequent to Locally Very Common	56
Frequent/Very Common	63
Very Common (61-100%)	**80**
Super Very Common	95

higher frequency than is generally present elsewhere. Table 4 also shows the numerical values of absolute frequency assigned to the classes used in the field.

In addition to frequency, a measure of the size/age distribution of individuals in the populations of woody species was made. Size/age categories included – seedling/sprouts (<50 cm height) which are considered to be a part of the herbaceous layer, shrubs (50 to 200 cm height), saplings (> 200 cm height and < 5 cm DBH) and trees (≥ 5 cm DBH, with DBH estimated to the nearest 5 cm). DBH is the diameter of a stem or trunk at breast height. An attempt was made to identify all of the size classes present for each woody species.

Species nomenclature is based on Eilers and Roosa (1994), but many taxonomic changes have occurred with the publication of the Flora of North America (1993). These changes are reflected in Appendix A where a list of all the species and taxa observed is available. Each species/taxon is assigned a number that is used in tables and will help locate species in the appendix. Appendix A also presents biological and ecological data for each species/taxon. Numerous photographs were made of the plant communities/ecosystems mapped and identified. They can be viewed in Appendix B.

Whittaker Plot Methods

The goal of the floristic inventory is to map the extant plant communities and associations in the park and to find and estimate the abundance of all vascular plant species present in each community. Another goal of this research was to ascertain the effect of an early growing season (April) application of herbicide to control non-native grasses. This work requires that a highly quantitative measurement of plant species abundance be made. A standard procedure I have developed to do this is with the establishment of a Whittaker plot. Named for Robert Whittaker, one of the most productive and eminent plant ecologists of the twentieth century, a Whittaker plot measures 20 x 50 m (0.1 ha). The details of how it is used varies among plant ecologists and the goals of the research. My Whittaker plots utilize a 10 x 30 m nested subplot located in the center (Figure 19). The 20 x 50 m area is only used to sample trees with a DBH (diameter at breast height) of 5 cm or more. The 10 x 30 m subplot is used to measure all other plants, meaning all the herbaceous species and all woody plants less than 5 cm DBH (saplings, shrubs, and seedling/sprouts). Thus in grasslands such as at Sand Prairie Park, where there are no trees, only the 10 x 30 m plot needs to be established. A nested plot design is used to accommodate the range in the size and spatial scale of vascular plant species. Four classes of woody plants are designated:

1) Trees – woody stems greater than or equal to 5 cm DBH. Tree identity, density and basal area (DBH) are recorded in the 20x50 m plot (Figure 19)

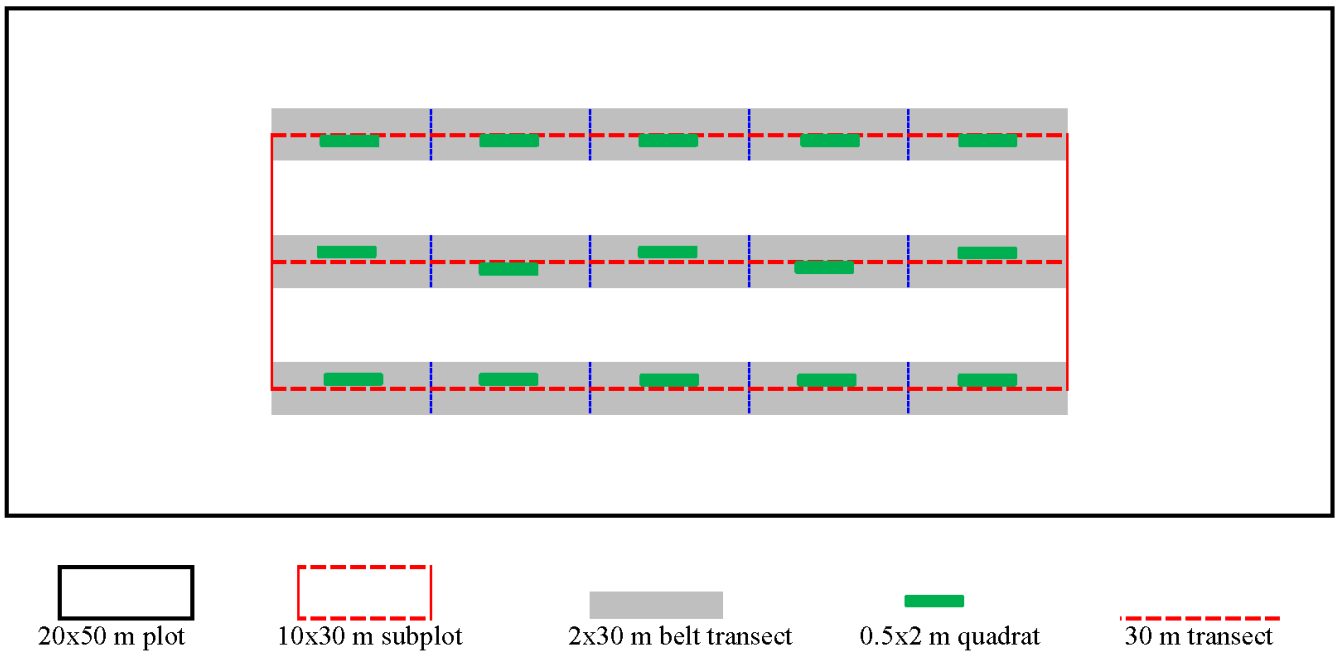


Figure 19. Nested plot design for measurement of plant species composition. The 20x50 m plot is the basis for a community sample and is called a Whittaker plot.

2) Saplings – woody stems 200 cm or more in height and less than 5 cm DBH. All saplings, living and dead, are identified and their density measured in the 10x30 m plot (Figure 19).
3) Shrubs – woody stems 50 to 200 cm in height. The identity and density of living shrub stems are measured in three 2x30 m belt transects (Figure 19).
4) Seedling/sprouts – woody stems less than 50 cm in height. Seedling/sprouts are included as a component of the herbaceous layer. Their frequency and density are measured in 50x200 cm quadrats (Figures 19 and 20).

The vascular plants present in the herbaceous layer are observed in 15 50x200 cm quadrats (Figure 20) located within the three belt transects (Figure 19). The absolute frequency of all herbaceous plant species, and the woody plants present as seedling/sprouts, is measured by recording the subquadrat where each species in the 50x200 cm quadrat is first observed starting with the smallest (subquadrat A, 12.5x12.5 cm) and progressing to the largest (quadrat G, 50x200 cm). Those species with higher numbers of ramets or genets present are more likely to be first encountered in the smaller subquadrats. The presence of species in a subquadrat (+1) is weighted (multiplied) by the scalar values in Table 5. The 15 50x200 cm quadrats provide a total area of 15 m^2 for the measurement of species abundance. A species' absolute frequency is given as a percentage (i.e., the measured frequency/the potential maximum frequency). It is a measurement with high resolution and accuracy. It conveys how often individuals of a species occur in the space of the plant community and therefore it is correlated with population size. In order to obtain a complete list of the plant species present in the community, the10x30 m subplot is searched for any new species not recorded in the 50x200 cm quadrats. These

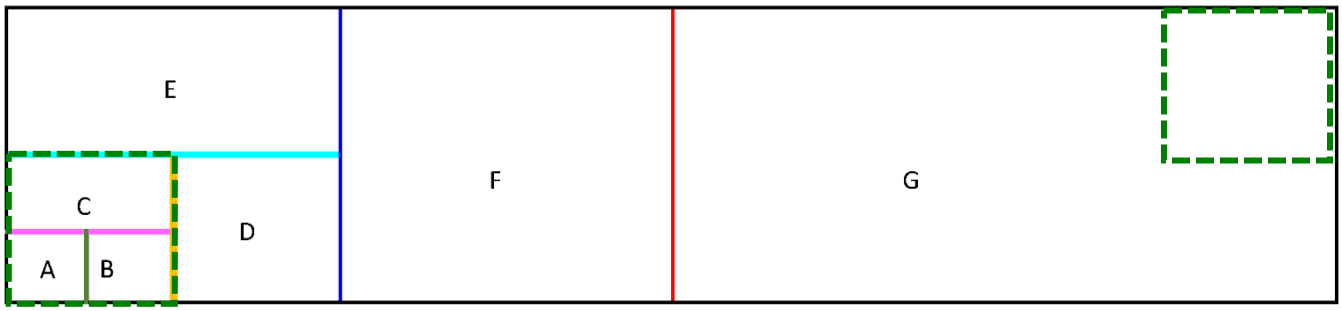


Figure 20. The 50x200 cm quadrat with nested subquadrats. Weighted frequency is measured in subquadrats A to G. Density of ramets is measured in the two 25x25 cm subquadrats (dashed green line).

Table 5. Subquadrat sizes, their areas, and the weight factor used for measurements of weighted frequency in the 50 x 200 cm quadrats.

Subquadrat Size (cm)	Area (cm2)	Weighted Frequency
A - 12.5x12.5	156.25	10
B - 12.5x25	312.5	8.5
C - 25x25	625	7
D - 25x50	1,250	5.5
E - 50x50	2,500	4
F - 50x100	5,000	2.5
G - 50x200	10,000	1

species are assigned a frequency of 0.5, which is one-half of the weighted frequency a species receives if it was observed in the 50x200 cm quadrats with the most minimal value possible, which is a single observation in the G quadrat of 1 of the 15 50x200 cm quadrats. Below are examples of the calculation of absolute frequency for 3 hypothetical species observed in the 10x30 m subplot. There are 15 measurements, one for each 50x200 cm quadrat. An "n" means not present. The sum of a species' weighted frequencies is divided by the maximum potential weighted frequency possible, which is 15 x 10 = 150. This proportion is converted to a percentage.

Species	subquadrats where first observed	weighted frequencies	absolute frequency
X	C, A, G, A, F, n, C, n, n, D, E, G, n, n, F	7,10,1,10,2.5,0,7,0,0,5.5,4,1,0,0,2.5	50.5/150 = 33.7%
Y	B, D, n, E, G, A, A, B, C, D, B, A, n, C, G	8.5,5.5,0,4,1,10,10,8.5,7,5.5,8.5,10,0,7,1	86.5/150 = 57.7%
Z	n, n, n, n, n, n, n, n, n, n, n, n, n, n, n	0.5 assigned	0.5/150 = 0.33%

All herbaceous plants and woody species in the seedling/sprout size class that are present in the 10x30 m subplot have a measurement of absolute frequency (%). The density of herbaceous layer species is also measured in each of the 15 50x200 cm quadrats. The number of ramets and tillers in two 25x25 cm subquadrats is determined (Figure 20). A total area of 1.875 m^2 is sampled for density (15 quadrats x 2 subquadrats x 0.25 m x 0.25 m). Plant species density is only available for a subset of the species present in the herbaceous layer, for those that are among the most common species. It is the most common species that provide the best assessment of treatment effects and density provides the most resolution and accuracy in assessing those effects. Density is given as the number of ramets per square meter.

This research was prompted by the decision by park staff to treat about 8 acres of the central grassland with a grass herbicide in April 2024. It was known from the work by Driftless Land Stewardship and

Applied Ecological Services that control and reduction of non-native forage grasses was a top priority for the prairie. An herbicide application of Clethodim was made on April 10, 2024. About 300 emerging panic grass plants (*Dichanthelium* sp.) were protected from the herbicide by covering them with styrofoam or paper bowls.

Two Whittaker plots (just the 10 x 30 m subplot) were established in the central grassland community (Figure 17), one on April 11 and the second on April 21, 2024. The vegetation was measured at two different times during the growing season in 2024. The first measurements were made on April 11 and 21, the second measurements were completed on August 5 and 12, 2024. The April data was collected to serve as a baseline condition of the vegetation prior to the herbicide treatment (i.e., pre-treatment). Those data were in fact collected a few days after the herbicide application, but Clethodim effects are not expected for at least a week or more after application. In an ideal situation and experimental design, the baseline data would have been collected during the summer of 2023, the growing season before herbicide application. The August data serve as the post-treatment data. In addition to providing insight on the outcomes of the Clethodim application, the Whittaker plots establish a baseline for the purpose of monitoring the vegetation over time.

Vegetation and Community Variables

A key goal in this research is to gain a science-based understanding of the current state of the extant ecosystems at Sand Prairie Park and their conservation value. Many variables were calculated from the plant species data to provide a quantitative assessment of vegetation quality in the eight plant communities observed. These variables are described in this section.

RICHNESS – These variables a convey a measure based on a count of the number of plant species present. There are 25 variables in this group.

1, 2 and 3) *Native, Non-native, and Total Forbs* – The number of species in each group. Forb means the plant species is herbaceous with generally broad, net-veined leaves and showy insect-pollinated flowers. All forbs, regardless of their lifespan, are included. In this study there are three prairie shrub or suffrutescent species that are included with the forbs because they are desirable members of prairie communities and function similarly to forbs. These species are lead plant (*Amorpha canescens*), prairie rose (*Rosa arkansana*) and pasture rose (*Rosa carolina*). Native means indigenous to Johnson County, non-native species are not indigenous to Johnson County. Non-native species may be either native to other counties of Iowa, native to other parts of North America but not Iowa, or not native to North America.

4, 5, and 6) *Native, Non-native, and Total Graminoids* – The number of species in each group. Graminoid means the species is herbaceous and grass-like, with linear, parallel veined leaves and small inconspicuous wind-pollinated flowers. All graminoids, regardless of their lifespan, are included. For this study, graminoid means any species in the grass family (Poaceae), the sedge family (Cyperaceae), and the rush family (Juncaceae).

7, 8, and 9) *Native, Non-native, and Total Woody* – The number of species in each group. Woody means the species is perennial and exhibits secondary growth and the formation of wood. Shrub, liana and tree growth forms are included.

10, 11 and 12) *Total Native, Total Non-native, and Total Species* – The number of species in each group.

13 and 14) *Native Ruderal Forbs, Non-native Ruderal Forbs* – The number of species in each group. Native, non-native, and forb are defined above. Ruderal is defined by the species exhibiting either an annual or biennial lifespan (i.e., less than two years). If the species is known to also exhibit a perennial lifespan it is excluded.

15 and 16) *Native Ruderal Graminoids, Non-native Ruderal Graminoids* – The number of species in each group. Native, non-native, and graminoid are defined above Ruderal is defined the same as above for forbs. Ruderal species are usually favored by disturbance and early successional habitats.

17) *Native High Conservative* – The number of species with an Iowa Coefficient of Conservatism (ICC) equal to 7 or higher. Only native species have a positive coefficient.

18) *Native High Conservative Relative Percentage* – The percentage of species with an Iowa Coefficient of Conservatism (ICC) equal to 7 or higher relative to the total number of native species.

19) *Native Low Conservative* – The number of species with an ICC equal to 1 or 2; only native species have a positive coefficient.

20) *Native Low Conservative Relative Percentage* – The percentage of species with an Iowa Coefficient of Conservatism (ICC) equal to 1, 2 or 3 relative to the total number of native species.

The Iowa Coefficients of Conservatism (ICC) is a measure of a plant species' conservatism. First developed by Swink and Wilhelm (1979), plant conservatism provides an analytical tool to assess habitat quality. Because plant species life history strategies represent a gradient of species response to environmental disturbance, plant species can be assigned a coefficient (from 1 to 10) that reflects the strategy the species has evolved. Those that allocate energy to reproduction, seed and fruit dispersal, and quick colonization do well in early successional, disturbed habitats and therefore are not conservative in their habitat affinities. These species have a low coefficient in the range of 1 to 3 and are species that

thrive in habitats characterized by anthropogenic disturbance. Those that allocate energy to competition, maintenance, and coping with stress, are able to flourish in late successional, more pristine habitats. These are highly conservative species which are assigned a coefficient in the range of 7 to 10. Highly conservative species require pristine habitats and are rarely if ever observed in anthropogenic environments.

Habitat assessment and comparison can be achieved by compiling a list of the plant species present and averaging their Coefficients of Conservatism. When species abundance data are collected (as in this study), a more accurate mean can be obtained by using abundance to weight the mean CC. Many states have developed their own state-specific CC that are based on the behavior the species exhibits in their region. The ICC utilized in this study are those recently provided in a revision completed by the Flora of Iowa Working Group, a team of seven botanists with extensive botanical field experience in Iowa. The original ICC were developed by Drobney et al. (2000). This study incorporated a modification that is not utilized as a standard method in the application of plant conservatism. Non-native species were assigned an ICC equal to -1 to -3, depending on their invasiveness. Therefore, the mean conservatism for all species in a community is decreased by an amount that is determined by the number of exotic species and their invasiveness. In this way the potential for non-native species to degrade the plant community is reflected. While conservatism and rarity are generally positively correlated, it's important to keep in mind that they are not the same thing. Conservatism is not a measure of rarity.

21) *Native/Non-native Richness Index* – The ratio of total native to total non-native species.

$$\text{Native Richness Index} = \frac{(\text{total native richnes})}{(\text{total exotic richness})}$$

If total non-native richness is 0, then the index is estimated by adding 1 to both numerator and denominator. A native richness index of 1 means that native and non-native richness are equal. Values less than 1 are indicative of lower quality, as non-native species outnumber native species. As the index increases above 1, the biological quality of the community increases due to native richness increasing more quickly than non-native richness. The index represents the number of native species present for each non-native species present. It serves as a quick and simple measure of vegetation quality.

22) *Native Forb/Graminoid Richness Index* – The ratio of native forb richness to native graminoid richness.

$$\text{Native Forb/Graminoid Richness Index} = \frac{(\text{total native forb richness})}{(\text{total native graminod richness})}$$

In most natural communities the number of native forbs outnumber the number of native graminoids, thus this index is usually greater than 1. The index represents the number of native forb species present for each native graminoid species present. It characterizes the nature and structure of the herbaceous layer. Indices above 1 indicate a more forb-dominated herb layer, values less than 1 indicate a more grass or graminoid-dominated herb layer.

23) *Herbaceous Ruderal Richness Relative Percentage* – This variable answers the question, what percentage of the herbaceous species present are ruderal in their life history, or in other words function as either annual or biennial species? It is the sum of variables 13, 14, 15 and 16 (total ruderal herb species) divided by the sum of variables 3 and 6 (total of all herb species). The higher the percentage, the more disturbance is implicated in the environment.

24) *Conservatism Successional Index* – The ratio of variable 17 (high conservatism richness) to variable 19 (low conservatism richness). This index gives the number of high conservative species present for each low conservative species. As succession proceeds from early to late successional stages, the number of low conservative species should decrease and the number of high conservative species should increase. The higher this index is, the greater the evidence that the community is further along the successional gradient towards a late successional stage.

25) *Overall Weighted Disturbance Index* – An index that combines 3 indicators of disturbance – ruderal species richness, low conservative richness, and non-native richness. It is weighted by the amount of duplicity in those species. A species that is both ruderal and low conservative is counted twice. Likewise a non-native species that is also ruderal is counted twice. It is the sum of variables 11, 13-16, and 19 divided by variable 12 (total richness) and multiplied by 100. Therefore it is expressed on a scale of 0 to approximately 100.

$$\textit{Overall Weighted Disturbance Index} = \frac{(S_{NN}+S_R+S_{LC})}{S_T} \times 100$$

Where S_{NN} = non-native richness; S_R = ruderal richness; S_{LC} = low conservative richness; and S_T = total richness

FREQUENCY – These variables utilize the measurement of species abundance in the community to convey information about growth, productivity and population sizes. There are 20 variables in this group. Keep in mind that frequency is a measure of the spatial occurrence of the individuals in a population. While it is correlated with the density of individuals and a species' productivity, the presence of individuals in a quadrat, which is the basis of the measurement of frequency, does not distinguish between a presence of 1 or 1,000 individuals. Since abundance is measured as absolute

frequency (the percentage of quadrats observed where a species is present), the sum of frequencies for a group of species can exceed 100%.

26, 27, and 28) *Native Forbs, Non-native Forbs, and Total Forbs* – Forb, native, and non-native are defined in the description for variables 1, 2 and 3. The sum of absolute frequencies for the species present in the community for each group.

29, 30, and 31) *Native Graminoids, Non-native Graminoids, and Total Graminoids* – Graminoid is defined for variables 4, 5, and 6. The sum of absolute frequencies for the species present in the community for each group.

32, 33, and 34) *Native Woody, Non-native Woody, and Total Woody* – Woody is defined for variables 7, 8, and 9. The sum of frequencies for the species present in the community for each group.

35, 36, and 37) *Total Native, Total Non-native, Total Species Frequency* – The sum of frequencies for all the species present in the community for each group.

38 and 39) *Ruderal Forbs and Ruderal Graminoids* – Ruderal is defined for variables 13 and 14. The sum of frequencies for the species present in the community for each group.

40) *Native/Non-native Frequency Index* – The ratio of total native abundance to total non-native abundance.

$$\text{Native/Non-native Frequency Index} = \frac{(\text{total native frequency})}{(\text{total non-native frequency})}$$

Similar to the native/non-native richness index (variable 21), this index expresses how much more or less native plant abundance there is compared to the non-native plant abundance. For example, an index of 5 means that the abundance of native vegetation is 5 times greater than the abundance of the non-native vegetation. An index of 0.6 means that non-native abundance is 1.67 times greater than native abundance.

41) *Native Forb/Graminoid Frequency Index* – The ratio of total native forb abundance to total native graminoid abundance.

$$\text{Native Forb/Native Graminoid Frequency Index} = \frac{(\text{total native forb frequency})}{(\text{total native graminoid frequency})}$$

Similar to the native forb/graminoid richness index (variable 22), this index expresses how much more or less native forb plant abundance there is compared to native graminoid plant abundance. While it is true that forb species typically outnumber graminoid species in natural communities, making the native forb/graminoid richness index greater than 1, the total abundance of forbs may not be greater than the total abundance of graminoids due to the strong capacity for clonal growth in graminoids. An index of 3.0 means that the abundance of native forbs is 3 times greater than the abundance of native graminoids. An index of 0.33 means that native graminoid abundance is 3 times greater than native forb abundance.

42) *Non-native Forb Relative Frequency Percentage* – The total frequency of all non-native forbs relative to the total frequency of all forb species. It answers the question how much of the total forb abundance is due to non-native forbs?

43) *Non-native Graminoid Relative Frequency Percentage* – The total frequency of all non-native graminoids relative to the total frequency of all graminoid species. It answers the question how much of the total graminoid abundance is due to non-native graminoids?

44) *Herbaceous Ruderal Relative Frequency Percentage*– The sum of abundances for all ruderal herbaceous species (variables 36 and 37) relative to the sum of abundances for all herbaceous species (variables 26 and 29). This variable answers the question, what percentage of the herbaceous vegetation is represented by ruderal species, or species that exhibit either annual or biennial growth.

45) *Total Woody Relative Frequency Pct* – The total abundance of all woody species relative to the total abundance of all species. It answers the question how much of the total vegetation is due to woody species.

CONSERVATISM – These variables convey measures of vegetation quality based on quantitative measures of conservatism. There are 11 variables in this group.

46) *Native Forb Mean Conservatism* – The average conservatism for all native forbs and prairie shrubs present.

47) *Native Graminoid Mean Conservatism* – The average conservatism for all native graminoids present.

48) *Native Woody Mean Conservatism* – The average conservatism for all native woody species present.

49) *Native Herbaceous Weighted Mean Conservatism* – The average conservatism for all native herbaceous species present weighted by their frequency (abundance). Weighting is used to make the mean conservatism more reflective of the abundance of species. As a species abundance increases, its ICC has a greater effect on the weighted mean conservatism.

$$\text{Native Herbaceous Weighted Mean Conservatism} = \frac{\sum_1^S (\text{CC}_i \times \text{F}_i)}{\sum_1^S \text{F}_i}$$

where CC_i = coefficient of conservatism for native herbaceous species *i*, F_i = frequency of native herbaceous species *i*, S = total native herbaceous species richness

50) *All Herbaceous Weighted Mean Conservatism* – The average conservatism for all herbaceous species (native and non-native) present weighted by their frequency (abundance).

$$\text{All Herbaceous Weighted Mean Conservatism} = \frac{\sum_1^S (\text{CC}_i \times \text{F}_i)}{\sum_1^S \text{F}_i}$$

where CC_i = coefficient of conservatism for herbaceous species *i*, F_i = frequency of herbaceous species *i*, S = total herbaceous species richness

51) *Native Woody Weighted Mean Conservatism* – The average conservatism for all native woody species present weighted by their frequency (abundance).

$$\text{Native Woody Weighted Mean Conservatism} = \frac{\sum_1^S (CC_i \times F_i)}{\sum_1^S F_i}$$

where CC_i = coefficient of conservatism for native woody species *i*, F_i = frequency of native woody species *i*, S = total native woody species richness

52) *All Woody Weighted Mean Conservatism* – The average conservatism for all woody species (native and non-native) present weighted by their frequency (abundance).

$$\text{All Woody Weighted Mean Conservatism} = \frac{\sum_1^S (CC_i \times F_i)}{\sum_1^S F_i}$$

where CC_i = coefficient of conservatism for woody species *i*, F_i = frequency of woody species *i*, S = total woody species richness

53) *Exotic Herbaceous Negativity Index* – An index that reflects the negative impact exotic herbaceous species have on the plant community. It is the difference of (variable 47 minus variable 48) multiplied by the square root of total herbaceous exotic richness (the sum of variables 2 and 5).

Exotic Herb Negativity Index =

$$(Nat\ Herb\ WM\ Cons - All\ Herb\ WM\ Cons) * \sqrt{Total\ Exotic\ Herb\ Rich}$$

If there are no exotic species, then the difference between variables 43 and 44 is 0, and the index is 0 meaning there is no negative effect. The greater the number and invasiveness of exotic species, the greater the difference between variables 43 and 44. This difference is weighted by the square root of the number of exotic herbaceous species present.

54) *Exotic Woody Negativity Index* – An index that reflects the negative impact exotic woody species have on the plant community. The difference between (variable 45 minus variable 46) multiplied by the square root of the exotic woody richness (variable 8).

Exotic Woody Negativity Index = $(Nat\ Wood\ WM\ Cons - All\ Wood\ WM\ Cons) * \sqrt{Exotic\ Wood\ Rich}$

A comparison of exotic herbaceous and exotic woody negativity indices will reveal which group, the herbaceous exotic or the woody exotic species, is a greater problem in the community.

55) *FQI Native Species* – The Floristic Quality Index (FQI) determined by only the presence of native species. The mean conservatism for all the species native to Johnson County that are present is multiplied by the square root of the total native richness.

$$\text{FQI Native Species} = \frac{\sum_1^S CC_i}{S} \times \sqrt{S}$$

where CC_i = coefficient of conservatism for native species *i*, S = native species richness

The FQI Native Species is not weighted by frequency, thus each species' conservatism carries the same weight (equal to 1). By including only native species and not weighting the mean, it is only affected by the conservatism of the native plants that have persisted. It's purely based on those native species; their population sizes do not matter. FQI Native Species is a measure of the residual and potential quality of remnant native ecosystems. An FQI of 35 can be considered indicative of moderately high quality.

56) *Weighted FQI All Species* – The Floristic Quality Index determined by all species present in the community with their conservatism weighted by their frequency (abundance). The weighted average conservatism for all species present is multiplied by the square root of the total richness.

$$\text{Weighted FQI All Species} = \frac{\sum_1^S (CC_i \times F_i)}{\sum_1^S F_i} \times \sqrt{S}$$

where CC_i = coefficient of conservatism for species *i*, F_i = frequency of species *i*, S = total species richness

An FQI of 30 to 35 can be considered indicative of a good-quality plant community. By including all species and their abundance, the Weighted FQI All Species is a more accurate and realistic measure of the ecosystem's quality.

WETLAND AFFINITY – These variables place a plant community along a gradient from a permanently-flooded wetland (with a substantial hydroperiod and high wetland affinity) to a non-wetland, upland environment (no hydroperiod and low wetland affinity). The wetland affinity utilizes numeric wetland values assigned to species based on its fidelity to wetland environments. Wetland values represent a measure of "wetness" for a community or habitat. Plant species' wetland affinities have been assigned and compiled by the National Wetland Inventory (US Fish and Wildlife Service) for plants in Region 3 (North Central) (Lichvar et al. 2016). The wetland affinity assigned to plant species represent one of 5 possible levels (Table 6). The more negative the affinities' numeric value, the more hydric the habitat. A measure of wetland affinity is obtained by calculating the average of the wetland affinities for the

Table 6. Wetland affinity levels that reflect a species' affinity for wetland environments.

Affinity Status	Occurrence in Wetlands within the Region	Numeric Value
Obligate wetland	99% or more of the time	-5
Facultative wetland	67-98% of the time	-3
Facultative	34-66% of the time	0
Facultative upland	2-33% of the time	3
Obligate Upland	1% or less of the time	5

species present in a community. There are 5 wetland affinity variables reported.

57) *Mean Native Forb Wetland Index* – The average wetland affinity for all native forbs in the community.

58) *Mean Native Graminoid Wetland Index* – The average wetland affinity for all native graminoids in the community.

59) *Mean Native Woody Wetland Index* – The average wetland affinity for all native woody species in the community.

60) *Mean Exotic Wetland Index* – The average wetland affinity for all exotic species in the community.

61) *All Species Weighted Mean Wetland Index* – The average wetland affinity for all species present in the community weighted by their absolute frequency (abundance).

PRAIRIE QUALITY – These variables provide a measure of prairie quality based on a plant species' fidelity to prairie and its abundance. Plant species that are considered to be natural members of prairie communities were assigned a prairie score ranging from 1 to 5, where 5 represents a species strongly associated with dry to mesic prairie (Figure 21). As a species becomes more tolerant to shade (grading to open woodland) or more tolerant to saturated soils (grading to wetland), its prairie score decreases. Those with a prairie score of 1 or higher are identified as prairie species. Those with a prairie score of 3 or more are identified as prairie indicator species. Their fidelity to prairie is sufficient to say that their presence in a community is good evidence that a remnant prairie is present. There are 9 prairie quality variables.

62) *Prairie Species Richness* – The number prairie species (a species with a prairie score of 1 or greater) present in the community.

63) *Prairie Indicator Richness* – The number of prairie indicator species (a species with a prairie score of 3 or greater) present in the community.

64) *Prairie Species Richness Relative Percentage* – Prairie species richness relative to the total richness. It is the answer to the question, what percentage of the total number of species are prairie species?

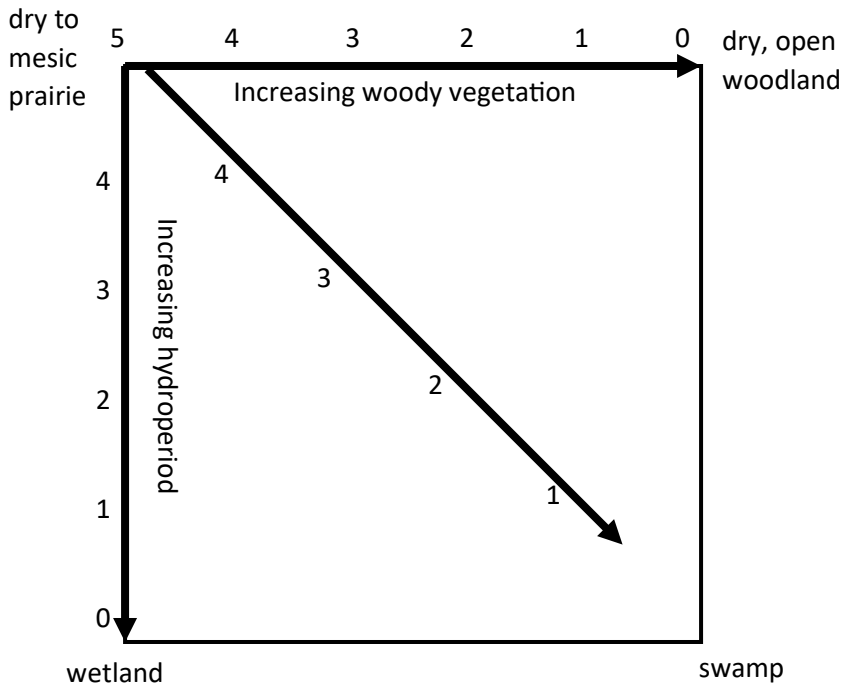


Figure 21. Gradients associated with prairie scores. Species strongly associated with dry to mesic prairie are given the maximum value of 5. Prairie scores decrease gradually if their population sizes are expected to decrease with increasing woody vegetation or increasing hydroperiod.

65) *Prairie Indicator Richness Relative Percentage* – Prairie indicator richness relative to the prairie species richness. It is the answer to the question, what percentage of the prairie species present are prairie indicators?

66) *Prairie Species Mean Prairie Score* – The average prairie score for the prairie species present.

67) *All Species Weighted Mean Prairie Score* – The weighted average prairie score for all species, where a species prairie score is weighted by its abundance (frequency).

$$\text{All Species Weighted Mean Prairie Value} = \frac{\sum_1^S (PV_i \times F_i)}{\sum_1^S F_i}$$

where PV_i = prairie value for species i, F_i = frequency of species i, S = total species richness

68) *Total Prairie Species Frequency* – The total abundance (frequency) for all prairie species present.

69) *Total Prairie Species Frequency Relative Percentage* – The total abundance for all prairie species present relative to the total abundance for all species. It answers the question, what percentage of the vegetation do the prairie species comprise?

70) *Prairie Quality Index (PQI)* – An index of prairie quality that incorporates six variables.

$$\text{PQI} = \left(\begin{matrix}\text{prairie}\\ \text{species}\\ \text{mean}\\ \text{prairie}\\ \text{score}\end{matrix}\right) * \left(\begin{matrix}\text{all species}\\ \text{weighted}\\ \text{mean}\\ \text{prairie}\\ \text{score}\end{matrix}\right) * (8) * \left(\frac{\begin{matrix}\text{prairie}\\ \text{species}\\ \text{richness}\\ \text{relative pct}\end{matrix}}{85}\right) * \left(\frac{\begin{matrix}\text{prairie}\\ \text{indicator}\\ \text{richness}\\ \text{relative pct}\end{matrix}}{75}\right) * \left(\frac{\begin{matrix}\text{total prairie}\\ \text{species}\\ \text{frequency}\\ \text{relative pct}\end{matrix}}{90}\right) * \left(\frac{\sqrt{\text{PIR}}}{6.7}\right)$$

where PIR = prairie indicator richness

The first two variables in the calculation of the PQI are averages of the prairie scores. The first one is the average prairie score for just the prairie species present. The second one includes all species and uses each species abundance to weight its prairie score. The target value for these means is 3.75 and 3.33 respectively. In other words, an excellent prairie (PQI ≈100) should have an average of at least 3.75 and 3.33 for these variables. The value 8 is used to scale the index to 100 (3.75 x 3.333 x 8 = 100.0). The next three variables are relative percentages. The first is the percentage of species present that are prairie species; the second is the percentage of prairie species present that are prairie indicator species, and the third is the percentage of the total abundance for all species that is contributed by prairie species. The target values for these percentages are 85%, 75% and 90% respectively. The last variable expresses the square root of prairie indicator richness as a percentage of 6.7. This incorporates the requirement that an excellent quality prairie should have at least 45 prairie indicator species (the square root of 45 is 6.7). The proportion is expressed using the square root function to help normalize the factor and reduce the effect of extremely low or high values of prairie indicator richness. Using the target amounts for all variables results in a prairie quality index of 100, which would be an excellent prairie. Values of 50 and above might be considered above average, a prairie in the range 60 to 75 is good quality, those in the range 75 to 90 are very good, and a score between 90 and 105 is excellent. Exceptionally high quality is indicated for prairie quality indices above 105.

WOODLAND AND FOREST – These variables convey information about the structure of the understory, the amount of woody regeneration, and the successional status of woodland and forest communities. There are 11 variables in this group.

71) *Total Frequency Native Shrubs and Lianas* – The sum of frequencies for all native woody species characterized as a shrub or liana (climbing woody species). The native prairie shrubs are excluded.

72) *Total Frequency Native Trees* – The sum of frequencies for all native woody species defined as the tree growth form.

73) *Total Frequency Non-native Shrubs and Lianas* – The sum of frequencies for all non-native woody species characterized as a shrub or liana.

74) *Total Frequency Non-native Trees* – The sum of frequencies for all non-native woody species defined as the tree growth form.
75) *Exotic Woody Frequency Relative to All Woody* – The total frequency of all exotic woody species relative to the total frequency of all woody species. It answers the question how much of the total amount of woody vegetation is due to exotic woody species.
76) *Native Understory Richness-Structure* – The combination of native woody richness and the structural size classes seedling/sprout, shrub and sapling are used to obtain a count of the total number of native woody "species-size" units present. For example, if red elm is present as a shrub, a sapling, and 30 and 40 cm DBH trees, it contributes 2 species-size units to this measurement (the shrub and sapling size classes). The higher this variable is, the more evidence there is for woody regeneration of native trees, shrubs and lianas, as well as the presence of adult native shrub species. The number obtained is not a measure of woody density, but it is positively correlated with density.
77) *Exotic Understory Richness-Structure* – The combination of exotic woody richness and the structural size classes seedling/sprout, shrub and sapling are used to obtain a count of the total number of non-native woody "species-size" units present.
78) *Total Understory Richness-Structure* – The combination of total woody richness and the structural size classes seedling/sprout, shrub and sapling are used to obtain a count of the total number of native and non-native woody "species-size" units present. The sum of variables 76 and 77.
79) *Exotic Understory Richness-Structure Relative Pct* – This variable answers the question, what percentage of the total understory richness-structure is occupied by non-native species. It is variable 77 divided by variable 78 and then multiplied by 100

A measure of a forest's or woodland's old growth status was obtained by calculating an old growth index. The floristic inventories included a list of the size classes present for each woody species. Tree size was estimated for all individuals with their DBH (cm). The presence of a single individual in a size class was sufficient to recognize that size class as present. Multiple individuals in the same size class were treated as redundancy. The presence of 1 or 20 trees in the same size class gives the same result, evidence the size class is present in the community. The indices for all the size classes present were summed to assign an old growth index to that species (Table 7). For example, if a bur oak population has trees in these size classes (shrub, 20, 45, 55, 60, 80, 85, 90, and 130), then its old growth index is 7 (obtained by adding 1 + 2 + 4). The trees with a DBH of 55 and 60 contribute an index of 1. The trees with a DBH of 80, 85, and 90 contribute an index of 2. The single individual with a DBH of 130 has an index of 4.

Table 7. Old growth index values assigned to tree size classes.

DBH (diameter at breast height) size classes in cm	Index Value
50 ≤ DBH < 75	1
75 ≤ DBH < 100	2
100 ≤ DBH < 125	3
125 ≤ DBH < 150	4
150 ≤ DBH < 175	5
175 ≤ DBH < 200	6
200 ≤ DBH < 250	7
250 ≤ DBH	8

80) *Total Native Old Growth Index* – The sum of old growth index values for all native trees present. These included hackberry (*Celtis occidentalis*), honey locust (*Gleditsia triacanthos*), black cherry (*Prunus serotina*), and black walnut (*Juglans nigra*).

81) *Non-Native Old Growth Index* – The sum of old growth index values for all non-native trees present. These included white mulberry (*Morus alba*) and Siberian elm (*Ulmus pumila*)

These 81 community variables are calculated from the plant species composition and structure data for the 8 plant communities inventoried. They are the basis for ecological and floristic understanding of the vegetation as well as important in describing the vegetation observed. An important use of these variable is in making comparisons among plant communities.

Results and Discussion

General Floristic Data

A total of 246 vascular plant taxa were observed and utilized in the floristic inventory and Whitter plots. Among them, 8 are generic taxa, meaning identification was limited to the genus, and 6 are double species, meaning that identification could be determined to be one of two species. The ambiguity in both of these is due to immaturity and the lack of key morphological features. Four of the generic taxa and four of the double species were considered to be redundant observations. This means that in terms of the overall number of species, their observation was considered to be a repeat and should not add to the total number of species. The generic taxa and double species are identified in Appendix A. An example of a redundant generic taxa is *Carex* sp. (sedges). Sedges were often observed in vegetative condition, and had to be recognized as only a sedge species. At other times during the growing season, identification to

species was possible, and as a result there were 14 sedge species observed. The observation of sedge species most likely is an observation of one of those 14 species. The double species tall/Canada goldenrod (*Solidago altissima/canadensis*) had to be used most of the growing season to recognize those species because flowers are needed to accurately distinguish them. Late season inventories were able to do that, and it was found that both species were present. Thus the double species tall/Canada goldenrod is redundant. After accounting for the 8 redundant taxa, the total number of species present is 238. This is 3 times the number of species reported by Driftless Land Stewardship and 2.7 times the number found by Applied Ecological Services.

Among the 238 species, 172 are native (72.3%) and 66 are non-native (27.7%). The percentage of non-native species is on the high end in my experience. The percentage of non-native species I typically see for natural areas in Iowa is in the range of 18 to 22%. About 26% of Iowa's flora, which includes native and naturalized species, is non-native. The distribution of growth forms among the 172 native species is 106 forbs (61.6%), 39 graminoids (22.7%), and 27 woody species (15.7%). For the 66 non-native species, it is 42 forbs (63.7%), 14 graminoids (21.2%) and 10 woody species (15.1%). Both groups, native and non-native species, are very similar in their growth form distribution.

There are 96 prairie species supported by the park, which is 55.8% of the native species. Of those 96 prairie species, 39 are prairie indicator species, or a species with sufficient quality to be indicative of remnant prairie. Prairie indicator species comprise 22.7% of the native species. The distribution of prairie scores among the 96 prairies species is given in Figure 22. There were 35 native wetland species observed, or 20.3% of the native flora. Another 4 wetland species are non-native species, for a total of 39 wetland species or 16.4% of the total flora. A species can be both a prairie and a wetland species. There are 13 species in that category. The distribution of wetland affinity or status for all 238 species is shown in Figure 23. There is a strong bias for mesic soil moisture (status=3), followed by dry-mesic to xeric (status=5 and wet-mesic (status=0).

There are 60 plant families represented in the plant list for Sand Prairie Park (Appendix A) using the nomenclature of Eilers and Roosa (1994). The 11 most species diverse families are Asteraceae (31), Poaceae (31), Cyperaceae (19), Fabaceae (14), Lamiaceae (11), Rosaceae (9), Euphorbiaceae (8), Brassicaceae (7) and Caryophyllaceae, Onagraceae, and Solanaceae (6 species each). Almost half of the families (46.7% or 28) are represented by a single species.

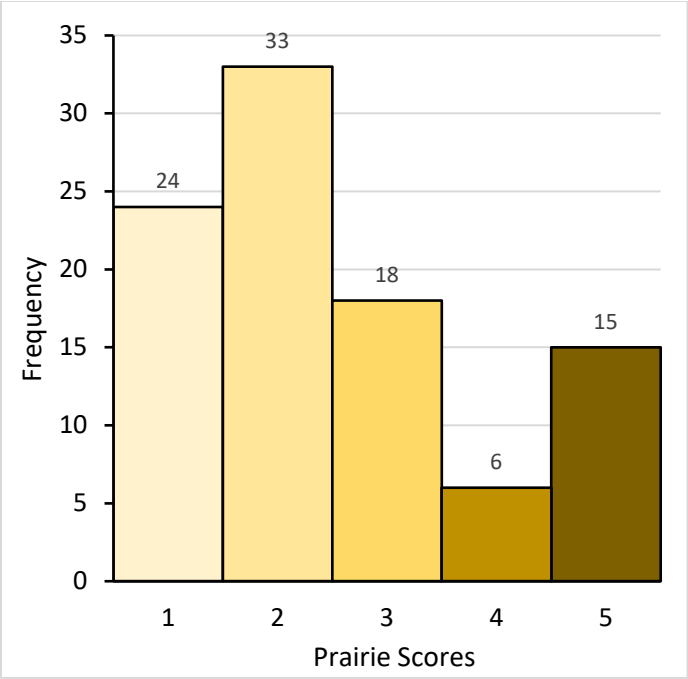


Figure 22. Distribution of prairie scores among the 96 prairie species observed at Sand Prairie Park.

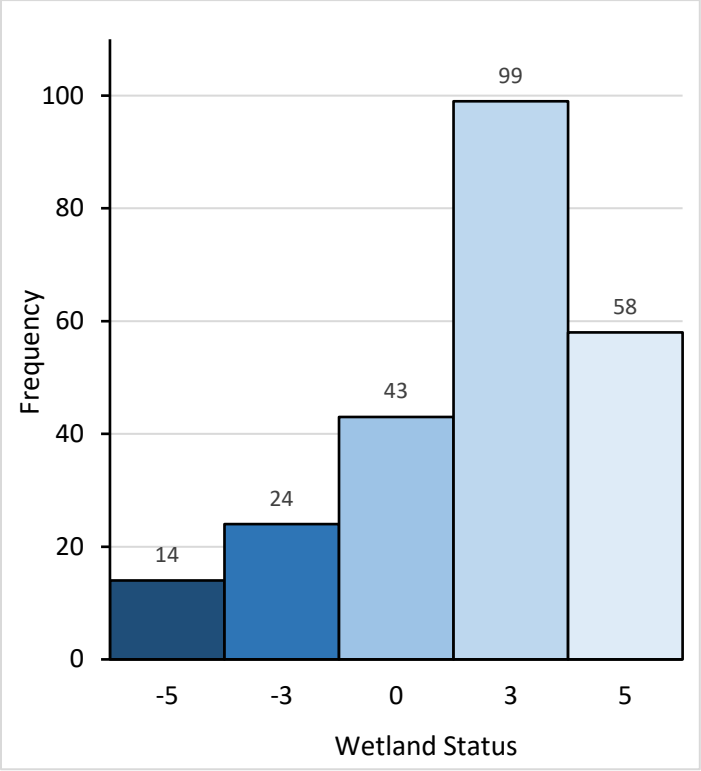


Figure 23. Distribution of wetland status (affinity) among 238 plant species observed at Sand Prairie Park.

Table 8. Imperiled species observed. E=endangered, T=threatened, SC=special concern

Taxa #	Common Name	Current Status	Proposed Status	Location (Plant Association)
1	Slender three seeded mercury	SC	T	Central Grassland
65	Eastern prickly pear	none	SC	Eastern Grassland
155	Smooth clustered sedge	SC	None	Central Grassland, South Forest

State-listed Species

There are two currently imperiled species at Sand Prairie Park (Table 8), and one that is proposed for listing in 2026. Imperiled means listed as endangered, threatened, or special concern by the Iowa Department of Natural Resources (DNR). These are the definitions for each classification used by the Iowa DNR:

Endangered - Any species of fish, plant life, or wildlife which is in danger of extinction throughout all or a significant part of its range. Protected by law. For the plant species, less than 6 contemporary populations are known to exist. Contemporary means an observation of a population between 1980 and present.

Threatened - Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Protected by law. For the plant species, 6 to 20 contemporary populations are known to exist.

Special Concern - Any species about which problems of status or distribution are suspected, but not documented. Not protected by the Iowa Threatened and Endangered Species law, but many animal species listed as Special Concern are protected under other state and federal laws addressing hunting, fishing, collecting, and harvesting. For the plant species, 21 to 40 contemporary populations are known.

Slender three seeded mercury (*Acalypha gracilens*) is an annual forb in the Euphorbiaceae. Shoots range between 10 and 60 cm tall. Its biogeographic range is south and east of a line from Massachusetts to southeastern Ohio to east-central Iowa to central Oklahoma and Texas. The Iowa Natural Areas Inventory (INAI) is an Iowa DNR database that tracks plant and animal species that are either listed or are under consideration for listing. There are 19 records for slender three seeded mercury in 11 counties in east-central and southeast Iowa. One of those records is from Johnson County, an observation at Ciha Preserve in 2006. Thus this is only the second record for the county. Slender three seeded mercury is mainly associated with moist sandy environments in Iowa. There are 6 contemporary records in the INAI. The observation at Sand Prairie Park makes the total records 7, which justifies elevating it from special concern to threatened.

Smooth clustered sedge (*Carex aggregata*) is a perennial graminoid in the Cyperaceae. It is currently listed as a special concern species. However there are now 136 documented populations in 62 counties, of which 105 were observed since 1980, in the INAI database. Since the number of known populations observed since 1980 far exceeds the threshold of 40 for listing as special concern, the ETSC (Endangered, Threatened, Special Concern) Plant Committee has recommended smooth clustered sedge be delisted. The population at Sand Prairie Park is the fifth reported population in Johnson County and the first reported since an observation in 1975 at Williams Prairie State Preserve. Three other records are all from 1941. It was initially listed as special concern because of the scarcity of records in the state's herbaria. However that was due mostly to incorrectly identified specimens. It is most often confused with heavy sedge (*Carex gravida*).

Eastern prickly pear is not listed at this time, but the ETSC Plant Committee has recommended it be listed as Special Concern. The Special Concern status is warranted by uncertainty surrounding this species. Recent systematic work by Majure et al. (2017) has redefined the taxonomy of the southeastern subclade of the Humifusa clade that commonly occur in the eastern United States. One result is that the traditional understanding of *Opuntia humifusa*, the species recognized in Iowa, is incorrect. The current range of *O. humisfusa* is much smaller than previously recognized, and limited to an area from southern New Hampshire to Virginia, with a disjunct population in central Mississippi. What was recognized as *O. humifusa* in Iowa is a different species, *O. cespitosa*. A key morphological trait of *O. cespitosa* is the reddish center of the flowers. Cactus flowers are characterized by many tepals (i.e., sepals and petals that are similar). In *O. cespitosa* the lower portions of the tepals are reddish. However, the same is true for another species present in Iowa, *O. macrorhiza*. *O. macrorhiza* is a southwestern and southern Great Plains species that comes into Iowa from the southwest. It is listed as endangered. There are reports of *O. macrorhiza* in eastern Iowa and even in southwest Wisconsin (Flora of Wisconsin). Because of the recent changes to *Opuntia* taxonomy and the uncertain identification of records in the INAI database, records of both *O. humifusa* (now *O. cespitosa*) and *O. macrorhiza* are under review.

The INAI database shows records for *O. humifusa* (presumably *O. cespitosa*) in 14 counties at 26 different locations (populations). Nearly all of them (24 observations) have occurred since 1980, thus *O. cespitosa* qualifies for Special Concern based on rarity. The plants at Sand Prairie Park make the third known population for Johnson County. Other populations have been observed on the Hawkeye Wildlife

Area in 2004 (latitude 41.763163, longitude -91.735897) and at Babcock Cemetery or Greencastle Cemetery in 2015 (latitude 41.771262, longitude -91.690869, 2250 Half Moon Ave NW).

The plants at Sand Prairie Park were not in bloom in 2024. But based on the extensive occurrence of *O. cespitosa* in Missouri and Illinois (Majure et al. 2017), it is highly likely that most eastern Iowa *Opuntia* are *O. cespitosa.* It would be good if flowering occurs in the future, to get photos and another field observation to verify the identification.

Plant Conservatism

The distribution of the coefficients of conservatism for the 172 native species is shown in Figure 24. The 10 high conservative species (CC=7, 8, 9, 10) account for 5.8%, the 68 medium conservative species (CC= 4, 5, 6) account for 39.5%, and the 94 low conservative species (CC=1, 2, 3) comprise 54.7%. Among the 10 high conservative species, 9 are prairie species and 1 is a wetland species (Table 9). There are 45 species with a coefficient of conservatism of 5 or 6, which is in the upper medium category.

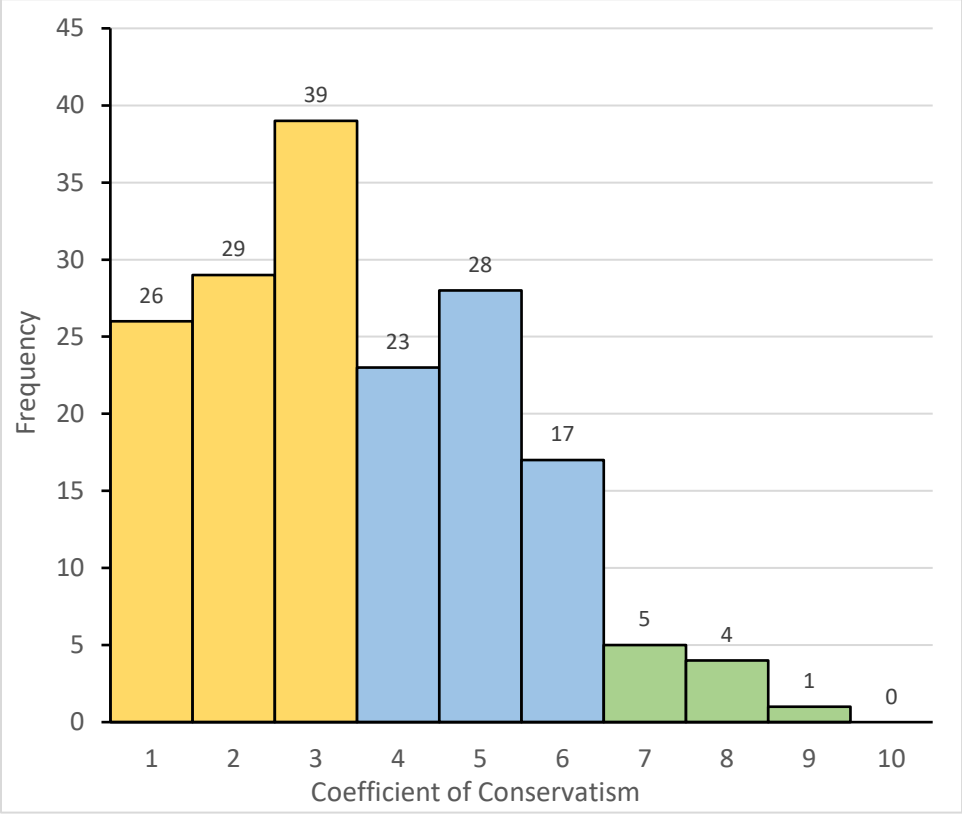


Figure 24. A histogram showing the distribution of the coefficients of conservatism for the 172 native species. Low, medium and high classes of conservatism are shown by the gold, blue, and green-colored bars respectively. The distribution is normal (Shapiro-Wilk test, p-value=0.27).

Table 9. High conservative species observed at Sand Prairie Park. Plant association labels are East Grassland (EG), Central Grassland (CG), West Grassland (WG) and East Wetland (EW).

Taxon number, common name, CC	Plant Association	Taxon number, common name, CC	Plant Association
192 - Prairie dropseed 9	EG	57 - False loosestrife 7	EW
11 - Lead plant 8	EG	99 - Slickseed wild bean 7	CG
55 - Sand puccoon 8	EG, WG	154 - Side-oats grama 7	EG
62 - Cleland's evening primrose 8	EG	165 - Sand sedge 7	CG, EG, WG
171 - Great Plains flat sedge 8	CG, EG	188 - Little bluestem 7	EG

These species are typically associated with a certain, native and relatively stable plant community but are able to persist even when that habitat has experienced moderate disturbance. They might be considered the "workhorses" of the plant community in maintaining ecosystem cohesiveness and resilience. Over half of those species (29, 64.4%) are also prairie species. A few examples are Illinois tick-trefoil, Great Plains goldentop, cutleaf evening primrose, prairie rose, and Indian grass.

There is a clear sand prairie signature in the flora of the park. Species with good fidelity to sand prairie include sand puccoon, Great Plains flat sedge, Schweinitz's flat sedge, purple lovegrass, fall witchgrass, bead grass, eastern prickly pear, Cleland's evening primrose, woolly croton and slender three seeded mercury.

Comparison with Other Floristic Inventories

Plant species reported by the "sand prairie saviors" in the mid-1990s that were not found are the grasses hairy grama, sand dropseed, and three-awn grass. Prairie forbs observed 30 years ago but not encountered in the present study include false boneset, starry campion, bracted plantain, field pussytoes, and western rock jasmine. Some notable plants reported by Driftless Land Stewardship (DLS) in 2005 but not observed in 2024 are sand milkweed, green milkweed, Bicknell's sedge, and Patagonia plantain. It is possible that the sedge was misidentified; one species on their list, pale bulrush (*Scirpus pallidus*), is highly likely to be inaccurate since it is a western Iowa species.

The list by Applied Ecological Services (AES) is much more recent, less than 10 years ago, so there should be less discrepancy between it and the current vegetation. There is only one prairie species reported by them that was not observed in the current study – *Carex bicknellii*. There are 14 *Carex* species reported by this study, while AES identifies 7 species. The two species lists have only 3 *Carex* species in common. I believe AES has probably misidentified at least a couple sedge species. It also

appears that AES may have misidentified 2 rush species (*Juncus*). This study found 3 rush species – *J. dudleyi*, *J. tenuis*, and *J. acuminatus*. The first two are very common species and easy to observe in damp or disturbed habitats. AES did not observe either of them. Instead they report *J. nodosus* and *J. torreyi*. Both of those species are very similar to *J. acuminatus*. In order to distinguish them, it is necessary to count the number of stamens per flower. This is often difficult to do with plants that are fruiting and requires the use of a good dissecting scope.

Obviously the work by both AES and DLS has far fewer species observed than does the current study, at least 150 species fewer. There are a few explanations for this, the most likely one being that both AES and DLS personnel invested much less in field time than the current study. Nonetheless it is not clear why both of those earlier reports missed species like eastern prickly pear, tall boneset and woolly croton. Furthermore, there are prairie species observed by DLS (in 2005) and in the current study that are not reported by AES (in 2017), like wild hairy petunia, little bluestem, Illinois tick trefoil, clammy ground cherry and narrow leaf mountain mint. It seems their natural area inventory and management plan for Sand Prairie Park has limited value.

Invasive Species

Invasive species are considered by many ecologists to be the greatest threat to native biodiversity, now more important than habitat loss. In many ways it is easier to protect natural areas from habitat loss through development or agriculture than it is to protect them from invasive species. The coefficients for the non-native species range between -1 and -3; the more invasive a non-native species is the lower the coefficient. There is a uniform distribution of the 66 non-native species observed; 22 species (33.3%) are rated -1; 21 species (31.8%) are assigned -2; and 23 species (34.8%) are considered very invasive and are -3. A measure of the invasive threat posed by a non-native species was generated by multiplying these three measures – its coefficient of conservatism, community constancy, and total abundance (Table 10). The invasive score is a negative number. The lower its value (or the higher its absolute value) the greater the negative impact the species has at Sand Prairie Park. It ranges from -5 for four plant species with a very minor impact (velvet leaf, Deptford pink, and 2 chickweed species) to -8,736 for smooth brome. There are 11 species with an invasive score lower than -400, a range that includes 95% of the invasive scores. Those species, listed from worst to least invasive, include smooth brome, amur honeysuckle, Kentucky bluegrass, Siberian elm, white mulberry, common mullein, Osage orange, white sweet clover, yellow sweet clover, reed canary grass, and multiflora rose (Table 10). A new invasive species for Iowa, Japanese stiltgrass (*Microstegium vimineum*), was observed in the south forest. It was

Table 10. Invasive score for non-native species at Sand Prairie Park. See the text for details on its calculation. Growth forms are forb (F), graminoid (G) and woody (W). Species with red shading have a coefficient of conservatism of -3 (maximum invasiveness).

Taxa No.	Common Name	Growth Form	Invasive Score	Taxa No.	Common Name	Growth Form	Invasive Score
196	Smooth brome	G	-8,736	137	Wild parsnip	F	-75
240	Amur honeysuckle	W	-3,717	120	Wild carrot	F	-60
205	Kentucky bluegrass	G	-2,256	152	Corn speedwell	F	-60
246	Siberian elm	W	-1,812	201	Tall fescue	G	-60
243	White mulberry	W	-1,386	117	Lamb's quarter	F	-45
151	Common mullein	F	-1,264	127	Motherwort	F	-45
242	Osage orange	W	-1,044	148	Goat's-beard	F	-45
132	White sweet clover	F	-540	112	Common burdock	F	-40
133	Yellow sweet clover	F	-540	125	Prickly lettuce	F	-40
203	Reed canary grass	G	-444	139	Spotted lady's thumb	F	-40
245	Multiflora rose	W	-420	199	Orchard grass	G	-40
144	White campion	F	-240	207	Yellow foxtail	G	-40
149	Red clover	F	-240	122	Creeping Charlie	F	-34
244	Common buckthorn	W	-240	194	Quack grass	G	-34
202	Japanese stiltgrass	G	-231	118	Blue mistflower	F	-20
111	Garlic mustard	F	-228	123	Dame's rocket	F	-20
141	Sheep sorrel	F	-200	124	Iris sp.	F	-20
119	Crown vetch	F	-198	128	Field pepperweed	F	-20
143	Bouncing bet	F	-176	147	Penny cress	F	-20
140	Sulphur cinquefoil	F	-165	200	Woolly cupgrass	G	-20
206	Giant foxtail	G	-162	129	Bird's-foot trefoil	F	-15
115	Hemp	F	-160	197	Japanese brome	G	-15
136	Catnip	F	-160	198	Downy chess	G	-15
146	Common dandelion	F	-160	238	Autumn olive	W	-15
114	Hoary-alyssum	F	-140	241	Tartarian honeysuckle	W	-15
142	Curly dock	F	-135	126	Henbit	F	-10
113	Blackberry lily	F	-112	131	Alfalfa	F	-10
130	Black medic	F	-112	138	English plantain	F	-10
150	White clover	F	-90	239	Privet sp.	W	-10
195	Redtop	G	-90	110	Velvet leaf	F	-5
237	Tree of heaven	W	-90	116	Clammy mouse-ear chickweed	F	-5
135	Carpetweed	F	-88	121	Deptford pink	F	-5
204	Timothy	G	-76	145	Common chickweed	F	-5

introduced to Tennessee from Asia around 1919 and is now established in much of the eastern United States (Thieret 2003). It occurs in forest and wetland areas and does well in many disturbed areas. In suitable habitats it quickly spreads by rooting from its prostrate culms, forming dense, monospecific stands. Blue mistflower (*Conoclinium coelestinum*) is another new non-native species for Iowa. It was observed in the east grassland. Blue mistflower is native to southeastern U.S. In Missouri, it is primarily found south of the Missouri River in bottomland forests, swamps, streambanks, riparian zones and marshes (Yatskievych 2006).

Community Constancy and Total Abundance

There are two measures utilized and reported that convey useful information about a species occurrence at Sand Prairie Park. The first one, community constancy, is a landscape scale variable. It measures how commonly a plant species is observed over space or across a landscape. It is the number of community samples, or floristic samples, where the species is present. It can be presented either as a count (i.e., frequency) or as a percentage (the number of community samples where a species is present relative to the total number of community samples observed). It is more useful to express it as a relative percentage, so that it is standardized for the number of community samples used. Ecologically community constancy reflects a plant species' ability to establish and be successful in the variety of environments present on a large landscape. Species with a broad niche, general habitat requirements, and an r-selected (ruderal) life history strategy are more likely to exhibit high community constancy. They tend to be more widespread and likely to be observed. However, species exhibiting high community constancy are not necessarily dominant species. Community constancy is based on the presence of a species in a community, which happens equally if the population is 3 individuals or 3,000. A species can have high community constancy and at the same time low population sizes making it a minor species in each community. Other important factors affecting community constancy are the method utilized in delineating community samples and the nature of the landscape. The larger a community sample is, the more species that are likely to be present. A study that uses 10 community samples on a 300-acre site (i.e., 30-acre average or coarse scale) will have less resolution and accuracy and be less meaningful as a measure of community constancy than if the study used 30 community samples (i.e., 10-acre average or fine scale). The community constancy of a species is likely to be higher in the coarse scale example than in a fine scale study. Also, a landscape with high environmental heterogeneity will require and usually have more community samples than the same size landscape with low environmental heterogeneity. In this study, the 37-acre research site has 8 community samples that provide floristic data. They range in size from 0.30 acre to 10.9 acres and have a mean size of 4.6 acres

Table 11. Plant communities and associations delineated and identified at Sand Prairie Park.

Plant Association	Map Label (Fig. 17)	Area (acres)	Weighted FQI
Grassland prairie	Central Grassland	10.9	19.0
Grassland prairie	West Grassland	10.3	14.5
Upland mixed forest	South Forest	5.0	4.2
Grassland prairie	East Grassland	3.6	11.9
Upland mixed woodland	North Woodland	3.6	6.5
Shrubland	West Shrubland	1.8	8.7
Upland mixed woodland	East Woodland	0.88	1.4
Upland mixed woodland	East Woodland	0.60	
Shallow wetland	East Wetland	0.3	21.5

(Figure 17, Table 11). Each plant community has a floristic sample, except for the upland mixed woodland in east woodland. The two east woodlands were combined to make one floristic sample. Community constancy is presented for 239 taxa observed at Sand Prairie Park (Table 12). The species and taxa are ranked by community constancy from high to low. Each species' total abundance (see below) is also given. Species shaded gray are non-native, those shaded green are high conservative species, and state-listed species are shaded yellow. All of the redundant species were eliminated except the generic taxon sedge species. There is no way to know which of the 14 species of sedges observed at Sand Prairie Park was the one observed when sedge species had to be used.

There are 22 species that were observed in 6 or more of the 8 floristic samples (constancy ≥ 75%). Among these most widespread species, 15 are native and 7 are non-native (Table 12). Eleven are woody species, 7 are forbs, and 4 are graminoids. The highest community constancy is 100% for common mullein (Table 12). Ten species are tied for second place with a constancy of 87.5%. These species, in order from highest to lowest, were smooth brome, poison ivy, wild black cherry, amur honeysuckle, honey locust, horse nettle, woodbine, common ragweed, white mulberry, and tall goldenrod. Another 11 species tied for third place round out the top 22 species for constancy. There are only 5 prairie species in the top 22 species, and none of them are prairie indicator species. The highest ranking high conservative species is sand sedge, with a constancy of 3 (37.5%).

Knowing the species that are the most widespread (i.e., high community constancy) is ecologically useful to a land manager. But it may be more useful to focus on the species at the other end of the

Table 12. Plant species (239) observed at Sand Prairie Park ranked by constancy and total abundance.

Taxa #	Common Name	Constancy		Tot Ab %
151	Common mullein	8	100.0%	158
196	Smooth brome	7	87.5%	416
232	Poison ivy	7	87.5%	287
218	Wild black cherry	7	87.5%	204
240	Amur honeysuckle	7	87.5%	177
213	Honey locust	7	87.5%	149
93	Horse nettle	7	87.5%	142
216	Woodbine	7	87.5%	123
8	Common ragweed	7	87.5%	84
243	White mulberry	7	87.5%	66
95	Tall goldenrod	7	87.5%	59
60	Wild bergamot	6	75.0%	204
205	Kentucky bluegrass	6	75.0%	188
246	Siberian elm	6	75.0%	151
97	Canada goldenrod	6	75.0%	141
169	Sedge sp.	6	75.0%	115
210	Rough-leaved dogwood	6	75.0%	108
28	Horseweed	6	75.0%	63
242	Osage orange	6	75.0%	58
214	Black walnut	6	75.0%	54
156	Woodland sedge	6	75.0%	30
235	Riverbank grape	6	75.0%	30
71	Clammy ground cherry	5	62.5%	99
163	Midland sedge	5	62.5%	85
38	White snakeroot	5	62.5%	79
107	Common blue violet	5	62.5%	72
18	Common milkweed	5	62.5%	48
144	White campion	5	62.5%	48
104	White vervain	5	62.5%	40
98	Giant goldenrod	5	62.5%	37
140	Sulphur cinquefoil	5	62.5%	33
45	Cleavers bedstraw	4	50.0%	99
193	Purple top	4	50.0%	60
157	Plains oval sedge	4	50.0%	58
143	Bouncing bet	4	50.0%	44
50	Stickseed	4	50.0%	40
203	Reed canary grass	4	50.0%	37
175	Scribner's panic grass	4	50.0%	36
114	Hoary-alyssum	4	50.0%	35
245	Multiflora rose	4	50.0%	35
103	Hoary vervain	4	50.0%	32
67	Slender yellow wood sorrel	4	50.0%	28
113	Blackberry lily	4	50.0%	28
141	Sheep sorrel	4	50.0%	25
226	Black raspberry	4	50.0%	25
4	Common yarrow	4	50.0%	20
27	Field thistle	4	50.0%	20
33	American burnweed	4	50.0%	20
115	Hemp	4	50.0%	20
136	Catnip	4	50.0%	20
146	Common dandelion	4	50.0%	20
149	Red clover	4	50.0%	20
162	Leavenworth's sedge	4	50.0%	20
244	Common buckthorn	4	50.0%	20
185	Fall witchgrass	3	37.5%	92
172	Schweinitz’s flatsedge	3	37.5%	87
29	Woolly croton	3	37.5%	81
85	Canada black snakeroot	3	37.5%	75
21	Hairy aster	3	37.5%	70
84	Wild petunia	3	37.5%	53
174	Common panic grass	3	37.5%	43
82	Prairie rose	3	37.5%	35
41	David's spurge	3	37.5%	30
195	Redtop	3	37.5%	30
48	White avens	3	37.5%	27
206	Giant foxtail	3	37.5%	27
39	Late thoroughwort	3	37.5%	23
160	Heavy sedge	3	37.5%	23
165	Sand sedge	3	37.5%	23
36	Tall boneset	3	37.5%	20
88	Prairie ragwort	3	37.5%	20
152	Corn speedwell	3	37.5%	20
220	Northern red oak	3	37.5%	17
19	Whorled milkweed	3	37.5%	15
30	Illinois tick-trefoil	3	37.5%	15
34	Daisy fleabane	3	37.5%	15
35	Prairie fleabane	3	37.5%	15
49	Sweet everlasting	3	37.5%	15
61	Common evening primrose	3	37.5%	15
63	Cutleaf evening primrose	3	37.5%	15
76	Solomon's seal	3	37.5%	15
92	Black nightshade	3	37.5%	15
102	Blue vervain	3	37.5%	15
117	Lamb's quarter	3	37.5%	15
127	Motherwort	3	37.5%	15
142	Curly dock	3	37.5%	15
148	Goat's-beard	3	37.5%	15
150	White clover	3	37.5%	15

Taxa #	Common Name	Constancy		Tot Ab %
159	Davis sedge	3	37.5%	15
187	Bead grass	3	37.5%	15
191	Rough dropseed	3	37.5%	15
209	Hackberry	3	37.5%	15
215	Eastern red cedar	3	37.5%	15
230	Coralberry	3	37.5%	15
132	White sweet clover	2	25.0%	90
133	Yellow sweet clover	2	25.0%	90
179	Purple lovegrass	2	25.0%	48
9	Western ragweed	2	25.0%	45
58	American bugleweed	2	25.0%	42
111	Garlic mustard	2	25.0%	38
204	Timothy	2	25.0%	38
16	Prairie sage	2	25.0%	34
119	Crown vetch	2	25.0%	33
83	Pasture rose	2	25.0%	30
130	Black medic	2	25.0%	28
180	Nodding fescue	2	25.0%	28
173	Straw-colored flat sedge	2	25.0%	25
55	Sand puccoon	2	25.0%	22
135	Carpetweed	2	25.0%	22
5	Slender-leaved false foxglov	2	25.0%	18
105	Wingstem	2	25.0%	18
171	Great Plains flat sedge	2	25.0%	18
100	American germander	2	25.0%	15
237	Tree of heaven	2	25.0%	15
2	Common three-seeded mercu	2	25.0%	10
15	Tower mustard	2	25.0%	10
20	Ontario aster	2	25.0%	10
23	American bindweed	2	25.0%	10
26	Tall thistle	2	25.0%	10
40	Flowering spurge	2	25.0%	10
52	Wood nettle	2	25.0%	10
59	Wild four-o'clock	2	25.0%	10
70	Lopseed	2	25.0%	10
72	Long leaf ground cherry	2	25.0%	10
86	Common black snakeroot	2	25.0%	10
94	Buffalo bur	2	25.0%	10
109	Rough cocklebur	2	25.0%	10
112	Common burdock	2	25.0%	10
118	Blue mistflower	2	25.0%	10
120	Wild carrot	2	25.0%	10
123	Dame's rocket	2	25.0%	10
124	Iris sp.	2	25.0%	10
125	Prickly lettuce	2	25.0%	10
128	Field pepperweed	2	25.0%	10
139	Spotted lady's thumb	2	25.0%	10
147	Penny cress	2	25.0%	10
155	Smooth clustered sedge	2	25.0%	10
168	Common fox sedge	2	25.0%	10
183	Path rush	2	25.0%	10
199	Orchard grass	2	25.0%	10
200	Woolly cupgrass	2	25.0%	10
201	Tall fescue	2	25.0%	10
207	Yellow foxtail	2	25.0%	10
208	Bittersweet	2	25.0%	10
228	Black willow	2	25.0%	10
202	Japanese stiltgrass	1	12.5%	77
176	Common spike rush	1	12.5%	70
184	Rice cutgrass	1	12.5%	54
188	Little bluestem	1	12.5%	43
181	Sharp-fruited rush	1	12.5%	30
224	Smooth sumac	1	12.5%	26
137	Wild parsnip	1	12.5%	25
78	Jumpseed	1	12.5%	20
161	James' sedge	1	12.5%	20
37	Spotted Joe-pye-weed	1	12.5%	17
122	Creeping Charlie	1	12.5%	17
194	Quack grass	1	12.5%	17
57	False loosestrife	1	12.5%	13
154	Side-oats grama	1	12.5%	10
1	Slender threeseeded mercury	1	12.5%	5
3	VA three-seeded mercury	1	12.5%	5
6	Yellow giant-hyssop	1	12.5%	5
7	Green amaranth	1	12.5%	5
10	Giant ragweed	1	12.5%	5
11	Lead plant	1	12.5%	5
12	Hog peanut	1	12.5%	5
13	Tall anemone	1	12.5%	5
14	Indian hemp	1	12.5%	5
17	Swamp milkweed	1	12.5%	5
22	Rattlesnake fern	1	12.5%	5
24	Tall bellflower	1	12.5%	5
25	Partridge pea	1	12.5%	5
31	Waterpod	1	12.5%	5
32	Smooth scouring-rush	1	12.5%	5
42	Carpet spurge	1	12.5%	5
43	Nodding spurge	1	12.5%	5
44	Grass-leaved goldenrod	1	12.5%	5
46	Sweet-scented bedstraw	1	12.5%	5

Taxa #	Common Name	Constancy		Tot Ab %
47	Cranesbill	1	12.5%	5
51	Rough pennyroyal	1	12.5%	5
53	VA pepperweed	1	12.5%	5
54	Yellow false pimpernel	1	12.5%	5
56	Seedbox	1	12.5%	5
62	Cleland's evening primrose	1	12.5%	5
64	Hairy evening primrose	1	12.5%	5
65	Eastern pricklypear	1	12.5%	5
66	Anise root	1	12.5%	5
68	Common yellow wood sorrel	1	12.5%	5
69	Pennsylvania pellitory	1	12.5%	5
73	VA ground cherry	1	12.5%	5
74	Obedient plant	1	12.5%	5
75	Pokeweed	1	12.5%	5
77	Pepper smartweed	1	12.5%	5
79	Pondweed sp.	1	12.5%	5
80	Narrow leaf mountain mint	1	12.5%	5
81	Small-flowered buttercup	1	12.5%	5
89	Ragwort sp.	1	12.5%	5
90	Sleepy catchfly	1	12.5%	5
91	Prairie blue-eyed grass	1	12.5%	5
99	Slickseed wild bean	1	12.5%	5
101	Stinging nettle	1	12.5%	5
106	Purslane speedwell	1	12.5%	5
110	Velvet leaf	1	12.5%	5
116	Clammy mouse-ear chickwee	1	12.5%	5
121	Deptford pink	1	12.5%	5
126	Henbit	1	12.5%	5
129	Bird's-foot trefoil	1	12.5%	5
131	Alfalfa	1	12.5%	5
138	English plantain	1	12.5%	5
145	Common chickweed	1	12.5%	5
153	Big bluestem	1	12.5%	5
158	Thin leaved sedge	1	12.5%	5
164	Field oval sedge	1	12.5%	5
166	Pointed broom sedge	1	12.5%	5
167	Blunt broom sedge	1	12.5%	5
170	Sandbur	1	12.5%	5
178	Silky wild rye	1	12.5%	5
182	Dudley's rush	1	12.5%	5
186	Nimblewill	1	12.5%	5
189	Hard stem bulrush	1	12.5%	5
190	Indian grass	1	12.5%	5
192	Prairie dropseed	1	12.5%	5
197	Japanese brome	1	12.5%	5
198	Downy chess	1	12.5%	5
211	Downy hawthorn	1	12.5%	5
212	Green ash	1	12.5%	5
217	Eastern cottonwood	1	12.5%	5
219	Choke cherry	1	12.5%	5
221	Bur oak	1	12.5%	5
222	Black oak	1	12.5%	5
225	Prickly/MO gooseberry	1	12.5%	5
227	Sandbar willow	1	12.5%	5
229	Bristly greenbrier	1	12.5%	5
233	American elm	1	12.5%	5
234	American/Red Elm	1	12.5%	5
236	Prickly ash	1	12.5%	5
238	Autumn olive	1	12.5%	5
239	Privet sp.	1	12.5%	5
241	Tartarian honeysuckle	1	12.5%	5

Gray shading = non-native

Green shading = high conservartism

Yellow shading = state-listed

spectrum, those with low community constancy. These species, observed in only 1 or 2 communities, are not widespread. They are much less likely to be easily encountered. They exhibit a type of rarity in that their presence is very limited within the geographical context of the study site. There are 94 plant species at Sand Prairie Park (39.3% of the flora) that were observed in only 1 of the 8 communities. The majority (77 or 81.9%) of these "locally rare" species are native and therefore contribute in important and positive ways to ecological processes that maintain ecosystem integrity. However, their local rarity exposes them to higher probability of extirpation if something unfavorable and stressful occurs. The species with the greatest conservation concern are those that combine local rarity with high conservatism. There are 7 "locally rare" species that are also high conservative (Table 9). One of the two listed species (slender three seeded mercury) was also observed in only one community, the central grassland. These are the species that are arguably of high conservation concern and at the same time most vulnerable to extirpation from the park. An understanding of these species' life history strategy, niche, population size and species interactions is important for evaluating their vulnerability.

The second measure of a species occurrence is its total abundance, or the sum of the abundances assigned to it in all the communities that were inventoried. Recall that a species' abundance in a community is measured by its absolute frequency, or how often individuals are observed over space. Absolute frequency is the percentage of quadrats a species is present in relative to the total number of quadrats sampled. Absolute frequency was estimated for each species present in the communities (quadrats were not used). Total abundance is the sum of a species' absolute frequencies (%) for all the communities where it was present, thus the total for a species can exceed 100%. It is affected by its community constancy (the number of communities where present), the method utilized in making community samples (how many communities are delineated and their size), the nature of the landscape (how heterogenous), and the species' biology and success in the landscape.

The total abundance (%) for 239 species observed at Sand Prairie Park is given in Table 12 (ranked by community constancy) and Table 13 (ranked by total abundance). There are 25 species that have a total abundance that exceeds 75% (Table 13). All of these are native except for 7 non-native species. The top five most abundant species are smooth brome, poison ivy, wild black cherry, wild bergamot and Kentucky bluegrass (Table 13). Nine of the top 25 are prairie species, but only two of them are prairie indicator species – fall witchgrass and Schweinitz's flatsedge. Additional prairie indicator species in the next 25 most abundant species (i.e., the top 50) include little bluestem, wild hairy petunia and purple lovegrass.

Table 13. Plant species (239) observed at Sand Prairie Park ranked by total abundance and constancy.

Taxa #	Common Name	Constancy		Tot Ab %
196	Smooth brome	7	87.5%	416
232	Poison ivy	7	87.5%	287
218	Wild black cherry	7	87.5%	204
60	Wild bergamot	6	75.0%	204
205	Kentucky bluegrass	6	75.0%	188
240	Amur honeysuckle	7	87.5%	177
151	Common mullein	8	100.0%	158
246	Siberian elm	6	75.0%	151
213	Honey locust	7	87.5%	149
93	Horse nettle	7	87.5%	142
97	Canada goldenrod	6	75.0%	141
216	Woodbine	7	87.5%	123
169	Sedge sp.	6	75.0%	115
210	Rough-leaved dogwood	6	75.0%	108
71	Clammy ground cherry	5	62.5%	99
45	Cleavers bedstraw	4	50.0%	99
185	Fall witchgrass	3	37.5%	92
132	White sweet clover	2	25.0%	90
133	Yellow sweet clover	2	25.0%	90
172	Schweinitz's flatsedge	3	37.5%	87
163	Midland sedge	5	62.5%	85
8	Common ragweed	7	87.5%	84
29	Woolly croton	3	37.5%	81
38	White snakeroot	5	62.5%	79
202	Japanese stiltgrass	1	12.5%	77
85	Canada black snakeroot	3	37.5%	75
107	Common blue violet	5	62.5%	72
21	Hairy aster	3	37.5%	70
176	Common spike rush	1	12.5%	70
243	White mulberry	7	87.5%	66
28	Horseweed	6	75.0%	63
193	Purple top	4	50.0%	60
95	Tall goldenrod	7	87.5%	59
242	Osage orange	6	75.0%	58
157	Plains oval sedge	4	50.0%	58
214	Black walnut	6	75.0%	54
184	Rice cutgrass	1	12.5%	54
84	Wild petunia	3	37.5%	53
18	Common milkweed	5	62.5%	48
144	White campion	5	62.5%	48
179	Purple lovegrass	2	25.0%	48
9	Western ragweed	2	25.0%	45
143	Bouncing bet	4	50.0%	44
174	Common panic grass	3	37.5%	43
188	Little bluestem	1	12.5%	43
58	American bugleweed	2	25.0%	42
104	White vervain	5	62.5%	40
50	Stickseed	4	50.0%	40
111	Garlic mustard	2	25.0%	38
204	Timothy	2	25.0%	38
98	Giant goldenrod	5	62.5%	37
203	Reed canary grass	4	50.0%	37
175	Scribner's panic grass	4	50.0%	36
114	Hoary-alyssum	4	50.0%	35
245	Multiflora rose	4	50.0%	35
82	Prairie rose	3	37.5%	35
16	Prairie sage	2	25.0%	34
140	Sulphur cinquefoil	5	62.5%	33
119	Crown vetch	2	25.0%	33
103	Hoary vervain	4	50.0%	32
156	Woodland sedge	6	75.0%	30
235	Riverbank grape	6	75.0%	30
41	David's spurge	3	37.5%	30
195	Redtop	3	37.5%	30
83	Pasture rose	2	25.0%	30
181	Sharp-fruited rush	1	12.5%	30
67	Slender yellow wood sorrel	4	50.0%	28
113	Blackberry lily	4	50.0%	28
130	Black medic	2	25.0%	28
180	Nodding fescue	2	25.0%	28
48	White avens	3	37.5%	27
206	Giant foxtail	3	37.5%	27
224	Smooth sumac	1	12.5%	26
141	Sheep sorrel	4	50.0%	25
226	Black raspberry	4	50.0%	25
173	Straw-colored flat sedge	2	25.0%	25
137	Wild parsnip	1	12.5%	25
39	Late thoroughwort	3	37.5%	23
160	Heavy sedge	3	37.5%	23
165	Sand sedge	3	37.5%	23
55	Sand puccoon	2	25.0%	22
135	Carpetweed	2	25.0%	22
4	Common yarrow	4	50.0%	20
27	Field thistle	4	50.0%	20
33	American burnweed	4	50.0%	20
115	Hemp	4	50.0%	20
136	Catnip	4	50.0%	20
146	Common dandelion	4	50.0%	20

Taxa #	Common Name	Constancy		Tot Ab %
149	Red clover	4	50.0%	20
162	Leavenworth's sedge	4	50.0%	20
244	Common buckthorn	4	50.0%	20
36	Tall boneset	3	37.5%	20
88	Prairie ragwort	3	37.5%	20
152	Corn speedwell	3	37.5%	20
78	Jumpseed	1	12.5%	20
161	James' sedge	1	12.5%	20
5	Slender-leaved false foxglov	2	25.0%	18
105	Wingstem	2	25.0%	18
171	Great Plains flat sedge	2	25.0%	18
220	Northern red oak	3	37.5%	17
37	Spotted Joe-pye-weed	1	12.5%	17
122	Creeping Charlie	1	12.5%	17
194	Quack grass	1	12.5%	17
19	Whorled milkweed	3	37.5%	15
30	Illinois tick-trefoil	3	37.5%	15
34	Daisy fleabane	3	37.5%	15
35	Prairie fleabane	3	37.5%	15
49	Sweet everlasting	3	37.5%	15
61	Common evening primrose	3	37.5%	15
63	Cutleaf evening primrose	3	37.5%	15
76	Solomon's seal	3	37.5%	15
92	Black nightshade	3	37.5%	15
102	Blue vervain	3	37.5%	15
117	Lamb's quarter	3	37.5%	15
127	Motherwort	3	37.5%	15
142	Curly dock	3	37.5%	15
148	Goat's-beard	3	37.5%	15
150	White clover	3	37.5%	15
159	Davis sedge	3	37.5%	15
187	Bead grass	3	37.5%	15
191	Rough dropseed	3	37.5%	15
209	Hackberry	3	37.5%	15
215	Eastern red cedar	3	37.5%	15
230	Coralberry	3	37.5%	15
100	American germander	2	25.0%	15
237	Tree of heaven	2	25.0%	15
57	False loosestrife	1	12.5%	13
2	Common three-seeded mercu	2	25.0%	10
15	Tower mustard	2	25.0%	10
20	Ontario aster	2	25.0%	10
23	American bindweed	2	25.0%	10
26	Tall thistle	2	25.0%	10
40	Flowering spurge	2	25.0%	10
52	Wood nettle	2	25.0%	10
59	Wild four-o'clock	2	25.0%	10
70	Lopseed	2	25.0%	10
72	Long leaf ground cherry	2	25.0%	10
86	Common black snakeroot	2	25.0%	10
94	Buffalo bur	2	25.0%	10
109	Rough cocklebur	2	25.0%	10
112	Common burdock	2	25.0%	10
118	Blue mistflower	2	25.0%	10
120	Wild carrot	2	25.0%	10
123	Dame's rocket	2	25.0%	10
124	Iris sp.	2	25.0%	10
125	Prickly lettuce	2	25.0%	10
128	Field pepperweed	2	25.0%	10
139	Spotted lady's thumb	2	25.0%	10
147	Penny cress	2	25.0%	10
155	Smooth clustered sedge	2	25.0%	10
168	Common fox sedge	2	25.0%	10
183	Path rush	2	25.0%	10
199	Orchard grass	2	25.0%	10
200	Woolly cupgrass	2	25.0%	10
201	Tall fescue	2	25.0%	10
207	Yellow foxtail	2	25.0%	10
208	Bittersweet	2	25.0%	10
228	Black willow	2	25.0%	10
154	Side-oats grama	1	12.5%	10
1	Slender threeseeded mercury	1	12.5%	5
3	VA three-seeded mercury	1	12.5%	5
6	Yellow giant-hyssop	1	12.5%	5
7	Green amaranth	1	12.5%	5
10	Giant ragweed	1	12.5%	5
11	Lead plant	1	12.5%	5
12	Hog peanut	1	12.5%	5
13	Tall anemone	1	12.5%	5
14	Indian hemp	1	12.5%	5
17	Swamp milkweed	1	12.5%	5
22	Rattlesnake fern	1	12.5%	5
24	Tall bellflower	1	12.5%	5
25	Partridge pea	1	12.5%	5
31	Waterpod	1	12.5%	5
32	Smooth scouring-rush	1	12.5%	5
42	Carpet spurge	1	12.5%	5
43	Nodding spurge	1	12.5%	5
44	Grass-leaved goldenrod	1	12.5%	5
46	Sweet-scented bedstraw	1	12.5%	5

Taxa #	Common Name	Constancy		Tot Ab %	Taxa #	Common Name	Constancy		Tot Ab %
47	Cranesbill	1	12.5%	5	145	Common chickweed	1	12.5%	5
51	Rough pennyroyal	1	12.5%	5	153	Big bluestem	1	12.5%	5
53	VA pepperweed	1	12.5%	5	158	Thin leaved sedge	1	12.5%	5
54	Yellow false pimpernel	1	12.5%	5	164	Field oval sedge	1	12.5%	5
56	Seedbox	1	12.5%	5	166	Pointed broom sedge	1	12.5%	5
62	Cleland's evening primrose	1	12.5%	5	167	Blunt broom sedge	1	12.5%	5
64	Hairy evening primrose	1	12.5%	5	170	Sandbur	1	12.5%	5
65	Eastern pricklypear	1	12.5%	5	178	Silky wild rye	1	12.5%	5
66	Anise root	1	12.5%	5	182	Dudley's rush	1	12.5%	5
68	Common yellow wood sorrel	1	12.5%	5	186	Nimblewill	1	12.5%	5
69	Pennsylvania pellitory	1	12.5%	5	189	Hard stem bulrush	1	12.5%	5
73	VA ground cherry	1	12.5%	5	190	Indian grass	1	12.5%	5
74	Obedient plant	1	12.5%	5	192	Prairie dropseed	1	12.5%	5
75	Pokeweed	1	12.5%	5	197	Japanese brome	1	12.5%	5
77	Pepper smartweed	1	12.5%	5	198	Downy chess	1	12.5%	5
79	Pondweed sp.	1	12.5%	5	211	Downy hawthorn	1	12.5%	5
80	Narrow leaf mountain mint	1	12.5%	5	212	Green ash	1	12.5%	5
81	Small-flowered buttercup	1	12.5%	5	217	Eastern cottonwood	1	12.5%	5
89	Ragwort sp.	1	12.5%	5	219	Choke cherry	1	12.5%	5
90	Sleepy catchfly	1	12.5%	5	221	Bur oak	1	12.5%	5
91	Prairie blue-eyed grass	1	12.5%	5	222	Black oak	1	12.5%	5
99	Slickseed wild bean	1	12.5%	5	225	Prickly/MO gooseberry	1	12.5%	5
101	Stinging nettle	1	12.5%	5	227	Sandbar willow	1	12.5%	5
106	Purslane speedwell	1	12.5%	5	229	Bristly greenbrier	1	12.5%	5
110	Velvet leaf	1	12.5%	5	233	American elm	1	12.5%	5
116	Clammy mouse-ear chickwee	1	12.5%	5	234	American/Red Elm	1	12.5%	5
121	Deptford pink	1	12.5%	5	236	Prickly ash	1	12.5%	5
126	Henbit	1	12.5%	5	238	Autumn olive	1	12.5%	5
129	Bird's-foot trefoil	1	12.5%	5	239	Privet sp.	1	12.5%	5
131	Alfalfa	1	12.5%	5	241	Tartarian honeysuckle	1	12.5%	5
138	English plantain	1	12.5%	5					

Gray shading = non-native

Green shading = high conservartism

Yellow shading = state-listed

Among the nine high conservative species observed, the top 5 most abundant are little bluestem, sand sedge, sand puccoon, Great Plains flat sedge and side-oats grama. The top 5 most abundant non-native species are smooth brome, Kentucky bluegrass, amur honeysuckle, common mullein, and Siberian elm.

Plant Species Composition of Communities and Associations

Field delineation of plant communities resulted in 9 mapped plant communities (i.e., 9 polygons) (Figure 17). These 9 plant communities were assigned to one of five plant associations (Table 11) – grassland prairie (24.8 acres, 67.0%), upland mixed woodland (5.1 acres, 13.7%), upland mixed forest (5.0 acres, 13.6%), shrubland (1.8 acres, 4.9%) and shallow wetland (0.3 acre, 0.8%). There were 8 floristic samples made for the 9 plant communities. The plant species composition and structure for the 8 samples are reported in Table 14. In other words, Table 14 identifies what species are present in each community and what its abundance is. The entire Table 14 is presented in two tables; Table 14a contains the four herbaceous dominated plant associations and Table 14b presents the four woody dominated plant associations.

As a reminder, the abundance of species in each community is given by its absolute frequency (%), an estimate of the percentage of 100 randomly-located, 50x50 cm quadrats the species would be present in. For the woody species that are present, the population's age/size structure is also given by listing the size classes that are present. Seedling/sprout (ss) indicates stems less than 50 cm in height. Shrub (sh) designates plants from 50 cm to 200 cm in height. Sapling (sap) is a stem over 200 cm tall and less than 5 cm DBH. Tree sizes are given as their DBH (cm). Plant communities are in the columns and plant species in the rows. The plant species are grouped by growth form and origin. Native forbs are presented first, followed by non-native forbs. The next group is native graminoids, followed by non-native graminoids. Native woody species comes next, and the table ends with non-native woody species.

Community Variables

The 81 community variables calculated from the species composition for each plant community are presented in Table 15 for the 8 floristic samples. These data provide information that describe, characterize and assess the communities and their plant associations. Each variable answers a specific question about the communities. All of the variables for a community taken together build an objective and thorough ecological description. Because there are 81 variables and 8 communities, a detailed discussion of every variable and a written description for each community is far beyond the scope and purpose of this report. The data are made available so that any time a question arises concerning a

Figure 14a. Plant species composition and woody structure for plant associations at Sand Praire Park in 2024. Species abundance is given as absolute frequency (%). Woody structure shows the presence of seedling/sprouts (ss), shrubs (sh), saplings (sap) and trees (DBH in cm). Species shaded gray are non-native. Use the Taxa Number and see Appendix A for more information on species biology.

Taxa		West Grassland		Central Grassland		East Grassland		East Wetland	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
1	Slender three-seeded mercury			5					
2	Common three-seeded mercury			5		5			
3	VA three-seeded mercury			5					
4	Common yarrow	5		5		5			
5	Slender-leaved false foxglove					5		13	
6	Yellow giant-hyssop								
7	Green amaranth								
8	Common ragweed	5		54		5		5	
9	Western ragweed			5		40			
10	Giant ragweed					5			
11	Lead plant					5			
12	Hog peanut								
13	Tall anemone					5			
14	Indian hemp			5					
15	Tower mustard	5							
16	Prairie sage	17				17			
17	Swamp milkweed							5	
18	Common milkweed	20		5		13			
19	Whorled milkweed	5		5		5			
20	Ontario aster								
21	Hairy aster			5		20		45	
22	Rattlesnake fern								
23	American bindweed			5					
24	Tall bellflower								
25	Partridge pea	5							
26	Tall thistle			5					
27	Field thistle			5		5			
28	Horseweed	10		33		5			
29	Woolly croton	45		31		5			
30	Illinois tick-trefoil	5		5		5			
31	Waterpod								
32	Smooth scouring-rush								
33	American burnweed			5		5			
34	Daisy fleabane					5		5	
35	Prairie fleabane			5		5		5	
36	Tall boneset	10		5		5			
37	Spotted Joe-pye-weed					17			
38	White snakeroot			5					
39	Late thoroughwort			5		5		13	
40	Flowering spurge	5				5			

Taxa		West Grassland		Central Grassland		East Grassland		East Wetland	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
41	David's spurge	20		5		5			
42	Carpet spurge			5					
43	Nodding spurge			5					
44	Great Plains goldentop							5	
45	Cleavers bedstraw	5							
46	Sweet-scented bedstraw								
47	Cranesbill								
48	White avens								
49	Sweet everlasting	5		5		5			
50	Stickseed			5					
51	Rough pennyroyal					5			
52	Wood nettle					5			
53	VA pepperweed								
54	Yellow false pimpernel							5	
55	Sand puccoon	5				17			
56	Seedbox							5	
57	False loosestrife							13	
58	American bugleweed			5				37	
59	Wild four-o'clock	5				5			
60	Wild bergamot	27		54		80			
61	Common evening primrose	5				5			
62	Cleland's evening primrose					5			
63	Cutleaf evening primrose	5		5		5			
64	Hairy evening primrose			5					
65	Eastern pricklypear					5			
66	Anise root								
67	Slender yellow wood sorrel	5		13		5			
68	Common yellow wood sorrel			5					
69	Pennsylvania pellitory								
70	Lopseed								
71	Clammy ground cherry	39		45		5			
72	Long leaf ground cherry	5		5					
73	VA ground cherry			5					
74	Obedient plant	5							
75	Pokeweed								
76	Solomon's seal	5		5					
77	Pepper smartweed							5	
78	Jumpseed								
79	Pondweed sp.							5	
80	Narrow leaf mountain mint			5					
81	Small-flowered buttercup								
82	Prairie rose	25	ss	5	ss	5	ss		
83	Pasture rose	5	ss	25	ss				
84	Wild petunia	38		5		10			
85	Canada black snakeroot			63					

Taxa		West Grassland		Central Grassland		East Grassland		East Wetland	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
86	Common black snakeroot								
88	Prairie ragwort			5		10			
89	Ragwort sp.								
90	Sleepy catchfly	5							
91	Prairie blue-eyed grass			5					
92	Black nightshade			5		5			
93	Horse nettle	20		39		63			
94	Buffalo bur			5		5			
95	Tall goldenrod	19		15		5			
97	Canada goldenrod	19		20		80			
98	Giant goldenrod			17		5			
99	Slickseed wild bean			5					
100	American germander			5					
101	Stinging nettle								
102	Blue vervain			5		5		5	
103	Hoary vervain	5		17		5			
104	White vervain	5		5					
105	Wingstem			13					
106	Purslane speedwell							5	
107	Common blue violet			5					
109	Rough cocklebur			5		5			
110	Velvet leaf								
111	Garlic mustard								
112	Common burdock								
113	Blackberry lily	5		5					
114	Hoary-alyssum	5		20		5			
115	Hemp			5		5			
116	Clammy mouse-ear chickweed					5			
117	Lamb's quarter			5		5			
118	Blue mistflower					5		5	
119	Crown vetch			28		5			
120	Wild carrot			5		5			
121	Deptford pink					5			
122	Creeping Charlie								
123	Dame's rocket								
124	Iris sp.			5					
125	Prickly lettuce	5		5					
126	Henbit	5							
127	Motherwort	5		5					
128	Field pepperweed	5		5					
129	Bird's-foot trefoil					5			
130	Black medic			5		23			
131	Alfalfa					5			
132	White sweet clover	5				85			
133	Yellow sweet clover	5				85			

Taxa		West Grassland		Central Grassland		East Grassland		East Wetland	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
135	Carpetweed			5		17			
136	Catnip			5		5			
137	Wild parsnip					25			
138	English plantain					5			
139	Spotted lady's thumb					5		5	
140	Sulphur cinquefoil	13		5		5			
141	Sheep sorrel	10		5		5		5	
142	Curly dock	5		5		5			
143	Bouncing bet	5		17		17			
144	White campion	5		5		28			
145	Common chickweed								
146	Common dandelion			5		5			
147	Penny cress			5					
148	Goat's-beard	5		5		5			
149	Red clover	5		5		5			
150	White clover			5		5		5	
151	Common mullein	45		41		35		5	
152	Corn speedwell	5				5			
153	Big bluestem					5			
154	Side-oats grama					10			
155	Smooth clustered sedge			5					
156	Woodland sedge			5		5			
157	Plains oval sedge	20		13		20			
158	Thin leaved sedge								
159	Davis sedge			5					
160	Heavy sedge	5		13		5			
161	James' sedge								
162	Leavenworth's sedge	5		5		5			
163	Midland sedge	20		20		20			
164	Field oval sedge							5	
165	Sand sedge	5		13		5			
166	Pointed broom sedge							5	
167	Blunt broom sedge							5	
168	Common fox sedge					5		5	
169	Sedge sp.	45		42		5			
170	Sandbur					5			
171	Great Plains flat sedge			5		13			
172	Schweinitz’s flatsedge	5		48		34			
173	Straw-colored flat sedge					5		20	
174	Common panic grass			5		5		33	
175	Scribner's panic grass	13		13		5			
176	Common spike rush							70	
178	Silky wild rye								
179	Purple lovegrass			5		43			
180	Nodding fescue								

Taxa		West Grassland		Central Grassland		East Grassland		East Wetland	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
181	Sharp-fruited rush							30	
182	Dudley's rush							5	
183	Path rush							5	
184	Rice cutgrass							54	
185	Fall witchgrass	42		22		28			
186	Nimblewill								
187	Bead grass	5		5		5			
188	Little bluestem					43			
189	Hard stem bulrush							5	
190	Indian grass			5					
191	Rough dropseed	5		5		5			
192	Prairie dropseed					5			
193	Purple top	17		33		5			
194	Quack grass	17							
195	Redtop			5		5		20	
196	Smooth brome	88		79		80			
197	Japanese brome					5			
198	Downy chess								
199	Orchard grass								
200	Woolly cupgrass	5				5			
201	Tall fescue					5		5	
202	Japanese stiltgrass								
203	Reed canary grass			5		17		10	
204	Timothy					33			
205	Kentucky bluegrass	63		45		45			
206	Giant foxtail			17		5			
207	Yellow foxtail			5		5			
208	Bittersweet	5	sh						
209	Hackberry	5	sh						
210	Rough-leaved dogwood	17	sh,sap	5	ss	20	ss,sh		
211	Downy hawthorn								
212	Green ash	5	sh						
213	Honey locust	33	ss,sh,sap	5	ss,sh	17	ss,sh		
214	Black walnut	17	ss,sh,sap	5	ss	17	sh,sap		
215	Eastern red cedar	5	ss,sh						
216	Woodbine	5	ss	5	ss	5	ss		
217	Eastern cottonwood	5	sap						
218	Wild black cherry	20	sh,sap,5	20	sh,sap	13	ss,sh,sap,15,25		
219	Choke cherry								
220	Northern red oak	5	10,15			7	ss,sap		

Taxa		West Grassland		Central Grassland		East Grassland		East Wetland	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
221	Bur oak	5	ss						
222	Black oak	5	15						
224	Smooth sumac			26	ss,sap				
225	Prickly/MO gooseberry								
226	Black raspberry			10	ss,sh				
227	Sandbar willow					5	sh		
228	Black willow					5	sh	5	sap
229	Bristly greenbrier								
230	Coralberry	5	sh	5	ss				
232	Poison ivy	39	ss,sh	54	ss	72	ss		
233	American elm								
234	American/Red Elm			5	ss				
235	Riverbank grape	5	ss,sh	5	ss	5	ss		
236	Prickly ash	5	sh						
237	Tree of heaven	10	sh,sap			5	sh		
238	Autumn olive								
239	Privet sp.								
240	Amur honeysuckle	5	sh,sap	5	ss,sh	5	sh		
241	Tartarian honeysuckle								
242	Osage orange	5	sap	5	ss,sh	5	ss,sh		
243	White mulberry	13	ss,sh	5	ss	5	ss		
244	Common buckthorn	5	sh	5	ss				
245	Multiflora rose			5	ss				
246	Siberian elm	46	ss,sh,sap,5	5		45	ss,sh,10,20		
	Total Species	90		123		125		37	

Figure 14b. Plant species composition and woody structure for plant associations at Sand Praire Park in 2024. Species abundance is given as absolute frequency (%). Woody structure shows the presence of seedling/sprouts (ss), shrubs (sh), saplings (sap) and trees (DBH in cm). Species shaded gray are non-native. Use the Taxa Number and see Appendix A for more information on species biology.

Taxa		West Shrubland		East Woodland		North Woodland		South Forest	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
1	Slender three-seeded mercury								
2	Common three-seeded mercury								
3	VA three-seeded mercury								
4	Common yarrow	5							
5	Slender-leaved false foxglove								
6	Yellow giant-hyssop					5			
7	Green amaranth	5							
8	Common ragweed	5				5		5	
9	Western ragweed								
10	Giant ragweed								
11	Lead plant								
12	Hog peanut							5	
13	Tall anemone								
14	Indian hemp								
15	Tower mustard	5							
16	Prairie sage								
17	Swamp milkweed								
18	Common milkweed					5		5	
19	Whorled milkweed								
20	Ontario aster			5				5	
21	Hairy aster								
22	Rattlesnake fern							5	
23	American bindweed					5			
24	Tall bellflower					5			
25	Partridge pea								
26	Tall thistle							5	
27	Field thistle					5		5	
28	Horseweed	5				5		5	
29	Woolly croton								
30	Illinois tick-trefoil								
31	Waterpod							5	
32	Smooth scouring-rush			5					
33	American burnweed					5		5	
34	Daisy fleabane	5							
35	Prairie fleabane								
36	Tall boneset								
37	Spotted Joe-pye-weed								
38	White snakeroot	5		5		45		19	
39	Late thoroughwort								
40	Flowering spurge								

Taxa		West Shrubland		East Woodland		North Woodland		South Forest	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
41	David's spurge								
42	Carpet spurge								
43	Nodding spurge								
44	Great Plains goldentop								
45	Cleavers bedstraw	5				56		33	
46	Sweet-scented bedstraw					5			
47	Cranesbill	5							
48	White avens	5				5		17	
49	Sweet everlasting								
50	Stickseed	5				25		5	
51	Rough pennyroyal								
52	Wood nettle							5	
53	VA pepperweed	5							
54	Yellow false pimpernel								
55	Sand puccoon								
56	Seedbox								
57	False loosestrife								
58	American bugleweed								
59	Wild four-o'clock								
60	Wild bergamot	33				5		5	
61	Common evening primrose					5			
62	Cleland's evening primrose								
63	Cutleaf evening primrose								
64	Hairy evening primrose								
65	Eastern pricklypear								
66	Anise root					5			
67	Slender yellow wood sorrel	5							
68	Common yellow wood sorrel								
69	Pennsylvania pellitory							5	
70	Lopseed					5		5	
71	Clammy ground cherry	5				5			
72	Long leaf ground cherry								
73	VA ground cherry								
74	Obedient plant								
75	Pokeweed					5			
76	Solomon's seal	5							
77	Pepper smartweed								
78	Jumpseed							20	
79	Pondweed sp.								
80	Narrow leaf mountain mint								
81	Small-flowered buttercup					5			
82	Prairie rose								
83	Pasture rose								
84	Wild petunia								
85	Canada black snakeroot	5						7	

Taxa		West Shrubland		East Woodland		North Woodland		South Forest	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
86	Common black snakeroot					5		5	
88	Prairie ragwort					5			
89	Ragwort sp.							5	
90	Sleepy catchfly								
91	Prairie blue-eyed grass								
92	Black nightshade					5			
93	Horse nettle	5		5		5		5	
94	Buffalo bur								
95	Tall goldenrod	5		5		5		5	
97	Canada goldenrod	5		5		12			
98	Giant goldenrod	5				5		5	
99	Slickseed wild bean								
100	American germander					10			
101	Stinging nettle					5			
102	Blue vervain								
103	Hoary vervain	5							
104	White vervain	5				20		5	
105	Wingstem							5	
106	Purslane speedwell								
107	Common blue violet	7		5		5		50	
109	Rough cocklebur								
110	Velvet leaf					5			
111	Garlic mustard					17		21	
112	Common burdock					5		5	
113	Blackberry lily					5		13	
114	Hoary-alyssum	5							
115	Hemp	5						5	
116	Clammy mouse-ear chickweed								
117	Lamb's quarter					5			
118	Blue mistflower								
119	Crown vetch								
120	Wild carrot								
121	Deptford pink								
122	Creeping Charlie							17	
123	Dame's rocket					5		5	
124	Iris sp.							5	
125	Prickly lettuce								
126	Henbit								
127	Motherwort	5							
128	Field pepperweed								
129	Bird's-foot trefoil								
130	Black medic								
131	Alfalfa								
132	White sweet clover								
133	Yellow sweet clover								

Taxa		West Shrubland		East Woodland		North Woodland		South Forest	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
135	Carpetweed								
136	Catnip	5				5			
137	Wild parsnip								
138	English plantain								
139	Spotted lady's thumb								
140	Sulphur cinquefoil	5				5			
141	Sheep sorrel								
142	Curly dock								
143	Bouncing bet	5							
144	White campion	5		5					
145	Common chickweed							5	
146	Common dandelion					5		5	
147	Penny cress					5			
148	Goat's-beard								
149	Red clover							5	
150	White clover								
151	Common mullein	17		5		5		5	
152	Corn speedwell	10							
153	Big bluestem								
154	Side-oats grama								
155	Smooth clustered sedge							5	
156	Woodland sedge	5		5		5		5	
157	Plains oval sedge	5							
158	Thin leaved sedge	5							
159	Davis sedge	5						5	
160	Heavy sedge								
161	James' sedge							20	
162	Leavenworth's sedge	5							
163	Midland sedge	20						5	
164	Field oval sedge								
165	Sand sedge								
166	Pointed broom sedge								
167	Blunt broom sedge								
168	Common fox sedge								
169	Sedge sp.	5				5		13	
170	Sandbur								
171	Great Plains flat sedge								
172	Schweinitz’s flatsedge								
173	Straw-colored flat sedge								
174	Common panic grass								
175	Scribner's panic grass	5							
176	Common spike rush								
178	Silky wild rye							5	
179	Purple lovegrass								
180	Nodding fescue					5		23	

Taxa		West Shrubland		East Woodland		North Woodland		South Forest	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
181	Sharp-fruited rush								
182	Dudley's rush								
183	Path rush	5							
184	Rice cutgrass								
185	Fall witchgrass								
186	Nimblewill	5							
187	Bead grass								
188	Little bluestem								
189	Hard stem bulrush								
190	Indian grass								
191	Rough dropseed								
192	Prairie dropseed								
193	Purple top	5							
194	Quack grass								
195	Redtop								
196	Smooth brome	50		5		80		34	
197	Japanese brome								
198	Downy chess	5							
199	Orchard grass					5		5	
200	Woolly cupgrass								
201	Tall fescue								
202	Japanese stiltgrass							77	
203	Reed canary grass							5	
204	Timothy	5							
205	Kentucky bluegrass	25		5				5	
206	Giant foxtail			5					
207	Yellow foxtail								
208	Bittersweet			5	ss,sh				
209	Hackberry					5	ss,55	5	ss,10,15
210	Rough-leaved dogwood	5	sh	5	sh	56	ss,sh,sap		
211	Downy hawthorn							5	5,10
212	Green ash								
213	Honey locust	5	ss,sap	5	10,15	39	sap,5,15,20,25,30,35,40,45,50,55,60	45	10,15,20,25,30,35,40,45,50,60,70
214	Black walnut	5	sh,sap,5			5	sh,sap,5,30	5	ss,40,45,50
215	Eastern red cedar			5	15	5	20,30		
216	Woodbine	5	ss	25	ss	45	ss	33	ss
217	Eastern cottonwood								
218	Wild black cherry	80	sh,sap,5	5	sh,sap,10	33	ss,sh,sap,5,10,25	33	ss,10,15,20,35,40,45,50,55
219	Choke cherry							5	sh
220	Northern red oak			5	10				

Taxa		West Shrubland		East Woodland		North Woodland		South Forest	
No.	Common Name	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody	AbFrq	Woody
221	Bur oak								
222	Black oak								
224	Smooth sumac								
225	Prickly/MO gooseberry							5	ss
226	Black raspberry	5	ss,sh			5	sh	5	ss,sh
227	Sandbar willow								
228	Black willow								
229	Bristly greenbrier							5	ss,sh
230	Coralberry	5	sh						
232	Poison ivy	54	ss	50	ss	5	ss	13	ss,sap
233	American elm							5	10
234	American/Red Elm								
235	Riverbank grape	5	ss	5	sh,sap	5	ss		
236	Prickly ash								
237	Tree of heaven								
238	Autumn olive	5	ss						
239	Privet sp.			5	sh				
240	Amur honeysuckle	5	sh,sap	29	ss,sh,sap,5	63	ss,sh,sap	65	ss,sh,sap,5,10
241	Tartarian honeysuckle							5	sap
242	Osage orange	5	ss			5	sap,20,30	33	15,20,25,30,45
243	White mulberry	5	sh	5	ss,10,15	5	60	28	5,10,15,20,25 ,45,50,55
244	Common buckthorn					5	sh	5	ss,sh
245	Multiflora rose	5	ss,sh	5	sh			20	ss,sh,sap
246	Siberian elm	5	sap	45	10,15,20,50,60			5	40,50
	Total Species	63		27		61		71	

community or area in the park, an answer may be found in Table 15. A few of the salient variables are briefly discussed here to provide ecological insight and to illustrate this valuable information.

Richness – Many of the richness variables are dependent on the area sampled as well as the sample effort or amount of time spent looking. The area of the communities varies substantially, from 0.3 acre to 10.9 acres (Table 11). Thus there is an area bias present in some variables. For example, the highest total native richness (87 species) is in the central grassland, which is the largest community. The lowest total native species richness (17 species) is in the east woodland which is 1.5 acres and the second to smallest community. Area is clearly a chief factor in explaining the difference. The variables that report an index or percentage are less affected by differences in area or sample effort because they are standardized. A good example is the native/non-native richness index, which is a simple measure of community quality and independent of area. The largest community, the central grassland, has an index of 2.4. The highest index is 3.6 for the east wetland, which has an area of 0.3 acre and is the smallest (Table 11). The lowest index is 1.7, which was observed for the east woodland and the second smallest area (1.5 acres). The second lowest index is 1.8 for the east grassland, which has the fourth largest area (3.5 acres). It is apparent the native/non-native richness index is determined more by quality than it is by area.

The conservatism successional index is also independent of area. In theory, the index could range from 0.0 (0 high conservative species for each low conservative species) to a value between 1.0 and 2.0 (meaning 1 or 2 high conservative species for each low conservative species). The range of indices at Sand Prairie Park is from 0.0 to 0.2, with an average index of 0.038. These are all very low and highly indicative of communities in the early stages of plant succession. The overall weighted disturbance indices are all very high, indicating a high disturbance factor. Based on this index, the most disturbed is the north woodland (113.1), and the least disturbed is the east wetland (86.5).

The native forb/graminoid richness index identifies the number of native forbs present for each native grass species and is independent of area. It conveys a measure of the native herbaceous diversity and structure and the different ecosystem functions provided by forbs versus graminoids. The top three indices are 10.3 in the north woodland, 7.0 in the east woodland, and 3.5 in the south forest. However, the highest native forb richness is 57 species observed in the central grassland. The east grassland has the second highest native forb richness with 48 species (Table 15).

The relative percentage for native high conservative is also independent of area and provides a straightforward measure of quality. There is a striking pattern exhibited. The highest percentage is 9.9% in the east grassland. The four herbaceous communities have an average percentage of 5.0%, while the four woody communities have an average percentage of 0.0% (Table 15). This pattern highlights the fact that grassland prairie and shallow wetland house the native plant diversity, while the extant woody communities are antithetical to native diversity and degrade the parks conservation value.

Absolute Frequency – The frequency variables are dependent on area unless expressed as an index or percentage. The native/non-native frequency index is a useful measure of quality that conveys the amount of native vegetation relative to the amount of non-native vegetation (e.g., an index equal to 3 means the native vegetation is 3 times more abundant than non-native vegetation). The top three indices are 7.1 for the east wetland, 2.7 for the central grassland, and 2.2 for both the north woodland and the west shrubland (Table 15). Which three communities have the highest relative percentage of herbaceous ruderal species (annuals and biennials) relative to all herbaceous species? The answer is the north woodland (37.6%), the east grassland (32.6%), and the west grassland (32.3%). This suggests that these communities are among the communities with the highest disturbance. At the other end of the spectrum, the community that is least disturbed and has the lowest percentage herbaceous ruderal species relative to all herbaceous species is the east wetland with a percentage of 11.1% (Table 15). The three communities that are most impacted by non-native cool-season forage grasses are the north woodland where those species comprise 85.0% of the graminoid abundance, the east woodland with a percentage of 75.0%, and the south forest with a percentage of 60.9%. The community with the least impact from non-native forage grasses is the east wetland (12.6%) (Table 15).

Conservatism – The variables that express mean conservatism are independent of area, but the negativity indices and the floristic quality indices utilize richness in their calculation, thus there is an element of area dependence in their measurement. The exotic herbaceous negativity index measures the amount of negative impact herbaceous non-native species have on the community. The three highest indices are 15.7 in the east grassland, 10.3 in the south forest, and 9.4 in west grassland (Table 15). The exotic woody negativity indices ($\bar{y}$=3.2) are 59% lower on average than the exotic herbaceous indices ($\bar{y}$=7.8). This means that overall, the non-native herbaceous species are a bigger problem than the non-native woody species. Non-native woody species are most negative in their impact in the south forest (7.3) and in the east woodland (4.5).

Table 15. Vegetation description and assessment variables for eight plant associations at Sand Prairie Park.

	Vegetation Variables	West Grassland	Central Grassland	East Grassland	East Wetland	West Shrubland	East Woodland	North Woodland	South Forest
Richness		10.3	10.9	3.6	0.3	1.8	1.5	3.6	5
1	Native Forbs	34	57	48	16	24	7	31	28
2	Non-native Forbs	17	24	29	5	9	2	11	11
3	Total Forbs	51	81	77	21	33	9	42	39
4	Native Graminoids	12	19	23	12	11	1	3	8
5	Non-native Graminoids	4	6	10	3	4	3	2	5
6	Total Graminoids	16	25	33	15	15	4	5	13
7	Native Woody	17	11	10	1	9	9	10	12
8	Non-native Woody	6	6	5	0	6	5	4	7
9	Total Woody	23	17	15	1	15	14	14	19
10	Total Native	63	87	81	29	44	17	44	48
11	Total Non-native	27	36	44	8	19	10	17	23
12	Total Species Richness	90	123	125	37	63	27	61	71
13	Native Ruderal Forbs	11	24	21	7	10	0	11	12
14	Non-native Ruderal Forbs	10	12	16	2	5	2	7	6
15	Native Ruderal Graminoids	0	0	1	0	0	0	0	0
16	Non-native Ruderal Graminoids	1	2	4	0	1	1	0	0
17	Native High Conservative (≥ 7)	2	3	8	1	0	0	0	0
18	Native High Conservative Relative Pct (%)	3.2	3.4	9.9	3.4	0.0	0.0	0.0	0.0
19	Native Low Conservative (≤ 3)	38	55	48	15	34	15	34	33
20	Native Low Conservative Relative Pct (%)	60.3	63.2	59.3	51.7	77.3	88.2	77.3	68.8
21	Native/Non-native Richness Index	2.3	2.4	1.8	3.6	2.3	1.7	2.6	2.1
22	Native Forb/Graminoid Richness Index	2.8	3.0	2.1	1.3	2.2	7.0	10.3	3.5
23	Herbacous Ruderal Richness Pct %	32.8	35.8	38.2	25.0	33.3	23.1	38.3	34.6
24	Conservatism Successional Index	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0
25	Overall Weighted Disturbance Index	96.7	104.9	107.2	86.5	109.5	103.7	113.1	104.2
Absolute Frequency									
26	Native Forbs %	414	654	554	176	150	35	293	256
27	Non-native Forbs %	138	206	420	25	62	10	67	91
28	Total Forbs %	552	860	974	201	212	45	360	347
29	Native Graminoids %	187	267	286	242	70	5	15	81

Vegetation Variables	West Grassland	Central Grassland	East Grassland	East Wetland	West Shrubland	East Woodland	North Woodland	South Forest
30 Non-native Graminoids %	173	156	205	35	85	15	85	126
31 Total Graminoids %	360	423	491	277	155	20	100	207
32 Native Woody %	186	145	166	5	169	110	203	164
33 Non-native Woody %	84	30	65	0	30	89	78	161
34 Total Woody %	270	175	231	5	199	199	281	325
35 Total Native %	787	1066	1006	423	389	150	511	501
36 Total Non-native %	395	392	690	60	177	114	230	378
37 Total Species Frequency %	1182	1458	1696	483	566	264	741	879
38 Ruderal Forbs %	205	392	453	53	92	10	173	136
39 Ruderal Graminoids %	5	22	25	0	5	5	0	0
40 Native/Non-native Frequency Index	2.0	2.7	1.5	7.1	2.2	1.3	2.2	1.3
41 Native Forb/Graminoid Frequency Index	2.2	2.4	1.9	0.7	2.1	7.0	19.5	3.2
42 Non-native Forb Relative Frequency Pct %	25.0	24.0	43.1	12.4	29.2	22.2	18.6	26.2
43 Non-native Graminoid Relative Frequency Pct %	48.1	36.9	41.8	12.6	54.8	75.0	85.0	60.9
44 Herbaceous Ruderal Relative Frequency Pct %	23.0	32.3	32.6	11.1	26.4	23.1	37.6	24.5
45 Total Woody Relative Frequency Pct %	22.8	12.0	13.6	1.0	35.2	75.4	37.9	37.0
Conservatism								
46 Native Forb Mean Conservatism	3.1	3.0	3.2	3.5	2.3	2.6	2.4	2.7
47 Native Graminoid Mean Conservatism	4.2	4.2	4.5	4.1	3.5	3.0	4.3	3.9
48 Native Woody Mean Conservatism	3.1	2.6	2.9	3.0	2.6	2.8	2.4	2.8
49 Native Herbaceous Weighted Mean Conservatism	3.6	3.3	3.6	4.3	2.8	2.6	2.2	3.1
50 All Herbaceous Weighted Mean Conservatism	1.5	1.7	1.1	3.5	1.1	0.3	0.8	0.5
51 Native Woody Weighted Mean Conservatism	2.6	2.1	2.2	3.0	2.3	2.1	2.7	2.6
52 All Woody Weighted Mean Conservatism	1.0	1.2	0.9	3.0	1.5	0.7	1.1	-0.2
53 Exotic Herbaceous Negativity Index	9.4	8.5	15.7	2.2	6.0	5.3	4.9	10.3
54 Exotic Woody Negativity Index	3.9	2.1	2.8	0.0	1.9	4.5	3.2	7.3
55 FQI Native Species	26.3	29.7	31.9	20.1	17.6	11.2	16.7	20.4
56 Weighted FQI All Species	14.5	19.0	11.9	21.4	8.7	1.4	6.5	4.2
Wetland								
57 Mean Native Forb Wetland Index	3.6	2.4	2.7	-2.2	2.8	1.3	1.7	1.4
58 Mean Native Graminoid Wetland Index	3.4	3.0	2.6	-3.1	1.8	0.0	0.7	2.3
59 Mean Native Woody Wetland Index	1.5	1.9	0.4	-5.0	1.9	1.7	1.7	1.7

Vegetation Variables	West Grassland	Central Grassland	East Grassland	East Wetland	West Shrubland	East Woodland	North Woodland	South Forest
60 Mean Exotic Wetland Index	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61 All Species Weighted Mean Wetland Index	3.0	2.8	2.7	-2.6	2.6	2.5	2.4	2.0
Prairie								
62 Prairie Species Richness	42	63	60	15	26	6	16	15
63 Prairie Indicator Richness	17	23	28	3	3	1	1	0
64 Prairie Species Richness Relative Pct %	46.7	51.2	48.0	40.5	41.3	22.2	26.2	21.1
65 Prairie Indicator Richness Relative Pct %	40.5	36.5	46.7	20.0	11.5	16.7	6.3	0.0
66 Prairie Species Mean Prairie Score	2.6	2.4	2.8	1.9	1.7	1.7	1.8	1.4
67 All Species Weighted Mean Prairie Score	1.2	1.2	1.2	0.7	0.5	0.2	0.2	0.2
68 Total Prairie Species Frequency %	576	390	807	214	454	5	578	588
69 Total Prairie Species Frequency Relative Pct %	48.7	26.7	47.6	44.3	80.2	1.9	78.0	66.9
70 Prairie Quality Index (scaled to 100)	2.6	1.5	4.1	0.2	0.1	0.0	0.0	0.0
Woodland/Forest								
71 Total Frequency Native Shrubs&Lianas %	81	110	107	0	79	90	116	66
72 Total Frequency Native Trees %	105	35	59	5	90	20	87	98
73 Total Frequency Non-native Shrubs/Lianas %	10	15	5	0	15	39	68	95
74 Total Frequency Non-native Trees %	74	15	60	0	15	50	10	66
75 Exotic Woody Frequency Relative Pct %	31.1	17.1	28.1	0.0	15.1	44.7	27.8	49.5
76 Native Understory Richness-Structure	24	15	16	1	13	9	14	12
77 Exotic Understory Richness-Structure	11	7	7	0	8	6	5	9
78 Total Understory Richness-Structure	35	22	23	1	21	15	19	21
79 Exotic Understory Rich-Struct Relative Pct %	31.4	31.8	30.4	0.0	38.1	40.0	26.3	42.9
80 Total Native Old Growth Index	0	0	0	0	0	0	2	3
81 Exotic Old Growth Index	0	0	0	0	0	1	1	2

The native FQI is based solely on the coefficients of conservatism for native species. The abundance of each species is not a factor in the calculation, thus the native FQI is a measure of the inherent, native quality of the vegetation, when only each species' quality (its conservatism) is equally considered. The weighted FQI for all species is adjusted to reflect the negative effect of non-native species and the differing contributions of species to quality due to their abundance. The weighted FQI for all species can be either lower or higher than the native FQI. If the weighted FQI for all species is lower, it means the community is 1) degraded to some degree by non-native species, and/or 2) lower conservative species are more abundant than high conservative species. If it goes up, it means the community is not impacted much by non-native species and the environment is especially favorable for high conservative species. The pattern at Sand Prairie Park is that the weighted FQI for all species is lower than the native FQI in all the communities except the east wetland (Table 15). This comparison of the two FQI values is helpful because it is independent of area. It provides a fair assessment of small versus large communities, and shows that the east wetland has the greatest floristic quality. The three grassland prairies have the highest native FQI (Table 15). Their average native FQI ($\bar{y}$=29.3) is very significantly larger than the average native FQI for the four woody communities ($\bar{y}$=16.5) (t-test p-value= 0.0048). Generally an FQI in the range of 30 to 35 is considered representative of good quality and floristically noteworthy.

Wetland – The all species weighted mean wetland index is a good measure of a community's status as a wetland as well as its position along a moisture gradient. It includes all of the species present and factors in their abundance. The index is based on a plant species' probability of occurring in a wetland environment. A negative index signifies a wetland. The more negative the index, the longer the hydroperiod of the wetland. A positive index implies an upland environment. The more positive the index, the drier the upland site. Based on this measure, the east wetland is the only wetland at Sand Prairie Park. Its index of -2.6 suggests its hydroperiod is midway between temporarily and permanently flooded (Table 15). The most xeric habitat, according to the all species weighted mean wetland index, is the west grassland with an index of 3.0. The average index for the 3 grassland prairies ($\bar{y}$=2.8) is significantly higher than the average index for the 4 woody communities ($\bar{y}$=2.4) (t-test p-value= 0.045). This indicates the grassland prairie is drier (i.e., has lower soil moisture) than the woody communities (the shrubland, woodland and forest). It is therefore possible that differences in soil moisture were a factor in where woody encroachment occurred, converting grassland prairie to a woody community, and contributing to the loss of prairie.

Prairie – All the communities mapped and surveyed at Sand Prairie Park have at least 6 or more prairie species present (Table 15), and all but one (south forest) have 1 or more prairie indicator species. This is most likely an outcome of a strong prairie legacy, the presence of prairie plants on the entire site historically, either as a prairie community or in the herb layer of a savanna. Thus prairie, or at least prairie plant populations, is still present throughout the site despite the appearance of non-prairie communities. In prairie mapping research completed in southern Iowa and northern Missouri (Rosburg 2003, Rosburg 2005, Rosburg 2016), the minimum requirement for mapping a prairie remnant was the presence of 5 prairie indicator species within a confined area (i.e., with sufficient proximity to each other to fit the definition of a community). Using that definition, only the 3 grassland prairie communities qualify as a prairie remnant (Table 15). The challenge in defining and mapping remnant prairie is deciding how much degradation can be tolerated and still maintain a reasonable claim that it is a prairie.

The presence of 5 prairie remnant species is simple and quick, and arguably fairly liberal in its identification of a prairie remnant. [Note: That definition is a bit more nuanced. The requirement is 5 prairie indicator species AND that at least 1 of them must be graminoid and 1 must be a forb]. A more quantitative and rigorous qualification for identifying a prairie remnant is a prairie quality index of 20 or higher. Under that definition, none of the communities qualify to be described as a prairie remnant. The best of the 3 prairie grasslands is the east grassland with a prairie quality index of 4.1. The east grassland has the highest number of prairie indicator species (28), the highest percentages of both prairie species (48.0%) and prairie indicator species (46.7%), the highest mean prairie score (2.8), and the highest total prairie species frequency (807%) (Table 15). It is worth noting that much of the east grassland corresponds to the area where intensive quarry operations occurred.

Woodland/Forest – These variables convey information about the structure and quality of woodlands and forests, which combined with shrublands occupy 11.9 acres (32.1%) of the study area at Sand Prairie Park. While these communities add to the floral diversity at Sand Prairie Park, by themselves and in their current state, they are not critical for the conservation of woodland plants. The Special Concern species observed in the south forest (smooth clustered sedge) will be delisted in the next official list of imperiled plants. And while the shrubland, woodland and forest communities support many prairie species, in most cases those species are also present and probably doing better in the grassland prairie communities. An exception to that statement might be a prairie species that was only observed in one of the woody communities. There are two such species to note – cranesbill and smooth scouring-rush – both are prairie indicator species. Smooth scouring-rush was only observed in the east woodland, and

cranesbill, which is a notable sand prairie specialist, was only observed in the west shrubland. Neither community is valuable as a native ecosystem, rather both are artifacts of the lack of fire and prairie management. Both plant species have been able to persist in an environment that is becoming more and more unfriendly. The prairie quality indices for the east woodland and the west shrubland are 0.0 and 0.1 respectively, so both are very degraded. The west shrubland has two additional prairie indicator species present. Despite the fact that neither the shrubland nor the upland mixed woodland look anything like prairie, prairie species are still present.

The total frequency (%) of all shrub/liana species (add variables 71 and 73) provides a measurement useful to management in that it identifies habitats that have high levels of woody encroachment by species that can form dense thickets and drastically decrease the amount of light to the herbaceous layer. The fact that all the communities, except the east wetland, have a total frequency above 90% (Table 15) implies that woody encroachment is a problem throughout the park. The highest amounts (> 150%) are in the north woodland and south forest, 184% and 161% respectively. The east woodland, central grassland, and east grassland each have a total frequency over 100% (ranging from 112% to 129%).

Native and exotic understory richness-structure variables are useful in that they reflect the amount of woody species regeneration present in terms of the number of woody species and their size classes. All woody species, whether they are a shrub, liana or tree growth form, spend time in the seedling/sprout, shrub, and sapling size classes used in this study. Richness-structure is a count of the species and size class combinations present. Exotic understory rich-struct relative pct % is the percentage of the total richness-structure that is non-native. In answers the question – what percentage of woody regeneration (essentially all woody stems less than 5 cm DBH) is from non-native species? On average and across all communities, except the east wetland, the non-native contribution to woody regeneration is about 34%. It is highest in the south forest and east woodland, and lowest in the east wetland, where it is 0%.

The old growth index is designed to identify communities with significant old growth forest, so it has no importance at Sand Prairie Park. The highest native old growth index observed was 3 in the south forest, a number much too low to be indicative of old growth.

Whittaker Plots and Herbicide Treatment

The species composition of the Whittaker plots is reported in Table 16 (plot 1) and Table 17 (plot 2). The locations of the plots can be seen in Figure 17. This research was done to provide data on the effect

of an application of Clethodim, a grass herbicide, to about 8 acres of the central grassland on April 10, 2024. Prior to the Clethodim application, park staff protected about 300 rosette plants of panic grass (*Dichanthelium* sp.) with upside down styrofoam bowls. The data are able to provide some insight on plant responses to the Clethodim, but those insights are limited due to the baseline data, or pretreatment data, having to be collected in early April soon after the Clethodim application occurred. This timing was too early in the growing season to get a full measure of the plant species composition of the plots. There were only 9 species observed in plot 1 and 16 species found in plot 2 during the April survey. The same plots surveyed in August, for the post-treatment data, resulted in observations of 50 species in plot 1 and 45 species in plot 2. A judgement concerning a plant's response to Clethodim requires both pre-treatment and post-treatment data. The correct way to have done this research is to have collected the pre-treatment data during the growing season prior to Clethodim application, in July or August of 2023. It didn't happen that way because this was seen as a "last minute" effort to put science in play as best as possible given the situation at hand.

Another deficiency of the research is there is not a control. There is not a plot where Clethodim application did not occur that can provide comparison with the treated plots. Since the study was limited in its design, the data are used to provide anecdotal trends. There was not a statistical analysis applied. The goals of the research were to provide answers to two questions – 1) Was Clethodim effective in controlling non-native grasses? 2) Did Clethodim cause collateral damage to native species?

Smooth brome was the target species for the Clethodim application. The data suggest that Clethodim was not effective in reducing the smooth brome population. In both plots, the weighted frequency of smooth brome was 99% to 100% in April and unchanged in August. The density of smooth brome tillers and shoots (i.e., ramets) increased from April to August by 280 ramets/m^2 in plot 1 and 207 ramets/m^2 in plot 2. It seems there was not a positive outcome for smooth brome. The result was similar for Kentucky bluegrass. Essentially no change in weighted frequency from April to August, and either a small decrease (-66 ramets/m^2) or moderate increase (103 ramets/m^2) for density (Tables 16 and 17). The protection given to emerging panic grasses was successful, or if plants were sprayed with Clethodim it was ineffective. Scribner's panic grass was observed on both dates in both plots, and it exhibited a consistent but slight increase from April to August for both weighted frequency and density (Tables 16 and 17).

Table 16. Plant species composition for Plot 1 at Sand Prairie Park in 2024. The apparent impact of Clethodim application for species observed in both April and August is shown with ≈ (no change), ↑ (increase), ↓(decrease). Gray shading indicates a non-native species. A species abundance is given by its weighted absolute frequency and its density. See the text for details.

Taxa		Wt Abs Frq (%)		Density (ram/m^2)		
No.	Common Name	April	Aug	April	Aug	
8	Common ragweed		0.3		0	
28	Horseweed		7.3		0.5	
29	Woolly croton		0.3		0	
33	American burnweed		1.7		0	
35	Prairie fleabane		2.7		0	
42	Carpet spurge		2.0		0.5	
50	Stickseed		1.7		0	
68	Common yellow wood sorrel		30.0		4.3	
92	Black nightshade		0.7		1.1	
99	Slickseed wild bean		1.7		1.1	
4	Common yarrow	0.3	0.3	0.0	0	≈
18	Common milkweed		0.3		0	
39	Late thoroughwort		2.7		0	
60	Wild bergamot	46.3	70.3	43.2	37.3	↑≈
71	Clammy ground cherry		10.7		0.5	
73	VA ground cherry		0.7		0	
93	Horse nettle		21.7		2.7	
97	Canada goldenrod	4.7	8.7	1.6	0.5	≈
98	Giant goldenrod		5.3		9.1	
102	Blue vervain		3.7		0	
103	Hoary vervain	7.3	21.0	0.5	4.8	↑
104	White vervain		2.7		0	
169	Sedge species	19.7	28.7	3.2	12.8	↑
171	Great Plains flat sedge		1.7		0	
172	Schweinitz's flat sedge		3.7		0	
175	Scribner's panic grass	0.3	0.7	0.0	3.7	↑
179	Purple lovegrass		0.3		0	
185	Fall witchgrass		5.7		1.1	
193	Purple top		52.0		35.7	
210	Rough-leaved dogwood		0.3		0	
216	Woodbine		4.3		0.5	
232	Poison ivy		34.7		33.1	
213	Honey locust		3.3		0	
218	Wild black cherry		8.7		0.5	
234	American/Red elm		0.3		0	
114	Hoary alyssum		0.3		0	
115	Hemp		0.7		0.5	
130	Black medic		0.3		0	

Taxa		Wt Abs Frq (%)		Density (ram/m^2)		
No.	Common Name	April	Aug	April	Aug	
136	Catnip		0.7		0	
141	Sheep sorrel		2.7		0	
149	Red clover		3.0		0	
150	White clover		49.7		27.2	
151	Common mullein		45.3		23.5	
195	Redtop	6.7	0	2.1	0	↓
196	Smooth brome	99.0	100.0	470.4	751.5	↑
205	Kentucky bluegrass	98.0	100.0	649.6	584.0	≈
207	Yellow foxtail		12.0		9.1	
243	White mulberry		11.3		0.5	
245	Multiflora rose		2.7		0	
246	Siberian elm		0.3		0	
	Forb Seedling	38.3	40.3	4.3	10.7	
	Graminoid Seedling/Tiller	0	22.3	0	10.1	

Table 17. Plant species composition for Plot 2 at Sand Prairie Park in 2024. The apparent impact of Clethodim application for species observed in both April and August is shown with ≈ (no change), ↑ (increase), ↓(decrease). Gray shading indicates a non-native species. A species abundance is given by its weighted absolute frequency and its density. See the text for details.

Taxa		Wt Abs Frq (%)		Density (ram/m^2)		
No.	Common Name	April	Aug	April	Aug	
1	Slender three seeded mercury		1.7		0	
8	Common ragweed		8.3		0.5	
28	Horseweed		10.0		0.5	
29	Woolly croton		1.7		0	
33	American burnweed		0.3		0	
68	Common yellow wood sorrel		4.3		0	
99	Slickseed wild bean		2.7		0	
26	Tall thistle		6.3		0.5	
27	Field thistle		0.3		0	
50	Stickseed		5.7		0.5	
4	Common yarrow	7.7	4.0	2.1	1.1	≈
18	Common milkweed		7.3		0.5	
19	Whorled milkweed		0.3		0	
21	Hairy aster	0.7	0.3	0	0	≈
30	Illinois tick-trefoil		0.3		0	
36	Tall boneset	0.3	14.7	0	0.5	↑≈
58	American bugleweed		0.7		0	
60	Wild Bergamont	33.7	50.3	28.8	25.6	↑≈
71	Clammy ground cherry		3.3		0.5	
73	VA ground cherry		10.0		2.7	
84	Wild petunia		23.7		6.9	
93	Horse nettle		26.3		1.1	
97	Canada goldenrod	11.7	19.0	1.1	3.2	↑
98	Giant goldenrod		0.7		0	
103	Hoary vervain	2.7	11.7	0.5	2.1	↑
104	White vervain		6.7		1.1	
23	American bindweed	1.7	1.7	0	0	≈
169	Sedge species	31.0	24.3	4.8	30.4	↑≈
175	Scribner's panic grass	3.7	9.3	0	1.1	↑
224	Smooth sumac		1.7		0	
216	Woodbine		24.3		6.9	
218	Wild black cherry	0.7	0	0	0	≈
232	Poison ivy		77.3		67.7	
213	Honey locust		5.0		0	
117	Lamb's quarter		3.7		0	
135	Carpetweed		0.7		0	
151	Common mullein	4.3	38.0	0	10.1	↑
142	Curly dock	0.3	0	0	0	≈

Taxa No.	Common Name	Wt Abs Frq (%) April	Wt Abs Frq (%) Aug	Density (ram/m^2) April	Density (ram/m^2) Aug	
149	Red clover	0.3	52.0	0	72.5	↑↑
150	White clover		33.3		8.5	
196	Smooth brome	100.0	100.0	490.7	697.7	↑
205	Kentucky bluegrass	92.3	96.0	653.9	756.6	↑
206	Giant foxtail		0.7		0	
207	Yellow foxtail		23.0		10.7	
240	Amur honeysuckle	0.3	0	0	0	≈
242	Osage orange		0.3		0	
243	White mulberry		10.0		1.1	
246	Siberian elm		3.7		0	
	Forb Seedling	46.7	39.0	14.9	11.7	
	Grass Seedling		6.0		1.6	

A great advantage with Clethodim is its specificity for grasses (family Poaceae), and that it has no effect on forbs and other graminoids like sedges. This was confirmed with the data obtained on sedges. In plot 1, sedge weighted frequency increased by 9% and density increased by 9.1 ramets/m^2 from April to August. In plot 2, weighted frequency decreased slightly by 6.7%, but density increased 25.6 ramets/m^2. There were 7 native forbs that were observed in both April and August. There were no negative impacts seen for any of them. Over 50% of the forb responses observed were positive, meaning at least a slight increase in frequency or density was seen.

The two methods for measuring the abundance of plant species that were used in plots 1 and 2, that is frequency and density, are not the most suitable for detecting and measuring the amount of growth by a plant. It is possible for the amount of growth to decrease, yet there is no change in the frequency or density. The number of plants present must decrease in order for a decrease in frequency (i.e., decrease in the number of quadrats containing at least one plant) or a decrease in density (i.e., decrease in the number of stems per unit area) to be recognized. An herbicide, or some other environmental factor, could cause less growth by a plant, but if that does not result in the removal of the plant, then both frequency and density does not change. The measurement best suited to reflect a decrease in growth is biomass data, or productivity measurements. In this method, all the living plant tissue of herbaceous species is cut and removed from a quadrat, sorted by species, dried in an oven for 24 hours, and then weighed. It is the most accurate measurement of a plant species' abundance. However, it is also very time-consuming and as a consequence, more expensive.

The biomass method was not used in this study because 1) biomass samples should be collected near the end of the growing season in order to reflect total growth, and the pre-treatment data in this study had to be collected in April of the same year of the treatment, 2) there was not a control plot available because the Clethodim application had already been made to the entire 8 acre site, and 3) the added time and expense was not appropriate.

There was a negative effect of Clethodim on the growth of smooth brome that could be seen throughout the growing season. Unfortunately, biomass data is not available to document this observation. The suppression of smooth brome was sufficient to reduce its growth and its competitive ability, but not enough to reduce the number of plants significantly. One reason may be related to the timing of the application and the size of the target plants. The Clethodim labels states, under the instructions for USE DIRECTIONS FOR PERENNIAL GRASSES:

- Make applications only to actively growing grasses at recommended weed heights.
- Apply when the first grass weed species in a mixed grass weed population reaches the recommended growth stage for treatment

A table then lists several perennial grass species and the recommended plant height, but it does not include smooth brome. It does list other non-native, perennial forage grasses similar to smooth brome, like tall fescue (4-8 inches), orchard grass (4-8 inches), quack grass (4-12 inches), and Kentucky bluegrass (2-4 inches). The label also highly recommends the use of a non-ionic surfactant.

At the time of the application on April 10 (and my surveys on April 11), the height of smooth brome was certainly less than 4 inches, and the height of Kentucky bluegrass was less than 2 inches. Because the plants were not within the recommended height range, there was not sufficient leaf area for herbicide absorption. Clethodim works by inhibiting the enzyme acetyl-CoA carboxylase (ACCase) in grasses (Chemical Warehouse 2026). This enzyme is crucial for fatty acid synthesis which is essential for cell membrane formation and plant growth, and the homomeric version of the enzyme is unique to grasses. By inhibiting ACCase, Clethodim disrupts the normal growth processes in grasses.

The Clethodim label advises that for perennial grasses where tillage is not available as a means of control, for example in perennial vegetation, it is likely that an additional application will be needed for complete control. In a five-year study of the renovation of a remnant sedge meadow, Rosburg (2024) showed that successful control and suppression of reed canary grass required 3 consecutive and annual applications of Clethodim. The best results were with an application on the regrowth of reed canary after a spring burn, and with an application in early September on the regrowth of reed canary that had been mown in June, July and August.

The suppression of smooth brome growth by Clethodim seen in this research at Sand Prairie Park most likely contributed to the growth and visibility of many sedges and forbs, which enhanced the efficiency and thoroughness of the floristic inventory. A possible negative outcome was observed in plot 2, where Clethodim may have indirectly supported an increase in the frequency and density of red clover from April to August (Table 17). On the other hand, this may also simply reflect the normal phenology and regrowth of red clover.

Summary Comments

The important role of Sand Prairie Park in protecting an example of a remnant sand prairie ecosystem is confirmed with this work. Sand prairies are one of Iowa's most distinctive prairie ecosystems and rarest types of prairie. They are mostly observed in the eastern half of Iowa in association with a major river valley. Sand prairie or sand savanna remnants are represented in the State Preserve System at Behrens Ponds and Woodland State Preserve in Linn County (Cedar River), Cedar Hills Sand Prairie State Preserve in Black Hawk County (Cedar River), Marietta Sand Prairie State Preserve in Marshall County (Iowa River), and the Rock Island State Preserve in Linn County (Cedar River). Many more are protected by County Conservation programs, like Sandhill in Polk County (Skunk River), Bearbower Sand Prairie in Buchanan County (Bear Creek?), and Eddyville Sand Prairie Park in Wapello and Mahaska Counties (Des Moines River). Some are owned and managed by conservation organizations like the Corriell Nature Preserve in Muscatine County (Cedar River), which is protected by Bur Oak Land Trust. The largest sand prairie in Iowa is at Big Sand Mound Preserve in Muscatine and Louisa Counties (Mississippi River) protected by MidAmerican Energy and Bayer AG.

1) There is a significant sand prairie element in the flora of Sand Prairie Park. These species have extant populations.

- eastern prickly pear - Five plants observed in the sand exposure in the west end of the east grassland. None produced flowers. This population is most likely *Opuntia cespitosa*.
- slender three seeded mercury
- sand puccoon
- sand sedge
- Schweinitz's flat sedge
- Great Plains flat sedge
- fall witchgrass
- bead grass
- Carolina cranesbill

Historically these species were observed.

- sand dropseed
- western rock jasmine

While the original flora of this sand prairie can never be determined, it is certain that many additional psammophilus and dry prairie plant species were a part of the native flora. The reintroduction of those species should be a conservation goal. A very careful and thoughtful approach is necessary to determine

which species should be included. The extant floras of sand prairie in adjacent counties and biogeographic distribution maps based on herbaria vouchers will provide valuable information.

2) Sand Prairie Park supports at least 96 prairie species and 39 prairie indicator species. Most of the prairie species are not prairie indicators, meaning that while they primarily occupied prairie communities on the native landscape, they are not reliable indicators of prairie on today's highly modified landscapes. Their predominance among the prairie species is a sign of the degradation the sand prairie has suffered. Even though many of these prairie species are common, the first tenet of conservation is to keep common species common. Notably there are 9 (9.4%) high conservative species among the 96 prairie species. They are considered to have substantial dependence on high quality ecosystems, those landscapes with a greater level of natural ecological processes intact. The prairie might serve as a valuable seed source for certain prairie (especially sand prairie) species needed for conservation efforts at other sites.

3) Despite nine days and 90 hours of field research, and nearly 1,000 plant species observations, it is known that two plant species were missed during the plant surveys. Luuk Clark, the Iowa-Cedar Habitat Specialist for The Nature Conservancy in Iowa, visited the park on April 15, 2025 and reported to me that he observed *Carex heliophila* (now *Carex inops* in FNA), also known as sun-loving sedge, in a small patch on the east side of the central grassland. He also reported *Scutellaria parvula* (small skullcap) as an associate of the sedge. The addition of these two native species makes the total number of native species 240.

4) The awakening and potential renovation of a remnant sand prairie provides great excitement and anticipation. However, the invasive species toll at Sand Prairie Park is substantial and damaging. There are 66 non-native species present, and over a third of them, or 23 specifically, are classified as highly invasive. Over half of them, or 13 high invasive species, have an invasive score less than -175, making them a high priority for immediate control. A landmark report released in 2023 by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), found that invasive species pose major global threats to nature, economies, food security and human health (IPBES 2023). Key findings include (IPBES Media Release):

a) More than 37,000 alien species have been introduced by many human activities to regions and biomes around the world. This conservative estimate is now rising at unprecedented rates. More than 3,500 of these are harmful invasive alien species.

Figure 25. The fire break utilized for a prescribed burn at Sand Prairie Park in March 2024. This section of the fire break is northwest of the east wetland along the north boundary of the east grassland. The date for the photo is April 21.

b) The global economic cost of invasive alien species exceeded $423 billion annually in 2019, with costs having at least quadrupled every decade since 1970.
c) Invasive alien species have been a major factor in 60% and the only driver in 16% of global animal and plant extinctions that have been recorded, and at least 218 invasive alien species have been responsible for more than 1,200 local extinctions.

It is now the case that invasive species are the number one cause for the loss of native biodiversity. It is a problem that often exceeds the resources that conservation organizations have available for successful control. Nevertheless, neglecting it only allows the problem to grow. Invasive species must be a high priority for successful protection of native flora and fauna.

5) Prior to the Clethodim application in early April 2024, park staff completed a prescribed burn on the area. In preparation for the burn, a fire break (also known as a fire line) was created on the perimeter of the area. While this is standard procedure to help ensure the fire stays in prescription, or within the area to burn, this fire break was created by tillage (Figure 25). While this may be appropriate for reconstructed prairie, for example in one planted in a former agricultural field, it is not suitable for a remnant prairie. Tillage is likely to cause irreversible damage to a remnant prairie, and simply is not

necessary to establish an effective fire break. A more conventional, effective and safe method is to mow a 4 to 6-foot-wide strip as low as possible and then either rake or blow the litter into the burn area. While some sections of the fire break may have been in areas where no damage to the remnant was possible, the area shown in Figure 23 is especially important as habitat for native plants. High conservative, sand prairie obligate species are present here, for example eastern prickly pear, sand puccoon, Cleland's evening primrose and sand sedge. It is likely some of those species, or other prairie species, were highly stressed or killed by this fire break.

6) Although the data from the Whittaker plots has limited ability for assessing the effects of the Clethodim application, there was useful insight obtained concerning the responses of many species. These data also have great value in describing the plant species composition of the central grassland with an accuracy far better than the floristic inventory can provide. The weighted frequencies observed make it clear which species are dominant. In plot 1 they are smooth brome, Kentucky bluegrass, wild bergamot, purple top, common mullein, and white clover. In plot 2 they are smooth brome, Kentucky bluegrass, poison ivy, red clover, and wild bergamot. These species have a weighted frequency above 40%. Other species fit in a group that are moderate in their abundance, with a weighted frequency between 20% and 40%. Species in this group include sedge species, horse nettle, common yellow wood sorrel, hoary vervain, wild petunia, woodbine, and yellow foxtail.

The density of 25 species in plot 1 and 26 species in plot 2 is known. These data are very explicit in their measure of abundance and species' success in an environment, and rarely available in a description of a plant community. These plot data are extremely useful as a baseline measure of the species composition. They provide a point of reference for management aimed at ecosystem renovation going forward. It will be possible if so desired, to inventory these plots again in the future to ascertain a scientific and objective measure of the outcome produced by conservation work at Sand Prairie Park.

7) Lastly, there is about 1 acre of decent sand prairie on the adjacent property north of the boundary fence in the east grassland (Figures 2 and 17). It lies on a northeast facing slope between the fence and a tree belt at the bottom of the slope. Sand puccoon, little bluestem and other sand prairie species were observed from the fence line. If possible, adding this acre of prairie to the park should be a high priority. It appears to be a part of the original Showers/McCollister tract,

Literature Cited

Anderson, Paul F. 1997. GIS research to digitize maps of Iowa 1832-1859 vegetation from General Land Office Township plat maps. Living Roadway Trust Fund, Iowa Department of Transportation and Iowa State University, 256 pp.

Chemical Warehouse. 2026. Clethodim. https://chemicalwarehouse.com/blogs/active-ingredients/clethodim?srsltid=AfmBOorhl05otpnutlO2ycEVB3Kw-V2C2Gm2RnTjxnjFNUBAvZoPpOdB

Drobney. P., D. Lewis, D. Horton, D. Roosa, D. Smith, J. Pearson, M. Leoschke, and G. Wilhelm. 2000. Floristic quality technique: Iowa database; draft version. Unpublished data.

Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico [Online]. 25+ vols. New York and Oxford. http://beta.floranorthamerica.org.

Flora of Wisconsin – Consortium of Wisconsin Herbaria. University of Wisconsin at Madison. https://wisflora.herbarium.wisc.edu/taxa/index.php?taxon=4364

Eilers, L., and D. Roosa. 1994. The vascular plants of Iowa: an annotated checklist and natural history. University of Iowa Press, Iowa City, IA.

Iowa Geographic Map Server. https://ortho.gis.iastate.edu/

IPBES 2023. Summary for policymakers of the thematic assessment report on invasive alien species and their control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H. E., Pauchard, A., Stoett, P., Renard Truong, T., Bacher, S., Galil, B. S., Hulme, P. E., Ikeda, T., Sankaran, K. V., McGeoch, M. A., Meyerson, L. A., Nuñez, M. A., Ordonez, A., Rahlao, S. J., Schwindt, E., Seebens, H., Sheppard, A. W., and Vandvik, V. (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430692

Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. The National Wetland Plant List: 2016 Midwest wetland ratings. Phytoneuron 2016-30: 1-17.

Majure, L.C., W.S. Judd, P.S. Soltis, and D.E. Soltis. 2017. Taxonomic revision of the *Opuntia humifusa* complex (Opuntieae: Cactaceae) of the eastern United States. Phytotaxa 290 (1):1-65.

Rosburg, T.R. 2003. Grand River grasslands project: an inventory of the remnant prairies of southeastern Ringgold County, Iowa. Final Report to The Nature Conservancy of Iowa, Des Moines, IA and the Iowa Academy of Science, Cedar Falls, IA.

Rosburg, T.R. 2006. Inventory, mapping and quality assessment of remnant prairies in the Grand River Grasslands, Harrison County, Missouri. Final Report to The Nature Conservancy of Missouri, St Louis, MO.

Rosburg, T.R. 2017. Remnant prairie inventory in the Grand River Grassland (Comprehensive Conservation Strategy Landscape) in northwestern Harrison County, Missouri. Final Report to the Missouri Department of Conservation, Jefferson City, MO. 96 pages

Rosburg, T.R. 2024. Ecological restoration of a sedge meadow community. Final Report to Living Roadway Trust Fund, Iowa Department of Transportation, Ames, IA. 52 pages.

Swink, F., and G. Wilhelm. 1979. Plants of the Chicago region. The Morton Aboretum, Lisle, IL.

Thieret, J.W. 2003. *Microstegium vimineum*. Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 25+ vols. New York and Oxford. Vol. 25.

U.S. Climate Data. https://www.usclimatedata.com/

Yatskievych, G. 2006. Steyermark's Flora of Missouri Volume 2. Missouri Botanical Garden Press, St. Louis, MO and Missouri Department of Conservation, Jefferson City, MO.

Acknowledgments

Financial support for this research was provided by Johnson County Conservation and the Johnson County Friends of Sand Prairie Park. The work reported could not have been completed without their generosity and commitment to conservation.

Aaron Basten, Dominic Balestrieri-Fox, and Max Friton provided assistance that was essential in completing the plant inventories on the Whittaker Plots. I am grateful for their availability and attention to detail in recording data.

Judy Felder furnished access to key documents that added important historical insight about the work of the "prairie saviors" in the 1990s.

Appendix A. Plant species list for Sand Prairie Park. Under column Note, SC=Special Concern and taxa represented as generic and double species are indicated. A taxa treated as a redundant species is shown with boldface blue font. For Growth Forms, A=annual, B=biennial, P=perennial, Suff=suffrutescent, Sub=submergent, Pter=pteridophyte, Gram=graminoid. RICC is Revised Iowa Coefficient of Conservatism. Wet Aff is Wetland Affinity. Gray shading indicates a non-native species. Red font indicates a plant species not recognized by Eilers and Roosa 1994. Current nomenclature in Flora of North America is shown if the species' family has been published.

Taxa #	Note	Common Name	Eilers and Roosa 1994	Flora of North America	Growth Form	RICC	Wet Aff	Prairie Score
1	SC	Slender threeseeded mercury	Acalypha gracilens	Acalypha gracilens	A-Forb	6	3	3
2		Common three-seeded mercury	Acalypha rhomboidea	Acalypha rhomboidea	A-Forb	5	3	
3		VA three-seeded mercury	Acalypha virginica	Acalypha virginica	A-Forb	2	3	1
4		Common yarrow	Achillea millefolium	Achillea millefolium	P-Forb	2	3	2
5		Slender-leaved false foxglove	Agalinis tenuifolia	Agalinis tenuifolia	A-Forb	6	-3	4
6		Yellow giant-hyssop	Agastache nepetoides		P-Forb	5	3	2
7		Green amaranth	Amaranthus hybridus	Amaranthus hybridus	A-Forb	1	5	
8		Common ragweed	Ambrosia artemisiifolia	Ambrosia artemisiifolia	A-Forb	1	3	
9		Western ragweed	Ambrosia psilostachya	Ambrosia psilostachya	P-Forb	3	3	2
10		Giant ragweed	Ambrosia trifida	Ambrosia trifida	A-Forb	1	0	
11		Lead plant	Amorpha canescens	Amorpha canescens	Suff/Shrub	8	5	5
12		Hog peanut	Amphicarpaea bracteata	Amphicarpaea bracteata	A-Vine	4	0	
13		Tall anemone	Anemone virginiana	Anemone virginiana	P-Forb	5	3	3
14		Indian hemp	Apocynum cannabinum	Apocynum cannabinum	P-Forb	2	0	2
15		Tower mustard	Arabis glabra	Turritis glabra	BP-Forb	4	5	2
16		Prairie sage	Artemisia ludoviciana	Artemisia ludoviciana	P-Forb	4	5	3
17		Swamp milkweed	Asclepias incarnata	Asclepias incarnata	P-Forb	4	-5	3
18		Common milkweed	Asclepias syriaca	Asclepias syriaca	P-Forb	1	3	1
19		Whorled milkweed	Asclepias verticillata	Asclepias verticillata	P-Forb	1	3	2
20		Ontario aster	Aster ontarionis	Symphyotrichum ontarionis	P-Forb	3	0	
21		Hairy aster	Aster pilosus	Symphyotrichum pilosum	P-Forb	1	3	1
22		Rattlesnake fern	Botrychium virginianum	Botrychium virginianum	P-Pter	5	3	
23		American bindweed	Calystegia sepium	Calystegia sepium	P-Vine	1	0	
24		Tall bellflower	Campanula americana		AB-Forb	4	0	
25		Partridge pea	Chamaecrista fasciculata	Chamaecrista fasciculata	A-Forb	3	3	2
26		Tall thistle	Cirsium altissimum	Cirsium altissimum	BP-Forb	3	5	2
27		Field thistle	Cirsium discolor	Cirsium discolor	BP-Forb	2	3	2

Taxa #	Note	Common Name	Eilers and Roosa 1994	Flora of North America	Growth Form	RICC	Wet Aff	Prairie Score
28		Horseweed	Conyza canadensis	Conyza canadensis	A-Forb	1	3	
29		Woolly croton	Croton capitatus	Croton capitatus	A-Forb	6	5	2
30		Illinois tick-trefoil	Desmodium illinoense	Desmodium illinoense	P-Forb	6	5	5
31		Waterpod	Ellisia nyctelea		A-Forb	1	0	
32		Smooth scouring-rush	Equisetum laevigatum	Equisetum laevigatum	P-Pter	5	-3	3
33		American burnweed	Erechtites hieracifolia	Erechtites hieraciifolius	A-Forb	1	0	
34		Daisy fleabane	Erigeron annuus	Erigeron annuus	A-Forb	1	3	
35		Prairie fleabane	Erigeron strigosus	Erigeron strigosus	ABP-Forb	3	3	2
36		Tall boneset	Eupatorium altissimum	Eupatorium altissimum	P-Forb	3	5	3
37		Spotted Joe-pye-weed	Eupatorium maculatum	Eutrochium maculatum	P-Forb	6	-5	2
38		White snakeroot	Eupatorium rugosum	Ageratina altissima	P-Forb	2	3	
39		Late thoroughwort	Eupatorium serotinum	Eupatorium serotinum	P-Forb	3	0	2
40		Flowering spurge	Euphorbia corollata	Euphorbia corollata	P-Forb	5	5	5
41		David's spurge	Not Included	Euphorbia davidii	A-Forb	2	5	1
42		Carpet spurge	Euphorbia maculata	Euphorbia maculata	A-Forb	1	3	
43		Nodding spurge	Euphorbia nutans	Euphorbia nutans	A-Forb	2	3	1
44		Great Plains goldentop	Euthamia graminifolia	Euthamia gymnospermoides	P-Forb	6	-3	4
45		Cleavers bedstraw	Galium aparine		A-Forb	1	3	
46		Sweet-scented bedstraw	Galium triflorum		P-Forb	5	3	
47		Carolina cranesbill	Geranium carolinianum		A-Forb	5	5	3
48		White avens	Geum canadense	Geum canadense	P-Forb	2	0	
49		Sweet everlasting	Gnaphalium obtusifolium	Pseudognaphalium obtusifoliun	A-Forb	3	5	3
50		Stickseed	Hackelia virginiana		BP-Forb	2	3	
51		Rough pennyroyal	Hedeoma hispidum		A-Forb	2	5	2
52		Wood nettle	Laportea canadensis	Laportea canadensis	AP-Forb	3	-3	
53		VA pepperweed	Lepidium virginicum	Lepidium virginicum	A-Forb	2	3	1
54		Yellow false pimpernel	Lindernia dubia	Lindernia dubia	A-Forb	4	-5	
55		Sand puccoon	Lithospermum caroliniense		P-Forb	8	5	5
56		Seedbox	Ludwigia alternifolia	Ludwigia alternifolia	P-Forb	4	-5	
57		False loosestrife	Ludwigia polycarpa	Ludwigia polycarpa	P-Forb	7	-5	
58		American bugleweed	Lycopus americanus		P-Forb	5	-5	2
59		Wild four-o'clock	Mirabilis nyctaginea	Mirabilis nyctaginea	P-Forb	2	5	1

Taxa #	Note	Common Name	Eilers and Roosa 1994	Flora of North America	Growth Form	RICC	Wet Aff	Prairie Score
60		Wild bergamot	Monarda fistulosa		P-Forb	3	3	2
61		Common evening primrose	Oenothera biennis	Oenothera biennis	B-Forb	2	3	2
62		Cleland's evening primrose	Oenothera rhombipetala (PTH)	Oenothera clelandii	B-Forb	8	3	4
63		Cutleaf evening primrose	Oenothera laciniata	Oenothera laciniata	A-Forb	5	3	4
64		Hairy evening primrose	Oenothera villosa	Oenothera villosa	B-Forb	2	0	2
65		Eastern prickly pear	Opuntia humifusa	Opuntia humifusa	P-Succ	6	5	3
66		Anise root	Osmorhiza longistylis		P-Forb	4	3	
67		Slender yellow wood sorrel	Oxalis dillenii	Oxalis dillenii	P-Forb	1	3	1
68		Common yellow wood sorrel	Oxalis stricta	Oxalis stricta	AP-Forb	1	3	1
69		Pennsylvania pellitory	Parietaria pensylvanica	Parietaria pensylvanica	A-Forb	3	3	
70		Lopseed	Phryma leptostachya	Phryma leptostachya	P-Forb	4	5	
71		Clammy ground cherry	Physalis heterophylla	Physalis heterophylla	P-Forb	3	5	2
72		Long leaf ground cherry	P. virginiana var. sonorae	Physalis longifolia	P-Forb	2	5	
73		VA ground cherry	Physalis virginiana	Physalis virginiana	P-Forb	5	5	3
74		Obedient plant	Physostegia virginiana		P-Forb	6	-3	
75		Pokeweed	Phytolacca americana	Phytolacca americana	P-Forb	2	3	
76		Solomon's seal	Polygonatum biflorum	Polygonatum biflorum	P-Forb	5	3	2
77		Pepper smartweed	Polygonum hydropiper	Persicaria hydropiper	A-Forb	3	-5	
78		Jumpseed	Polygonum virginianum	Persicaria virginiana	P-Forb	5	0	
79	generic	Pondweed sp.	Potamogeton species	Potamogeton sp.	P-Forb/Sub	3	-5	
80		Narrow leaf mountain mint	Pycnanthemum tenuifolium		P-Forb	5	0	4
81		Small-flowered buttercup	Ranunculus abortivus	Ranunculus abortivus	BP-Forb	1	-3	
82		Prairie rose	Rosa arkansana	Rosa arkansana	Shrub	5	3	5
83		Pasture rose	Rosa carolina	Rosa carolina	Shrub	4	3	5
84		Wild petunia	Ruellia humilis		P-Forb	5	3	5
85		Canada black snakeroot	Sanicula canadensis		B-Forb	5	3	1
86		Common black snakeroot	Sanicula gregaria		P-Forb	3	0	
87	**double**	Canada/common black snakeroot	Sanicula canadensis/gregaria		BP-Forb	4	1	
88		Prairie ragwort	Senecio plattensis	Packera plattensis	BP-Forb	4	3	5
89	generic	Ragwort sp.	Senecio species	Packera sp.	P-Forb	5	0	
90		Sleepy catchfly	Silene antirrhina	Silene antirrhina	A-Forb	3	5	1
91		Prairie blue-eyed grass	Sisyrinchium campestre	Sisyrinchium campestre	P-Forb	6	5	5

Taxa #	Note	Common Name	Eilers and Roosa 1994	Flora of North America	Growth Form	RICC	Wet Aff	Prairie Score
92		Black nightshade	Solanum americanum	Solanum americanum	AP-Forb	1	3	
93		Horse nettle	Solanum carolinense	Solanum carolinense	P-Forb	1	3	1
94		Buffalo bur	Solanum rostratum	Solanum rostratum	A-Forb	1	5	1
95		Tall goldenrod	Solidago canadensis var. scabra	Solidago altissima	P-Forb	2	3	2
96	**double**	Tall/Canada goldenrod	Solidago altissima/canadensis	Solidago altissima/canadensis	P-Forb	2	3	2
97		Canada goldenrod	Solidago canadensis	Solidago canadensis	P-Forb	2	3	2
98		Giant goldenrod	Solidago gigantea	Solidago gigantea	P-Forb	3	-3	2
99		Slickseed wild bean	Strophostyles leiosperma	Strophostyles leiosperma	AP-Vine	7	5	3
100		American germander	Teucrium canadense		P-Forb	4	-3	2
101		Stinging nettle	Urtica dioica	Urtica dioica	P-Forb	2	-3	
102		Blue vervain	Verbena hastata		P-Forb	4	-3	2
103		Hoary vervain	Verbena stricta		P-Forb	2	5	2
104		White vervain	Verbena urticifolia		P-Forb	2	0	1
105		Wingstem	Verbesina alternifolia	Verbesina alternifolia	P-Forb	5	-3	
106		Purslane speedwell	Veronica peregrina	Veronica peregrina	A-Forb	1	-3	
107		Common blue violet	Viola sororia	Viola sororia	P-Forb	3	0	1
108	**generic**	Violet sp.	Viola species	Viola sp.	P-Forb	4	0	
109		Rough cocklebur	Xanthium strumarium	Xanthium strumarium	A-Forb	1	0	
110		Velvet leaf	Abutilon theophrasti	Abutilon theophrasti	A-Forb	-1	3	
111		Garlic mustard	Alliaria petiolata	Alliaria petiolata	B-Forb	-3	0	
112		Common burdock	Arctium minus	Arctium minus	B-Forb	-2	3	
113		Blackberry lily	Belamcanda chinensis	Belamcanda chinensis	P-Forb	-1	5	
114		Hoary-alyssum	Berteroa incana	Berteroa incana	AB-Forb	-1	5	
115		Hemp	Cannabis sativa	Cannabis sativa	A-Forb	-2	5	
116		Clammy mouse-ear chickweed	Not Included	Cerastium glomeratum	A-Forb	-1	3	
117		Lamb's quarter	Chenopodium album	Chenopodium album	A-Forb	-1	3	
118		Blue mistflower	Not Included	Conoclinium coelestinum	P-Forb	-1	-3	
119		Crown vetch	Coronilla varia	Securigera varia	P-Forb	-3	5	
120		Wild carrot	Daucus carota		B-Forb	-3	5	
121		Deptford pink	Dianthus armeria	Dianthus armeria	AB-Forb	-1	5	
122		Creeping Charlie	Glechoma hederacea		P-Forb	-2	3	
123		Dame's rocket	Hesperis matronalis	Hesperis matronalis	B-Forb	-1	3	

Taxa #	Note	Common Name	Eilers and Roosa 1994	Flora of North America	Growth Form	RICC	Wet Aff	Prairie Score
124	generic	Iris sp.	Iris species	Iris sp.	P-Forb	-1	0	
125		Prickly lettuce	Lactuca serriola	Lactuca serriola	A-Forb	-2	3	
126		Henbit	Lamium amplexicaule		A-Forb	-2	5	
127		Motherwort	Leonurus cardiaca		P-Forb	-1	5	
128		Field pepperweed	Lepidium campestre	Lepidium campestre	A-Forb	-1	5	
129		Bird's-foot trefoil	Lotus corniculatus	Lotus corniculatus	P-Forb	-3	3	
130		Black medic	Medicago lupulina	Medicago lupulina	A-Forb	-2	3	
131		Alfalfa	Medicago sativa	Medicago sativa	P-Forb	-2	3	
132		White sweet clover	Melilotus alba	Melilotus alba	B-Forb	-3	3	
133		Yellow sweet clover	Melilotus officinalis	Melilotus officinalis	B-Forb	-3	3	
134	**double**	White/Yellow sweet clover	Melilotus alba/officinalis	Melilotus alba/officinalis	B-Forb	-3	3	
135		Carpetweed	Mollugo verticillata	Mollugo verticillata	A-Forb	-2	0	
136		Catnip	Nepeta cataria		P-Forb	-2	3	
137		Wild parsnip	Pastinaca sativa		B-Forb	-3	5	
138		English plantain	Plantago lanceolata	Plantago lanceolata	P-Forb	-2	3	
139		Spotted lady's thumb	Polygonum persicaria	Persicaria maculosa	A-Forb	-2	-3	
140		Sulphur cinquefoil	Potentilla recta	Potentilla recta	P-Forb	-1	5	
141		Sheep sorrel	Rumex acetosella	Rumex acetosella	P-Forb	-2	3	
142		Curly dock	Rumex crispus	Rumex crispus	P-Forb	-3	0	
143		Bouncing bet	Saponaria officinalis	Saponaria officinalis	P-Forb	-1	3	
144		White campion	Silene pratensis	Silene latifolia	AP-Forb	-1	5	
145		Common chickweed	Stellaria media	Stellaria media	A-Forb	-1	3	
146		Common dandelion	Taraxacum officinale	Taraxacum officinale	P-Forb	-2	3	
147		Penny cress	Thlaspi arvense	Thlaspi arvense	A-Forb	-1	3	
148		Goat's-beard	Tragopogon dubius	Tragopogon dubius	B-Forb	-1	5	
149		Red clover	Trifolium pratense	Trifolium pratense	P-Forb	-3	3	
150		White clover	Trifolium repens	Trifolium repens	P-Forb	-2	3	
151		Common mullein	Verbascum thapsus	Verbascum thapsus	AB-Forb	-1	5	
152		Corn speedwell	Veronica arvensis	Veronica arvensis	A-Forb	-1	3	
153		Big bluestem	Andropogon gerardii	Andropogon gerardii	P-Gram	6	0	5
154		Side-oats grama	Bouteloua curtipendula	Bouteloua curtipendula	P-Gram	7	5	5
155	SC	Smooth clustered sedge	Carex aggregata	Carex aggregata	P-Gram	2	5	

Taxa #	Note	Common Name	Eilers and Roosa 1994	Flora of North America	Growth Form	RICC	Wet Aff	Prairie Score
156		Woodland sedge	Carex blanda	Carex blanda	P-Gram	3	0	1
157		Plains oval sedge	Carex brevior	Carex brevior	P-Gram	4	0	2
158		Thin leaved sedge	Carex cephaloidea	Carex cephaloidea	P-Gram	6	3	
159		Davis sedge	Carex davisii	Carex davisii	P-Gram	4	0	1
160		Heavy sedge	Carex gravida	Carex gravida	P-Gram	3	3	2
161		James' sedge	Carex jamesii	Carex jamesii	P-Gram	4	3	
162		Leavenworth's sedge	Carex leavenworthii	Carex leavenworthii	P-Gram	3	5	3
163		Midland sedge	Not Included	Carex mesochorea	P-Gram	3	5	2
164		Field oval sedge	Carex molesta	Carex molesta	P-Gram	3	0	1
165		Sand sedge	Carex muhlenbergii	Carex muehlenbergii	P-Gram	7	5	4
166		Pointed broom sedge	Carex scoparia	Carex scoparia	P-Gram	5	-3	1
167		Blunt broom sedge	Carex tribuloides	Carex tribuloides	P-Gram	3	-5	1
168		Common fox sedge	Carex vulpinoidea	Carex vulpinoidea	P-Gram	3	-3	1
169	**generic**	Sedge sp.	Carex species	Carex sp.	P-Gram	4	-1	1
170		Sandbur	Cenchrus longispinus	Cenchrus longispinus	A-Gram	1	5	
171		Great Plains flat sedge	Cyperus filiculmis	Cyperus lupulinus	P-Gram	8	3	3
172		Schweinitz's flat sedge	Cyperus schweinitzii	Cyperus schweinitzii	P-Gram	5	3	3
173		Straw-colored flat sedge	Cyperus strigosus	Cyperus strigosus	P-Gram	3	-3	
174		Common panic grass	Dichanthelium acuminatum	Dichanthelium acuminatum	P-Gram	3	0	2
175		Scribner's panic grass	Dichanthelium oligosanthes	Dichanthelium oligosanthes	P-Gram	5	3	3
176		Common spike rush	Eleocharis smallii	Eleocharis palustris	P-Gram	6	-5	
177	**generic**	Spike-rush sp.	Eleocharis species	Eleocharis sp.	P-Gram	5	-5	
178		Silky wild rye	Elymus villosus	Elymus villosus	P-Gram	5	3	
179		Purple lovegrass	Eragrostis spectabilis	Eragrostis spectabilis	P-Gram	4	5	3
180		Nodding fescue	Festuca obtusa	Festuca subverticillata	P-Gram	6	3	
181		Sharp-fruited rush	Juncus acuminatus	Juncus acuminatus	P-Gram	5	-5	
182		Dudley's rush	Juncus dudleyi	Juncus dudleyi	P-Gram	4	-3	2
183		Path rush	Juncus tenuis	Juncus tenuis	P-Gram	2	0	1
184		Rice cutgrass	Leersia oryzoides	Leersia oryzoides	P-Gram	6	-5	
185		Fall witchgrass	Leptoloma cognatum	Digitaria cognata	P-Gram	5	5	3
186		Nimblewill	Muhlenbergia schreberi	Muhlenbergia schreberi	P-Gram	2	0	1
187		Bead grass	Paspalum setaceum	Paspalum setaceum	P-Gram	5	3	3

Taxa #	Note	Common Name	Eilers and Roosa 1994	Flora of North America	Growth Form	RICC	Wet Aff	Prairie Score
188		Little bluestem	Schizachyrium scoparium	Schizachyrium scoparium	P-Gram	7	3	5
189		Hard stem bulrush	Scirpus acutus	Schoenoplectus acutus	P-Gram	6	-5	
190		Indian grass	Sorghastrum nutans	Sorghastrum nutans	P-Gram	6	3	5
191		Rough dropseed	Sporobolus asper	Sporobolus compositus	P-Gram	4	5	5
192		Prairie dropseed	Sporobolus heterolepis	Sporobolus heterolepis	P-Gram	9	3	5
193		Purple top	Tridens flavus	Tridens flavus	P-Gram	2	5	2
194		Quack grass	Agropyron repens	Elymus repens	P-Gram	-2	3	
195		Redtop	Agrostis gigantea	Agrostis gigantea	P-Gram	-1	-3	
196		Smooth brome	Bromus inermis	Bromus inermis	P-Gram	-3	3	
197		Japanese brome	Bromus japonicus	Bromus japonicus	A-Gram	-3	5	
198		Downy chess	Bromus tectorum	Bromus tectorum	A-Gram	-3	5	
199		Orchard grass	Dactylis glomerata	Dactylis glomerata	P-Gram	-2	3	
200		Woolly cupgrass	Eriochloa villosa	Eriochloa villosa	A-Gram	-1	5	
201		Tall fescue	Festuca arundinacea	Schedonorus arundinaceus	P-Gram	-3	3	
202		Japanese stiltgrass	Not Included	Microstegium vimineum	A-Gram	-3	0	
203		Reed canary grass	Phalaris arundinacea cultivar	Phalaris arundinacea	P-Gram	-3	-3	
204		Timothy	Phleum pratense	Phleum pratense	P-Gram	-1	3	
205		Kentucky bluegrass	Poa pratensis	Poa pratensis	P-Gram	-2	0	
206		Giant foxtail	Setaria faberi	Setaria faberi	A-Gram	-2	3	
207		Yellow foxtail	Setaria glauca	Setaria pumila	A-Gram	-2	0	
208		Bittersweet	Celastrus scandens	Celastrus scandens	Liana	3	3	
209		Hackberry	Celtis occidentalis	Celtis occidentalis	Tree	3	0	
210		Rough-leaved dogwood	Cornus drummondii	Cornus drummondii	Shrub/Tree	3	0	
211		Downy hawthorn	Crataegus mollis	Crataegus mollis	Tree/Shrub	3	0	1
212		Green ash	Fraxinus pennsylvanica		Tree	2	-3	
213		Honey locust	Gleditsia triacanthos	Gleditsia triacanthos	Tree	2	3	
214		Black walnut	Juglans nigra	Juglans nigra	Tree	4	3	
215		Eastern red cedar	Juniperus virginiana	Juniperus virginiana	Tree	1	3	
216		Woodbine	Parthenocissus vitacea	Parthenocissus vitacea	Liana	3	3	
217		Eastern cottonwood	Populus deltoides	Populus deltoides	Tree	2	0	
218		Wild black cherry	Prunus serotina	Prunus serotina	Tree	3	3	
219		Choke cherry	Prunus virginiana	Prunus virginiana	Shrub/Tree	4	3	

Taxa #	Note	Common Name	Eilers and Roosa 1994	Flora of North America	Growth Form	RICC	Wet Aff	Prairie Score
220		Northern red oak	Quercus borealis	Quercus rubra	Tree	6	3	
221		Bur oak	Quercus macrocarpa	Quercus macrocarpa	Tree	5	0	2
222		Black oak	Quercus velutina	Quercus velutina	Tree	5	5	
223	**generic**	Oak sp.	Quercus species	Quercus sp.	Tree	6	2	
224		Smooth sumac	Rhus glabra		Shrub	3	5	
225	double	Prickly/MO gooseberry	Ribes cynosbati/missouriense	Ribes cynosbati/missouriense	Shrub	4	3	
226		Black raspberry	Rubus occidentalis	Rubus occidentalis	Shrub	1	5	
227		Sandbar willow	Salix exigua ssp. interior	Salix interior	Shrub/Tree	1	-3	
228		Black willow	Salix nigra	Salix nigra	Tree	3	-5	
229		Bristly greenbrier	Smilax hispida	Smilax tamnoides	Liana	3	0	
230		Coralberry	Symphoricarpos orbiculatus		Shrub	3	3	
231	**double**	Wolfberry/Coralberry	Symphoricarpos occidentalis/orbiculatus		Shrub	3	4	
232		Poison ivy	Toxicodendron radicans		Liana	1	0	
233		American elm	Ulmus americana	Ulmus americana	Tree	3	-3	
234	double	American/Red Elm	Ulmus americana/rubra	Ulmus americana/rubra	Tree	2	-1	
235		Riverbank grape	Vitis riparia	Vitis riparia	Liana	3	-3	
236		Prickly ash	Zanthoxylum americanum		Shrub	4	3	
237		Tree of heaven	Ailanthus altissima		Tree	-3	3	
238		Autumn olive	Elaeagnus umbellata	Elaeagnus umbellata	Shrub	-3	5	
239	generic	Privet sp.	Not Included	(Ligustrum sp.)	Shrub	-2	4	
240		Amur honeysuckle	Not Included	(Lonicera maackii)	Shrub	-3	5	
241		Tartarian honeysuckle	Lonicera tatarica		Shrub	-3	3	
242		Osage orange	Maclura pomifera	Maclura pomifera	Tree	-3	3	
243		White mulberry	Morus alba	Morus alba	Tree	-3	0	
244		Common buckthorn	Rhamnus cathartica	Rhamnus cathartica	Shrub	-3	0	
245		Multiflora rose	Rosa multiflora	Rosa multiflora	Shrub	-3	3	
246		Siberian elm	Ulmus pumila	Ulmus pumila	Tree	-2	5	

PTH = Permanent Translocation Heterozygosity (Plants do not undergo normal meiosis. Instead, their chromosomes form a ring of 14 during meiosis. They are sel

Appendix B. Photos



Left and Center: Sand exposure in the east grassland supporting many sand prairie specialists. Right: Tilled fire break between the central grassland and south forest.



Left: Location for plot 2 (on April 21). Center: Location for plot 1 (on April 21). Right: Tilled fire break along the north property boundary in the northwest end of the east grassland.



Left: Location for plot 1 (on June 15). Center and Right: Mown fire breaks in the east grassland (on October 2).

Appendix B. Photos



Left: Common milkweed. Center: Mown fire break along the north property boundary near the border of the east and central grasslands. Right: Invasive Japanese stiltgrass in the south forest.



All: Central grassland

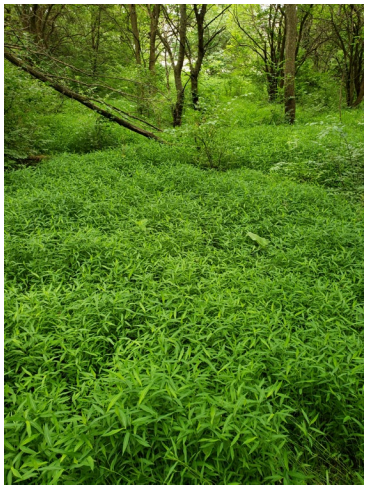


Left and Center: Northwest end of the south forest. Right: Cups covering young emerging panic grass plants.

Appendix B. Photos




Left: Smooth brome on April 21. Center left: Young shoot of sand puccoon. Center right: Tilled/plowed fire break in the northeast section of the east grassland on April 21. Right: Clethodim effects seen in the suppressed smooth brome in contrast to the strip of smooth brome that is in flower and fruit (apparently a strip that was missed during application).



Left: Invasive Japanese stiltgrass in the south forest. Center, Right, and All Below: Five eastern prickly pear plants in the eastern grassland