

THE BARRENS FLORA OF WISCONSIN'S NORTHWEST SANDS ECOLOGICAL LANDSCAPE

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ABSTRACT

The barrens of Wisconsin's Northwest Sands Ecological Landscape are a dynamic mosaic shifting between dry forests and woodlands to open, prairie-like communities depending on the frequency of disturbance. We examined the floristics of eight sites within the barrens that were selected to represent the full latitudinal gradient of the ecological landscape. In the course of this study, we collected 2,213 voucher specimens representing 71 plant families, 217 genera, and 404 taxa. We compared the sites to one another using floristic quality assessments, the Sørensen–Dice similarity index, and various qualitative comparisons. The barrens flora becomes less diverse as you move from the southwest to the northeast. Prairie species are more common and dominant in the southwestern sites, and northern dry forest species are more common and dominant in the northeastern sites.

KEYWORDS: pine barrens, oak barrens, sand prairie, floristics

INTRODUCTION

The diversity of vascular plants in the barrens of Wisconsin's Northwest Sands Ecological Landscape is poorly documented. Natural plant community succession and pine plantations have greatly reduced and fragmented what remains as barrens in this region. Recognizing the importance of this landscape, several management and property master plans were developed by the Wisconsin Department of Natural Resources (2015, 2016, 2017a, 2017b). In a collaborative effort, the Wisconsin Department of Natural Resources hired a Northwest Sand's liaison in 2017 to work with national, state, county, industrial and private landowners to expand the early successional barrens. Documenting the flora of this landscape now is an important step toward creating a base line for future comparisons of vascular plant diversity and for measuring the successes of prescribed management.

The barrens of the Northwest Sands Ecological Landscape are a dynamic mosaic that shift between dry forests and woodlands to open, prairie-like communities depending on the frequency of disturbance. However, ecologically defining the barrens plant community is difficult. The historical records in the Midwest contain several instances of barrens that refer to plant communities that fall somewhere between forest and prairie (Hutchison 1994). Many terms (e.g., sa-

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vanna, brush prairie, oak opening) have been used synonymously with places described as barrens (Heikens and Robertson 1994). Generally, barrens may be described as savanna-like communities dominated by grasses and low-growing shrubs and trees, with scattered larger oaks and pines (Curtis 1959, Wisconsin Department of Natural Resources 2015). Furthermore, these communities tend to be edaphic and to receive periodic disturbances, often in the form of fire (Anderson et al. 1999, Curtis 1959, Hutchison 1994).

While plant communities described as barrens have been documented throughout much of North America (Anderson et al. 1999), this study focuses on those of the Northwest Sands Ecological Landscape in northwestern Wisconsin, which covers approximately 5,066 square kilometers stretching from northwest Polk County to north-central Bayfield County (Figure 1) (Curtis 1959, Radeloff et al. 1998, Wisconsin Department of Natural Resources 2015). Most of the upland soils of this region are comprised of sand, loamy sand, and sand mixed with gravel. This combination results in quick infiltration of water into the ground and produces xeric conditions for the flora of the uplands (Wisconsin Department of Natural Resources 2015).

The barrens flora of the Northwest Sands has been influenced by several environmental and climatic conditions arising from the end of the Pleistocene approximately eleven thousand years ago. At the peak of the Wisconsin glaciation, the survey sites of this study would have been covered with glacial ice (Anderson 2006). As the climate changed and started to warm, species more adapted to the colder climate would have followed the retreating glaciers. Grasslands would have started to migrate northward as broadleaf forest species started moving into the region from the east and south. A dynamic interaction began to form as climate and fires interacted along this prairie and forest border (Anderson 2006). Interspersed between the boreal forest along the Great Lakes to the north, the broadleaf forests to the southeast, and the grasslands and savannas to the southwest were vast open areas of outwash sands, shallow glacial lakes, and tills. It is in this confluence that the Northwest Sands' barrens developed, resulting in the diversity of species that we see today.

Prior to European settlement in the mid-1800s, the Wisconsin barrens, described as pine barrens in the Northwest Sands region by Curtis (1959), would have covered about 930,777 hectares (2.3 million acres). This plant community was concentrated in central, northeastern, and northwestern Wisconsin. Approximately 62%, or 3,141 square km, of the Northwest Sands Ecological Landscape was described as barrens communities (Wisconsin Department of Natural Resources 2015). The land also supported sedge marshes, lowland forests, and upland pine forests. These communities were often maintained by natural and intentional wildfires (Murphy 1931). Today, maybe as little as 20,000 hectares of barrens remain in a fragmented landscape on several county, state, and federally protected public lands (Radeloff et al. 1999).

The Ojibwe are believed to have moved into the area of the Northwest Sands about 400 to 600 years ago (Milwaukee Public Museum 2023; Minnesota Historical Society 2023; Peacock 2022). They likely were using fire at varying intervals to support their communities (Loope and Anderton 1998), thus helping to maintain the openness of this barrens landscape. These intentional fires served

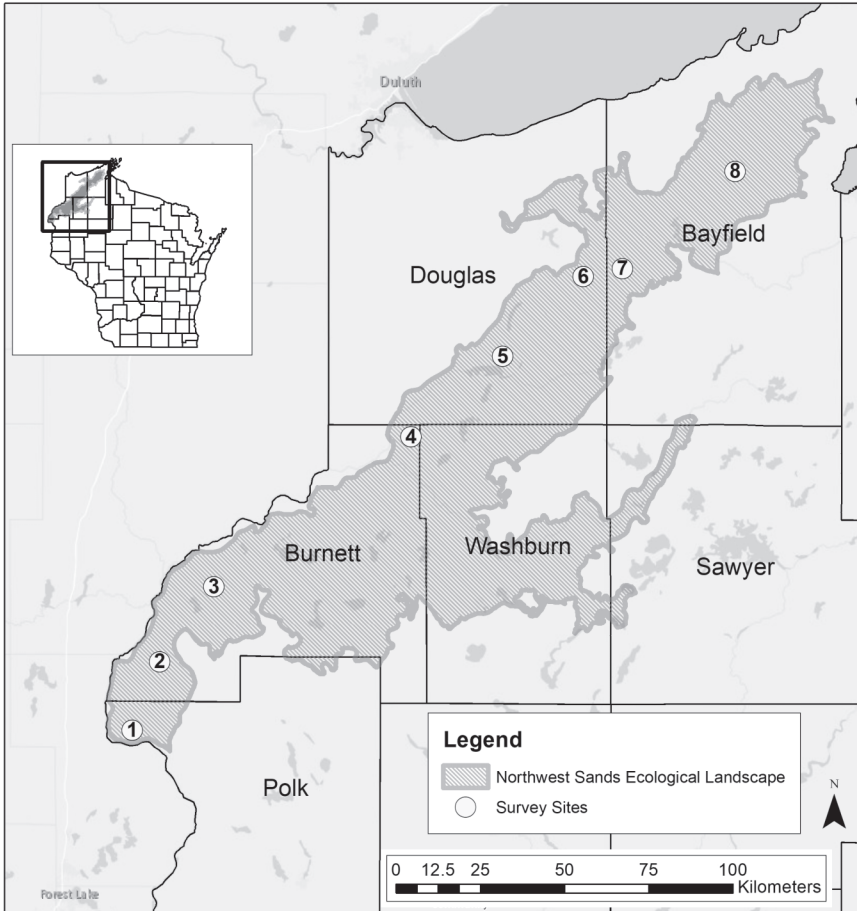


FIGURE 1. The Northwest Sand Ecological Landscape of northwestern Wisconsin, indicated by the hatched area. The specific study sites are indicated by numbered, circled points. (1) Sterling Barrens State Natural Area, (2) Fish Lake Wildlife Area, (3) Crex Meadows Wildlife Area, (4) Namekagon Barrens Wildlife Area, (5) Douglas County Wildlife Area, (6) Motts Ravine State Natural Area, (7) Barnes Barrens, and (8) Moquah Barrens. Inset: location of study area in Wisconsin. The map was created in ESRI ArcGIS 9.3 using publicly available data layers and a shapefile of the Northwest Sands Ecological Landscape provided by the Wisconsin Department of Natural Resources.

many purposes that included regenerating and stimulating the growth of blueberries and other fruits and nuts, clearing brush for campsites and maintaining trails and portages (Anderton 1999; Miller and Davidson-Hunt 2010; Williams 1994). During the mid-1800s, European settlers began draining wetlands and logging the pines. This led to large-scale landscape alteration, fire control, and the disappearance of wildlife, including waterfowl and cranes. Many sites were over-logged, farming was unsuccessfully attempted, and abandoned lands be-



FIGURE 2. Prescribed fire is an important tool used by land managers to maintain the barrens of the Northwest Sands Ecological Landscape. The smoke from a spring fire at Crex Meadows can be seen from miles away. Photo by Richard W. Haug.

came tax delinquent. By the 1940s, the sandy soils were depleted of resources, and nearly two thirds of the land in the region was tax delinquent. The State of Wisconsin, with help from federal financing, began purchasing some of these tax delinquent lands to restore the original uplands and wetlands as public wildlife areas. It was also during this last period that an intensive tree planting and fire suppression program was implemented throughout the landscape. This resulted in closed canopies and forests for industrial uses. By the 1950s, managers were realizing that the early stages of barrens and prairie habitat were dependent on fire at frequent intervals (5–10 years) (Radeloff et al. 2000). As a result of this missing disturbance, the prairie and open barrens were disappearing from the landscape.

The barrens of the Northwest Sands Ecological Landscape include three natural communities described by the Wisconsin Department of Natural Resources (2015). The natural communities are comprised of pine barrens, oak barrens, and sand prairies. These communities form a mosaic on the landscape that grade into one another, making firm distinctions between the community types difficult. The communities are maintained today with frequent prescribed fires by site managers (Figure 2).

The pine barrens community of Wisconsin is savanna-like and usually comprises *Pinus banksiana* (jack pine) and less commonly *P. resinosa* (red pine) at the more northern sites. Shrubby *Quercus ellipsoidalis* (northern pin oak), *Q. macrocarpa* (bur oak), *Corylus americana* (American hazel), *Salix humilis*

(prairie willow), *Prunus pumila* (sand cherry), and *P. virginiana* (chokecherry) are often common. The ground layer is dominated by prairie grasses and forbs (Wisconsin Department of Natural Resources 2022a). This type of pine barrens exists primarily in the upper Midwest, especially in Wisconsin, Michigan and Minnesota. These barrens are considered rare and globally imperiled by NatureServe (2020). Wisconsin has one of the most significant opportunities (and possibly the best opportunity) in North America to preserve, restore, and manage large-scale pine barrens communities (Wisconsin Department of Natural Resources 2017). Other similar barrens communities exist in the northeastern United States, but they are composed of a different assemblage of plant species. They often lack the prairie grasses and forbs that are present in Wisconsin's barrens plant communities.

The oak barrens community of Wisconsin is similar to the pine barrens described above. One observable difference between the two communities is seen in the dominant trees. In the oak barrens community, *Quercus macrocarpa* and *Q. ellipsoidalis* are typically dominant. However, frequent disturbance through fire, poor nutrient levels, and low moisture levels usually leaves these trees stunted, multi-stemmed, and shrubby in appearance (thus they are occasionally referred to as grub oaks). These shrubby oaks often have an extensive root system that is much older than their above ground stems (Johnson et al. 2019). In southern and central Wisconsin, *Q. velutina* (black oak) often replaces *Q. ellipsoidalis* as a dominant oak. An additional difference from the pine barrens community is the presence of a more diverse prairie flora (Wisconsin Department of Natural Resources 2022b).

Sand prairie is the third natural community found in the surveyed sites. These areas typically lack the trees and woody shrubs seen in the pine and oak barrens communities. The sand prairie is dominated by prairie grasses such as *Andropogon gerardii* (big bluestem), *Dichanthelium* spp. (panic grasses), *Hesperostipa spartea* (porcupine grass), *Koeleria macrantha* (June grass), *Schizachyrium scoparium* (little bluestem) and prairie forbs (Wisconsin Department of Natural Resources 2022c). This community is found in the southern sites of our study.

One of our primary goals in this study was a thorough documentation of the flora with voucher specimens that would be accessible to future researchers. Additionally, this comprehensive study allows for site comparisons across the Northwest Sands Ecological Landscape using several different metrics. These data can be used to inform future plant community restoration efforts, invasive species monitoring, rare plant species monitoring and to serve as a point of comparison for future floristic work in the region.

MATERIALS AND METHODS

Survey Sites

We selected eight sites (Figure 1) that span approximately 170 km to represent the barrens found in the Northwest Sands Ecological Landscape. We made site visits to each property throughout the growing seasons of 2017 to 2022. We followed Mladenoff (2004) for the names of the plants found in the Public Land Survey notes included in the site descriptions below.



FIGURE 3. A large area of sand prairie at Sterling Barrens. The prairie is dominated by *Hesperostipa spartea*, *Andropogon gerardii*, *Schizachyrium scoparium*, *Koeleria macrantha*, *Dichanthelium* spp., *Carex siccata*, and *Carex pensylvanica*. In the foreground *Delphinium carolinianum* subsp. *virescens*, *Lithospermum caroliniense*, and *Phlox pilosa* are in bloom. In the distance, grub oaks (*Quercus ellipsoidalis* and *Q. macrocarpa*), along with denser stands of *Prunus pensylvanica* and *Amelanchier* spp., can be seen. Photo by Derek S. Anderson.

Sterling Barrens State Natural Area (Polk County, 45° 34.0' N, 92° 49.0' W) (Sterling Barrens): Figure 1, Site 1. Wisconsin Department of Natural Resources (2022d)

The Sterling Barrens is the southwesternmost site of our study. It is located in northwest Polk County within the Governor Knowles State Forest approximately 12 km west of Cushing, Wisconsin on moderate to gently rolling slopes of sand outwash above the St. Croix River. While the state natural area includes extensive areas of sedge meadows and floodplain forest near the river, our efforts focused on the upland natural communities of the site. Historically, in the Public Land Survey records, Maddin (1848) describes this area as, “a sand plain covered with small scrubby pine and destitute of water.” The site is 398 hectares, of which approximately 100 hectares are barrens (Figure 3).

Fish Lake Wildlife Area (Burnett County, 45° 43.0' N, 92° 45.0' W) (Fish Lake): Figure 1, Site 2. Wisconsin Department of Natural Resources (2016, 2022e)

Fish Lake is in southwest Burnett County approximately 8 km southwest of Grantsburg, Wisconsin. The gentle topography of the site is a mosaic of uplands dominated by barrens, while sedge meadows and marshes are characteristic of the lowlands. The landscape was created by an ancient glacial lake that covered most of the area. Our survey efforts focused on the uplands scattered throughout the property. The uplands of this area were described by Fellows (1853a) as, “gently rolling with a foundation of sandy loam soil and very thinly timbered with small pitch pine [*Pinus banksiana*].” The site is approximately 5,666 hectares, of which about 1,214 are barrens.

Crex Meadows Wildlife Area (Burnett County, 45° 51.5' N, 92° 36.5' W) (Crex Meadows): Figure 1, Site 3. Wisconsin Department of Natural Resources (2022f)

Crex Meadows is in west-central Burnett County approximately 9 km north-northeast of Grants-



FIGURE 4. *Ceanothus americanus* in bloom in the barrens of Crex Meadows. It is interspersed with other shrubs such as *Corylus americana*, *Quercus ellipsoidalis* grubs, and *Prunus* spp. *Carex pensylvanica*, *Andropogon gerardii*, *Carex siccata*, *Koeleria macrantha*, and *Dichanthelium* spp. dominate the area between the shrubs. Photo by Richard W. Haug.

burg, Wisconsin. Crex Meadows sits within the same ancient glacial lake basin as Fish Lake (Wisconsin Department of Natural Resources 2016). It consists of gentle topography and is a mosaic of uplands dominated by barrens and woodlands, with lowlands dominated by sedge meadows, marshes and lakes. The landscape today remains similar to what was described by Fellows (1853b) in the public land survey records, where he said, “All of this fractional township except the river bottoms is pine barrens, rolling surface, poor sandy soil, and thinly timbered with pitch pine [*Pinus banksiana*].” The site is approximately 11,533 hectares, of which about 2,833 hectares are barrens (Figure 4).

Namekagon Barrens Wildlife Area (Burnett & Washburn Counties, 46° 7.5' N, 92° 4.5' W) (Namekagon Barrens): Figure 1, Site 4. Wisconsin Department of Natural Resources (2017a, 2022g)

The Namekagon Barrens consists of two units located at the junction of Burnett, Douglas, and Washburn Counties approximately 19 km west of Minong, Wisconsin. Both units occur within a matrix of scattered jack pine and, to a lesser extent, red and white pine, which are interspersed with openings in which oak grubs (*Quercus macrocarpa* and *Q. ellipsoidalis*) are prominent, along with prairie grasses and forbs. Historically, the public land survey records describe the general area as having, “a level surface, light sandy soil and thinly timbered with black pine [*Pinus banksiana*]” (Fellows 1855). The north and south units comprise approximately 2,609 hectares of which about 2,183 hectares are barrens.

Douglas County Wildlife Area (Douglas County, 46° 17.0' N, 91° 50.5' W) (Douglas County): Figure 1, Site 5. Wisconsin Department of Natural Resources (2017a, 2022h)

The Douglas County Wildlife Area, locally known since 1935 as The Bird Sanctuary, was established in 1948. It is in southern Douglas County west of U.S. Hwy. 53 and between the towns of Solon Springs to the north and Gordon to the south. The sandy uplands of this wildlife area are a result of sandy outwash plains from the retreat of ice during the last glaciation period. Historically



FIGURE 5. Douglas County. The sandy uplands are a result of sandy outwash plains from the retreat of ice during the last glaciation period. The rolling topography as depicted here supports a diverse array of grassland species interspersed with pockets of scrub shrub communities. *Pedicularis canadensis*, *Antennaria howellii*, *Packera paupercula*, *Andropogon gerardii*, *Bromus kalmii*, *Schizachyrium scoparium*, and *Koeleria macrantha* are common. Photo by Paul S. Hlina.

these lands supported jack pine, oak savannah, and barrens. Daugherty (1856) does not provide much specific detail, but his description in the public land survey records gives an impression of pine barrens: “the surface of the township is principally rolling land 3rd rate (sandy). Timber black and yellow pine [*Pinus banksiana* and *P. resinosa* respectively], birch, linden, white cedar and spruce.” The site is approximately 1,536 hectares of which about 1,451 hectares are barrens (Figure 5).

Motts Ravine State Natural Area (Douglas County 46° 26.0' N, 91° 36.5' W) (Motts Ravine): Figure 1, Site 6. Wisconsin Department of Natural Resources (2022i)

Motts Ravine is located about 14 km south-southwest of Brule, Wisconsin on a rolling glacial outwash plain and consists of natural jack pine forest, scrubby Hill's and bur oak thickets, and small pine barrens remnants. The condition of the state natural area is similar to the description of the township by Fellows (1856a): “This is one of those barren townships that is almost worthless for agriculture purposes. The surface is rolling excepting that section adjoining the Brule which is very broken” The Brule River State Forest manages for this rare community type on the watershed. As noted in the Brule River State Forest Master Plan (Wisconsin Department of Natural Resources 2017b), the extent of Motts Ravine may expand through working with landowners adjacent to the property in the future but is unlikely to be large enough to support significant population of rare plants and animals of the pine barrens ecosystem. Motts Ravine consists of 265 hectares of barrens.

Barnes Barrens (Bayfield County 46° 26.5' N, 91° 30.5' W): Figure 1, Site 7. (Bayfield County Forestry Department 2013)

The Barnes Barrens management area is located in Barnes Township in western Bayfield County about 13 km south-southeast of Brule, Wisconsin. Most of the area is dominated by later stages of



FIGURE 6. Barnes Barrens. These are relatively young barrens, having been recently restored and managed (2012–2022) in an extensive sandy outwash plain in western Bayfield County. Most of the area is dominated by *Quercus macrocarpa*, *Corylus americana*, *Salix humilis*, and, to a lesser extent, *Q. ellipsoidalis*. Small bands of pine trees remain on the site, but the greatest diversity is found in grass-dominated communities in the western end of the site. Photo by Paul S. Hlina.

the pine barrens community (i.e., mid- to late jack pine forests and oak scrub/pine savanna). Fellows' (1856b) public land survey description of the township provides perspective on the area: "This is a township of barrens that is almost worthless for agricultural purposes or anything else as there is but very little timber in it and that is scrubby black pine [*Pinus banksiana*], and there is hardly a drop of water in the township . . ." Today, the site is managed by the Bayfield County Forestry Department and is included in Wisconsin's priority conservation opportunity areas for wildlife species. Overall, this matrix of pine forest and late successional-stage barrens communities covers roughly 4,654 hectares. A core area of about 400 hectares of early successional barrens has been created or enhanced in the past decade (Bayfield County Forestry Department 2013). Additional open barrens will be created as harvests occur around this core area. During the duration of this project, we surveyed the 162 hectares being maintained as barrens (Figure 6).

Moquah Barrens (Bayfield County 46° 37.0' N, 91° 15.5' W): Figure 1, Site 8. (USDA Forest Service 2004, 2009)

Moquah Barrens is about 35 km southwest of Bayfield, Wisconsin and only 19 km to Ashland and the Chequamegon Bay on Lake Superior (Figure 1, Site 8). Moquah Barrens, which is within the Chequamegon-Nicolet National Forest, was created as glaciers retreated 10,000 years ago exposing rolling to very steep topography of pitted outwash plains consisting of glacial drift (i.e., sand, gravel, and silt). The unique topography of pitted outwash plains, its proximity to Lake Superior and its climatic effects influence plant communities of these barrens. Stuntz (1858) described the township as "high rolling, without any running water in it of a sandy gravelly soil, covered with a scattering growth of black [*Pinus banksiana*], yellow [*Pinus resinosa*] and white pine, aspen, birch and maple." While he does not specifically characterize this area as barrens, his description is representative of

later successional stages of the barrens communities. Today, the Chequamegon-Nicolet National Forest manages the 8903 hectares of the Moquah Barrens.

Field Methods

We conducted multiple floristic surveys at each site each year throughout the growing seasons of 2017 through 2022. We excluded areas from our survey efforts where mature tree cover was visually estimated to be greater than approximately 25%. These areas represented older successional shifts to woodland and dry forests communities that were outside the scope of our definition of early successional barrens. The surveys were restricted to the upland communities of each site. We identified and targeted survey areas by examining aerial imagery available on GoogleEarth, reviewing plant community maps created by the Wisconsin Department of Natural Resources (2015, 2016, 2017a), recommendations from site managers, and from decades of previous experience visiting these sites. Meander surveys were used on site to find microhabitats that may harbor more uncommon species (Goff et al. 1982).

We made specimen collections of any vascular plant species in a reproductive state that had not already been collected on a previous visit to the site as well as specimens needing additional identification in the lab. We also noted species that would need to be collected on a return visit to obtain a more mature specimen. In a few instances, we failed to make those collections. These observations are noted in Appendix 1 with a dagger. Vouchers from each site were deposited at the University of Wisconsin-Madison herbarium (WIS). Any duplicate specimens were submitted to the University of Wisconsin-Stevens Point (UWSP), University of Wisconsin-Superior (SUWS) or the University of Minnesota (MIN).

In addition to our own vouchers, we used the Wisconsin State Herbarium internet portal (Wisconsin State Herbarium 2019) to review past collections made at our survey sites. Species we did not find but had been documented in the past were added to the list in Appendix 1 and cited using the collectors name and collection number.

Species identification and nomenclature follows Voss and Reznicek (2012), or, for several western ranging species at Sterling Barrens State Natural Area, Fish Lake Wildlife Area and Crex Meadows Wildlife that are not included in this regional treatment, Flora of North America Editorial Committee (1993+). Specimen collections from State Natural Areas were made under Wisconsin Department of Natural Resources Permits #SNA18-3 and #SNA20-1.

Floristic Quality Assessment (FQA)

The calculation of FQA metrics is based on the Coefficient of Conservatism (C), which is a numerical rating (0–10) of the fidelity of an individual plant species to specific habitats and its tolerance to disturbance, whether natural or anthropogenic (Swink and Wilhelm 1994). Species that have narrow habitat requirements and/or little tolerance to disturbance (referred to as conservative) are assigned high C-values, while species that are found in more disturbed habitats (tolerant) are assigned low C-values. C-values for species occurring in Wisconsin were assigned by expert botanists from Wisconsin in the early 2000's and assigned for each vascular plant species in the state (Bernthal 2003; Chung-Gibson et al. 2017).

We calculated four metrics of barrens floristic quality using the approach of the Wisconsin Floristic Quality Analysis (Bernthal 2003). Calculations were made for each survey and cumulatively evaluated by barren site. The four metrics are:

1. Mean C_n is the arithmetic average of the C-values of all native plant species observed in a site.

$$\text{Mean } C_n = (C_1 + C_2 + C_3 + \dots + C_n) / n,$$

Where C_1, C_2, \dots, C_n are the C-values of each of the native species in the site and n is the number of native species in the site.

2. Mean C_t is the arithmetic average of the C-values of all plant species, native and introduced, observed in a site.

$$\text{Mean } C_t = (C_1 + C_2 + C_3 + \dots + C_t) / t,$$

Where C_1, C_2, \dots, C_t are the C-values of each of the species in the site and t is the number of native and introduced species in the site.

3. Native FQI is calculated by dividing Mean C_n by the square root of the number of native species (n).

$$\text{Native FQI} = \frac{\text{Mean } C_n}{\sqrt{n}}$$

4. Total FQI is calculated by dividing Mean C_t by the square root of the number of all species, native and introduced (t).

$$\text{Total FQI} = \frac{\text{Mean } C_t}{\sqrt{t}}$$

After all calculations were completed, results of native species were compared with total species to illustrate natural versus impacted communities.

Herman et al. (2001) developed an FQI quality scale for natural communities in the state of Michigan. According to this scale, communities with an FQI < 20 have minimal significance for natural quality; those with an FQI between 35 and 50 have sufficient composition for natural quality; and those with an FQI > 50 are highly significant in composition for natural quality and are extremely rare.

Similarity Index

The Sørensen–Dice Coefficient (Dice 1945; Sørensen 1948) is a measure of similarity that was used to compare the floras of each pair among the eight sites included in this study. The Sørensen–Dice Coefficient is calculated as:

$$S = \frac{2c}{(a+b)}$$

where c is the number of species in common between two sites being compared, a is the total number of species from the first site, and b is the total number of species from the second site. The resulting coefficient will range from 0 to 1. The larger the coefficient, the more similar the two sites are to each other.

RESULTS

The barrens flora of the Northwest Sands Ecological Landscape was documented with 2,213 collections representing 71 families, 217 genera and 404 taxa. The largest family was the Asteraceae family with 81 different taxa. The *Solidago* (Figure 7) and *Symphyotrichum* genera were two of the most diverse genera documented in the family, each with ten taxa. Poaceae, Rosaceae, and Fabaceae were the next largest families, with 56, 30, and 22 taxa respectively. Crex Meadows had the highest species richness, with 264 taxa. The site with the lowest species richness was Motts Ravine with 140 species. Douglas County and Moquah Barrens also had a lower species richness with 159 and 157 species respectively. Table 1 compares the total and introduced species at each site. A complete list of species documented in this study is presented in Appendix 1.

We documented 78 new county records of 70 different taxa. Nineteen new records were collected from Polk County, 47 from Burnett County, six from Douglas County, and six from Bayfield County (Table 2).

Several species are nearly ubiquitous across all of the survey sites in the Northwest Sands. Many of these species are common or abundant throughout each site. They are often included in species lists and descriptions for the sites and barrens in the region. Table 3 lists taxa that were observed in at least seven of the eight survey sites. This list includes 12 graminoids, 56 forbs, and 22



FIGURE 7. *Solidago speciosa* is one of the more common goldenrods observed in the barrens. This species, along with *Solidago juncea*, *S. nemoralis*, and *S. ptarmicoides* are documented at all of the sites we surveyed. Photo by Richard W. Haug.

TABLE 1. The total number of species and the number of introduced species documented at each site. The “% of Flora” is the percentage of the total flora for all sites documented at a particular site. The “% Introduced” is the percentage of species at the site that are introduced.

	Sterling Barrens	Fish Lake	Crex Meadows	Namekagon Barrens	Douglas County	Motts Ravine	Barnes Barrens	Moquah Barrens
Species	218	262	264	191	159	140	172	157
% of Flora	54.0%	64.9%	65.3%	47.3%	39.4%	34.7%	42.6%	38.9%
Introduced	27	36	36	29	34	22	30	24
% Introduced	12.4%	13.7%	13.6%	15.2%	21.4%	15.7%	17.4%	15.3%

shrubs and trees. One species on this list, *Lilium philadelphicum* (wood lily) (Figure 8), is rare and appears to be declining at these sites. Over the last decade, regional State Natural Area staff have seen substantial declines in many forbs, including *L. philadelphicum*. This is thought to be caused in part by increased deer herbivory and a greater reliance on herbicides for management (Magana, personal communication 2023).

Site Findings

Sterling Barrens State Natural Area

While Sterling Barrens is one of the smallest sites surveyed, it is also one of the most diverse. Oak barrens and sand prairie are the dominant plant communi-

TABLE 2. New county records documented in the barrens survey, indicated by an X in the column for the county in which the record was documented.

Species	Polk	Burnett	Douglas	Bayfield
<i>Alyssum alyssoides</i> (L.) L.		X		
<i>Ambrosia psilostachya</i> DC.	X			
<i>Amelanchier interior</i> Nielsen	X			
<i>Amelanchier spicata</i> (Lam.) K. Koch	X			
<i>Antennaria howellii</i> Greene subsp. <i>canadensis</i> (Greene) Bayer		X		
<i>Antennaria howellii</i> Greene subsp. <i>neodioica</i> (Greene) Bayer	X	X		
<i>Arabis pycnocarpa</i> M. Hopkins	X	X		
<i>Aristida tuberculosa</i> Nutt.	X	X		
<i>Boechera grahamii</i> (Lehm.) Windham & Al-Shehbaz		X		
<i>Botrychium matricariifolium</i> (Döll) A. Braun		X		
<i>Bouteloua curtipendula</i> (Michx.) Torr.	X			
<i>Carex bicknellii</i> Britton		X		
<i>Carex foenea</i> Willd.		X		
<i>Carex muehlenbergii</i> Willd.		X		
<i>Carex richardsonii</i> R.Br.	X			
<i>Carex tomsa</i> (Fernald) E. P. Bicknell var. <i>tonsa</i>		X		
<i>Ceanothus americanus</i> L.				X
<i>Ceanothus herbaceus</i> Raf.	X			
<i>Cenchrus longispinus</i> (Hack.) Fernald				X
<i>Daucus carota</i> L.		X		
<i>Dichanthelium columbianum</i> (Scribn.) Freckmann		X		
<i>Dichanthelium depauperatum</i> (Muhl.) Gould	X			
<i>Dichanthelium perlongum</i> (Nash) Freckmann		X		X
<i>Digitaria sanguinalis</i> (L.) Scop.				X
<i>Equisetum laevigatum</i> A. Braun	X			
<i>Euphorbia geyeri</i> Engelm.		X		
<i>Euthamia gymnospermoides</i> Greene	X			
<i>Festuca octoflora</i> Walter		X		
<i>Festuca rubra</i> L.			X	
<i>Froelichia floridana</i> (Nutt.) Moq.		X		
<i>Froelichia gracilis</i> (Hook.) Moq.		X		
<i>Helianthus hirsutus</i> Raf.		X	X	
<i>Hieracium longipilum</i> Torr. ex Hook.			X	
<i>Hypoxis hirsuta</i> (L.) Coville		X		
<i>Kummerowia stipulacea</i> (Maxim.) Makino		X		
<i>Lactuca hirsuta</i> Muhl.			X	X
<i>Liparis loeselii</i> (L.) Rich.		X		
<i>Luzula multiflora</i> (Ehrh.) Lej.		X		
<i>Oenothera clelandii</i> W. Dietr., P.H. Raven & W.L. Wagner		X	X	
<i>Oenothera oakesiana</i> (A. Gray) S. Watson & Coult.		X		
<i>Oenothera perennis</i> L.		X		
<i>Oenothera villosa</i> Thunb.	X			
<i>Oxalis dillenii</i> Jacq.		X		
<i>Packera plattensis</i> (Nutt.) W. A. Weber & A. Löve	X			
<i>Physalis heterophylla</i> Nees.		X		
<i>Polygala polygama</i> Walter	X			
<i>Polygala senega</i> L.		X		
<i>Prenanthes racemosa</i> Michx.		X		
<i>Prunus americana</i> Marshall		X		
<i>Pseudognaphalium obtusifolium</i> (L.) Hilliard & B. L. Burt			X	X
<i>Rosa arkansana</i> Porter		X		
<i>Rosa woodsii</i> Lindl.		X		

(Continued on next page)

TABLE 2. (Continued).

Species	Polk	Burnett	Douglas	Bayfield
<i>Sceptridium multifidum</i> (S.G.Gmel.) M.Nishida		X		
<i>Sceptridium rugulosum</i> (W.H.Wagner) Skoda		X		
<i>Scleria triglomerata</i> Michx.		X		
<i>Scrophularia lanceolata</i> Pursh		X		
<i>Setaria faberi</i> R.A.W.Herrm.		X		
<i>Smilax lasioneura</i> Hook.		X		
<i>Solidago altissima</i> L.		X		
<i>Sporobolus cryptandrus</i> (Torr.) A.Gray	X			
<i>Stellaria graminea</i> L.		X		
<i>Symphotrichum lanceolatum</i> (Willd.) G.L. Nesom var. <i>lanceolatum</i>			X	
<i>Symphotrichum robynsonianum</i> (J.Rousseau) Brouillet & Labrecque		X		
<i>Taraxacum erythrospermum</i> Besser	X			
<i>Taraxacum officinale</i> F.H.Wigg.		X		
<i>Tragopogon dubius</i> Scop.		X		
<i>Verbena bracteata</i> Lag. & Rodr.	X			
<i>Vicia cracca</i> L.		X		
<i>Viola pedata</i> L.	X			
<i>Zizia aptera</i> (A.Gray) Fernald		X		

ties. Grub oaks of *Quercus ellipsoidalis* and *Q. macrocarpa* are dominant with occasional scattered *Pinus banksiana*. There are several large open areas of sand prairie, which are dominated by *Andropogon gerardii*, *Carex pensylvanica*, *Carex siccata*, *Danthonia spicata*, *Dichanthelium* spp., *Schizachyrium scoparium*, and *Sorghastrum nutans*. A number of prairie species were documented only at the Sterling Barrens. These include *Bouteloua curtipendula*, *B. hirsuta*, *Packera platensis*, and *Pemseranthus rugospermus*. A few additional prairie species, including *Aristida tuberculosa*, *Asclepias viridiflora*, *Dalea villosa*, and *Geum triflorum*, are documented here and Fish Lake.

Fish Lake Wildlife Area

The gentle topography of the Fish Lake area also supported oak barrens and sand prairie, along with small areas of pine barrens where *Pinus banksiana* and *P. resinosa* were more common (Figure 9). The more open sand prairies here are quite similar in composition to those found at the Sterling Barrens. Small populations of *Calamovilfa longifolia* are found here and also at the Sterling Barrens. An interesting observation of the flora of the site were small regions where the only populations of *Botrychium matricariifolium*, *Botrychium simplex*, *Hypoxis hirsuta*, *Prenanthes racemosa*, and *Pycnanthemum virginianum* are documented during our surveys. This site also supported the largest populations of *Hudsonia tomentosa* among all eight sites.

Crex Meadows Wildlife Area

Overall, the barren and prairie plant communities are similar to those at Fish Lake which, as noted above, is situated in the same glacial lake basin. Crex Meadows is one of the largest sites we surveyed. It also contained the highest

TABLE 3. Species documented in at least seven of the eight survey sites, separated into three growth forms. An asterisk indicates an introduced species.

Graminoids	Forbs	Shrubs and Trees
<i>Agrostis scabra</i>	<i>Achillea millefolium</i>	<i>Acer rubrum</i>
<i>Andropogon gerardii</i>	<i>Ambrosia artemisiifolia</i>	<i>Amelanchier interior</i>
<i>Aristida basiramea</i>	<i>Anemone quinquefolia</i>	<i>Amelanchier spicata</i>
<i>Bromus kalmii</i>	<i>Antennaria howellii</i>	<i>Arctostaphylos uva-ursi</i>
<i>Carex pensylvanica</i>	<i>Antennaria parlinii</i>	<i>Ceanothus herbaceus</i>
<i>Danthonia spicata</i>	<i>Apocynum androsaemifolium</i>	<i>Comptonia peregrina</i>
<i>Dichanthelium acuminatum</i>	* <i>Berteroa incana</i>	<i>Corylus americana</i>
* <i>Elymus repens</i>	<i>Calystegia spithamea</i>	<i>Diervilla lonicera</i>
<i>Koeleria macrantha</i>	<i>Campanula rotundifolia</i>	<i>Pinus banksiana</i>
* <i>Poa compressa</i>	* <i>Centaurea stoebe</i>	<i>Pinus resinosa</i>
<i>Schizachne purpurascens</i>	<i>Chamerion angustifolium</i>	<i>Populus tremuloides</i>
<i>Schizachyrium scoparium</i>	<i>Chenopodium album</i>	<i>Prunus pensylvanica</i>
	<i>Comandra umbellata</i>	<i>Prunus pumila</i>
	<i>Conyza canadensis</i>	<i>Prunus virginiana</i>
	<i>Crocianthemum bicknellii</i>	<i>Quercus ellipsoidalis</i>
	<i>Crocianthemum canadense</i>	<i>Quercus macrocarpa</i>
	<i>Erigeron strigosus</i>	<i>Rosa acicularis</i>
	* <i>Fallopia convolvulus</i>	<i>Rosa blanda</i>
	<i>Fragaria virginiana</i>	<i>Rubus flagellaris</i>
	<i>Helianthus occidentalis</i>	<i>Rubus idaeus</i>
	<i>Helianthus pauciflorus</i>	<i>Salix humilis</i>
	<i>Heuchera richardsonii</i>	<i>Vaccinium angustifolium</i>
	* <i>Hieracium aurantiacum</i>	
	<i>Hieracium umbellatum</i>	
	<i>Houstonia longifolia</i>	
	<i>Krigia biflora</i>	
	<i>Lechea intermedia</i>	
	<i>Liatris aspera</i>	
	<i>Lilium philadelphicum</i>	
	<i>Lithospermum canescens</i>	
	<i>Maianthemum canadense</i>	
	<i>Maianthemum stellatum</i>	
	* <i>Mollugo verticillata</i>	
	<i>Monarda fistulosa</i>	
	<i>Oenothera biennis</i>	
	<i>Oenothera oakesiana</i>	
	<i>Packera paupercula</i>	
	<i>Pedicularis canadensis</i>	
	<i>Plantago rugelii</i>	
	<i>Polygala polygama</i>	
	<i>Polygonella articulata</i>	
	* <i>Potentilla argentea</i>	
	<i>Potentilla norvegica</i>	
	<i>Pseudognaphalium obtusifolium</i>	
	<i>Pteridium aquilinum</i>	
	<i>Rudbeckia hirta</i>	
	* <i>Rumex acetosella</i>	
	* <i>Silene latifolia</i>	
	<i>Solidago juncea</i>	
	<i>Solidago nemoralis</i>	
	<i>Solidago ptarmicoides</i>	
	<i>Solidago speciosa</i>	
	<i>Stachys arenicola</i>	
	<i>Symphotrichum oolentangiense</i>	
	<i>Uvularia sessilifolia</i>	
	* <i>Verbascum thapsus</i>	



FIGURE 8. *Lilium philadelphicum* is found at all of the surveyed sites with the exception of the Sterling Barrens. While the species has a broad distribution across the Northwest Sands Ecological Landscape, ongoing survey work has seen this species decline at several sites. Photo by Richard W. Haug.



FIGURE 9. The barrens of Fish Lake shows little topography. Much of the site is within the basin of Glacial Lake Grantsburg. In the foreground younger *Betula papyrifera* and *Pinus resinosa* are seen. On the horizon, scattered *Pinus resinosa*, *P. banksiana*, *Quercus ellipsoidalis* and *Q. macrocarpa* can be seen. Photo by Derek S. Anderson.



FIGURE 10. Namekagon Barrens. A small grove of about ten, large *Pinus resinosa* trees in the pine barrens is shown to the right. Fire charring of the bark is seen on the lower portion of the trunks. In the background, the area is dominated by grub oaks (*Quercus ellipsoidalis* and *Q. macrocarpa*), *Corylus americana*, *Comptonia peregrina*, *Ceanothus herbaceus*, and *Prunus* spp. Common graminoids include *Danthonia spicata*, *Koeleria macrantha*, *Schizachyrium scoparium*, and *Carex pennsylvanica*. Photo by Derek S. Anderson.

number of taxa documented from any one site. It is at Crex Meadows where *Comptonia peregrina* becomes more common in the barrens landscape, increasing in abundance from here northward. Species found only at this site include *Carex bicknellii*, *Carex foenea*, *Erigeron pulchellus*, *Liatris pycnostachya*, and *Spartina pectinata*.

Namekagon Barrens Wildlife Area

The Namekagon Barrens is a large barrens site found within a matrix of pine plantations and pine and oak forests. Large, scattered *Pinus resinosa* stand tall in the matrix of shrubby *Comptonia peregrina*, *Corylus americana*, *Quercus ellipsoidalis*, and *Q. macrocarpa* grubs (Figure 10). It is also evident that many of the prairie species more common to the southwest, such as *Allium stellatum*, *Amorpha canescens*, *Dalea candida*, *Dalea purpurea*, *Solidago rigida*, *Symphotrichum sericeum*, start to disappear before reaching this latitude. Nevertheless, the site does support several species not documented at other sites, including *Polygala senega* and *Rosa woodsii*.

Douglas County Wildlife Area

Pine barrens is the dominant plant community found at the Douglas County site. *Pinus banksiana* and *P. resinosa* are common. The shrub layer consists of



FIGURE 11. The gently rolling topography of Motts Ravine. In the distance, a *Pinus resinosa* plantation is visible. A few lone individuals of *Pinus resinosa* are visible to the right in the photograph. The foreground is dominated by oak grubs (*Quercus ellipsoidalis*). Scattered among the oaks are occasional individuals of *Corylus americana*, *Comptonia peregrina*, and *Prunus* spp. *Andropogon gerardii*, *Schizachyrium scoparium*, *Koeleria macrantha*, *Danthonia spicata*, and *Carex pensylvanica* make up the common graminoids. Photo by Derek S. Anderson.

oak grubs (*Quercus ellipsoidalis* and *Q. macrocarpa*), *Comptonia peregrina*, *Corylus americana*, and several species of *Prunus*. It is one of the more disturbed barren sites in our survey. The wildlife area has been a training site for horses and hunting dogs since 1935, which resulted in numerous trails, paths, and other disturbances. It is the site with the highest percentage of its flora made up of introduced species, at 21.4%. This includes large populations of the introduced *Robinia pseudoacacia*. However, this site and the Namekagon Barrens are the only sites in which *Erigeron glabellus* (a western species) is found. *Hieracium longipilum* is observed at this site as a new Douglas County record, expanding its known range farther northward. Also of interest, two grapeferns, *Sceptridium multifidum* and *S. rugulosum*, have been documented at the site. This is also the only site in which *Juniperus communis* was observed.

Motts Ravine State Natural Area

This is the second smallest of the barren sites surveyed, which likely contributes to it having the lowest species diversity among all the sites, with 140 taxa. The area is heavily managed with frequent burns to control tree dominance (Figure 11). Though it is small, many interesting finds were observed here. *Comptonia peregrina*, *Vaccinium angustifolium*, *Amelanchier spicata*, *Prunus pumila*, and *Arctostaphylos uva-ursi* are important small shrub species in these open areas. A healthy suite of grasses and forbs, such as *Andropogon gerardii*,

Bromus kalmii, *Liatis aspera*, and *Lithospermum* spp. are commonly found here. *Agastache foeniculum*, *Oenothera clelandii*, and *Froelichia floridana* reach the northernmost limits of their ranges here. The highlight of this site occurred in 2015 during a floral study of the Brule River watershed, when *Lactuca hirsuta* was found, for only the second time in the state (Hlina et al. 2020; Raimond 2021). Mott's Ravine and Barnes Barrens are the only two locations in the Northwest Sands that support small populations of this new state record.

Barnes Barrens

This site was newly created over the last decade (2012–2022) as open barrens. The 162 hectares of the core barren area studied was forested up through 2012. Frequent burns, chemical applications, and mechanical scarification have all been used as management tools at this site. There are several large areas with uniform vegetation of grub oaks of *Quercus macrocarpa*, with a lesser extent of *Quercus ellipsoidalis*, as well as *Corylus americana*, *Salix humilis*, and *Pteridium aquilinum*. Other pockets at this site are quite diverse with notable species including *Lactuca hirsuta*, *Cynoglossum boreale*, *Carex houghtoniana*, *Zizia aptera*, *Ceanothus americanus*, and *Carex adusta*.

Moquah Barrens

Moquah Barrens is the largest of the barren sites studied and is heavily influenced by the climate of Lake Superior. It also has the greatest elevation changes among the sites with dry valleys and tall hilltops (Figure 12). *Hudsonia tomentosa* occurs in these barrens only at this site at the windblown hilltops, which are likely part of the old Glacial Lake Duluth shorelines. Many sidehills support a mix of *Quercus* spp., *Corylus americana*, and *Pteridium aquilinum*. Flat areas support extensive grasslands of *Carex pensylvanica*, *Andropogon gerardii*, *Danthonia spicata*, *Bromus kalmii*, *Schizachyrium scoparium*, and *Avenella flexuosa*. The site contains more northern dry forest species than any of the other sites. These include *Gaultheria procumbens*, *Maianthemum canadense*, *Uvularia sessilifolia*, *Melampyrum lineare*, *Trientalis borealis*, *Spiranthes lacera*, and *Prenanthes alba*. Common throughout these barrens in the fall is the striking *Liatis ligulistylis*, which was also found in one small area at Fish Lake. Interestingly, *Liatis aspera* is absent here, but common to abundant at all of the other study sites.

Latitudinal Distribution of Species

As alluded to in the previous section, the ranges of several species are distributed along a latitudinal gradient within the Northwest Sands Ecological Landscape. The northern sites (Moquah Barrens, Barnes Barrens, and Motts Ravine) are more influenced by the northern forests. As a result, several species reach their southern extent here in the Northwest Sands. These include *Agrostis hyemalis*, *Avenella flexuosa*, *Carex adusta*, *Crataegus macrosperma*, *Cynoglossum boreale*, *Dichanthelium xanthophysum*, *Epigaea repens*, *Geranium bicknellii*, *Geum fragarioides*, and *Lactuca hirsuta*. *Arctostaphylos-uva-ursi* (Figure 13), a species that was documented at all of our study sites, has a greater pres-



FIGURE 12. The rolling topography of the Moquah Barrens seen from a hilltop view. Small groves and isolated individuals of *Pinus banksiana* are visible in the distance. Graminoids in the large open swaths between the groves include *Schizachyrium scoparium*, *Carex pensylvanica*, *Danthonia spicata*, and occasionally *Avenella flexuosa*. In the foreground, *Solidago speciosa*, *Liatris ligulistylis*, *Comptonia peregrina*, and *Prunus pumila* can be seen. Photo by Paul S. Hlina.

ence in the northern sites, where it is sometimes locally dominant. It diminishes in abundance and presence southward to Burnett and Polk Counties.

Similarly, the southern sites (Crex Meadows, Fish Lake, and Sterling Barrens) exhibit a floristic influence from the prairies. Species that approach their northern limits within these barren sites include *Allium stellatum*, *Ambrosia psilostachya*, *Amorpha canescens*, *Artemisia serrata*, *Aristida tuberculosa*, *Asclepias viridiflora*, *Calystegia sepium*, *Castilleja coccinea*, *Celastrus scandens*, *Cirsium discolor*, *Coreopsis palmata*, *Dalea candida*, *D. purpurea*, *D. villosa*, *Delphinium carolinianum*, *Euphorbia corollata*, *Gaylussacia baccata*, *Geum triflorum*, *Hesperostipa spartea*, *Juniperus virginiana*, *Liatris cylindracea*, *L. pycnostachya*, *Lobelia spicata*, *Lupinus perennis*, *Mirabilis alba*, *Penstemon gracilis*, *P. grandiflorus*, *Physalis heterophylla*, *Phemeranthus rugospermus*, *Polygonatum biflorum*, *Ranunculus rhomboideus*, *Rhus glabra*, *Scutellaria parvula*, *Sisyrinchium campestre*, *Solidago missouriensis*, *Sporobolus cryptandrus*, *Symphotrichum sericeum*, *Tradescantia occidentalis*, *Veronicastrum virginicum*, and *Viola sagittata*.

The central sites (Douglas County and Namekagon Barrens) exhibit a con-



FIGURE 13. *Arctostaphylos uva-ursi* grows in large patches in Moquah Barrens, Barnes Barrens, Motts Ravine, and Douglas County and produces large amounts of berries for consumption by birds, mammals, and other wildlife. This circumpolar species reaches the northern latitudes of the arctic, but dwindles in abundance southward through the northwest sand barrens communities. Photo by Paul S. Hlina.

vergence of northern and southern influences. Several species reach their northern limits in the Northwest Sands including *Anemone patens*, *Artemisia ludoviciana*, *Asclepias ovalifolia*, *Boechera grahamii*, *Cornus foemina*, *Cycloloma atriplicifolium*, *Lespedeza capitata*, *Phlox pilosa*, *Selaginella rupestris*, and *Solidago rigida*. Northern species reaching their southern limits within these sites include *Capnoides sempervirens*, *Erigeron glabellus*, *Hieracium scabrum*, *Oryzopsis asperifolia*, *Sibbaldiopsis tridentata*, *Sisyrinchium montanum*, *Solidago hispida*, *Symphoricarpos albus*, *Symphyotrichum laeve*, and *Turritis glabra*.

Floristic Quality Assessment

Mean C_n values were consistent across all barrens with a range from 4.6 to 4.9 (Table 4). Mean C_t values had a slightly greater range from 3.8 to 4.2 (Table 4). These values of Mean C indicate communities that have a moderate level of

TABLE 4. Floristic Quality Assessment metrics for each of the eight sites.

	Sterling Barrens	Fish Lake	Crex Meadows	Namekagon Barrens	Douglas County	Motts Ravine	Barnes Barrens	Moquah Barrens
Mean C_n	4.7	4.9	4.6	4.8	4.8	4.7	4.8	4.8
Native FQI	64.9	73.2	69.3	61.4	54.0	50.9	57.1	54.8
Mean C_t	4.1	4.2	4.0	4.1	3.8	4.0	4.0	4.0
Total FQI	60.1	68.0	64.5	56.5	47.9	46.7	51.8	50.4

TABLE 5. The number of species at each site that have C-values in each of three ranges of values, 0–3 (tolerant), 4–6 (moderately conservative), and 7–10 (most conservative), and the ratio of tolerant to most conservative species in each site.

	Sterling Barrens	Fish Lake	Crex Meadows	Namekagon Barrens	Douglas County	Motts Ravine	Barnes Barrens	Moquah Barrens
0–3	88	100	108	72	65	53	66	62
4–6	84	104	109	80	68	62	74	65
7–10	46	58	47	39	26	25	32	30
Ratio	1.9:1	1.7:1	2.3:1	1.8:1	2.5:1	2.1:1	2.1:1	2.1:1

floristic integrity with a greater amount of habitat tolerant species to habitat conservative species. These values of Mean C_t reflect to some degree the level of introduced plants influencing the quality and suitability of the community.

FQI values indicate a different story about the conditional quality of the barrens. Native FQI values are very high in comparison to other plant community types in Wisconsin. The Native FQI ranges from 50.9 to 73.2, while Total FQI ranges from 46.7 to 68.0 (Table 4). Using the scale in Herman (2001), all the FQI values, whether native or total, reflect communities of high to extremely high natural quality. These high FQI values overall indicate a community with high species richness that forms a matrix of relationships that provide a large suite of habitat needs. These high FQI values also reflect the protected status of all the sites visited. We would expect to see a decline in FQA values on more anthropogenically disturbed sites.

Habitat Tolerant and Conservative Species

Habitat tolerant species can thrive over a wide variety of environmental conditions while adapting to fluctuating levels of resources and nutrients, whereas habitat conservative species exist only in a narrow range of environmental conditions and lower levels of disturbance. A community that has a lower ratio of tolerant to most conservative species is highly susceptible to changing conditions and is under threat of either decreasing or disappearing altogether on the landscape. Table 5 provides a summary of the number of species at each site in the barrens flora that are tolerant to disturbance (C-values between 0 and 3), moderately conservative (C-values between 4 and 6), and most conservative or sensitive (C-values between 7 and 10). The average ratio of tolerant species to most conservative species for all sites was 2.0:1. Fish Lake had the lowest ratio at 1.7:1, while Douglas County had the highest at 2.5:1.

Sørensen–Dice Similarity Index

Calculations of the Sørensen–Dice Similarity Index show a strong similarity between sites that are geographically close to one another. Table 6 compares all of the surveyed sites. The highest similarity between two sites is seen between Fish Lake and Crex Meadows with a coefficient of 0.7833. These two sites are separated by about 20 km. The lowest similarity is found between the Sterling

TABLE 6. Sørensen–Dice Similarity Indices for each pair of the eight barrens sites surveyed in the Northwest Sands Ecological Landscape. Shading of cells in the upper right of the table indicates the degree of similarity. The darker the shading the more similar the two sites are to one another. Values in the lower left of the table are the number of species in common between the two sites.

	Sterling Barrens	Fish Lake	Crex Meadows	Namekagon Barrens	Douglas County	Motts Ravine	Barnes Barrens	Moquah Barrens
Sterling Barrens	X	0.7542	0.7095	0.6161	0.5782	0.4916	0.5333	0.4907
Fish Lake	181	X	0.7833	0.6799	0.6176	0.5224	0.5346	0.5060
Crex Meadows	171	206	X	0.6989	0.6052	0.5347	0.5596	0.5131
Namekagon Barrens	126	154	159	X	0.7429	0.7130	0.7052	0.6379
Douglas County	109	130	128	130	X	0.6890	0.6828	0.6646
Motts Ravine	88	105	108	118	103	X	0.7564	0.6869
Barnes Barrens	104	116	122	128	113	118	X	0.7538
Moquah Barrens	92	106	108	111	105	102	124	X

Barrens and the Moquah Barrens with a coefficient of 0.4907. These two sites are separated by the greatest distance, approximately 165 km.

Rare Species

Several populations of rare plant species tracked by the Natural Heritage Program of the Wisconsin Department of Natural Resources were documented in the course of this study. Eight species (one threatened and seven species of special concern) were observed (Table 7).

TABLE 7. Listing status and S-rank of species in the barrens sites listed by the Wisconsin Department of Natural Resources and the sites in which each occur.

Species	Listing Status	S-Rank	Sites
<i>Asclepias ovalifolia</i>	Threatened	S3	Sterling Barrens, Fish Lake, Crex Meadows, Namekagon Barrens
<i>Coreopsis lanceolata</i>	Special Concern	S2	Moquah Barrens
<i>Dalea villosa</i>	Special Concern	S2	Sterling Barrens, Fish Lake
<i>Packera plattensis</i>	Special Concern	S3	Sterling Barrens
<i>Phemeranthus rugospermus</i>	Special Concern	S3	Sterling Barrens
<i>Sceptridium rugulosum</i>	Special Concern	S2	Namekagon Barrens, Douglas County, Moquah Barrens
<i>Scleria triglomerata</i>	Special Concern	S2	Fish Lake, Crex Meadows
<i>Symphotrichum robynsianum</i>	Special Concern	S1	Crex Meadows



FIGURE 14. *Asclepias ovalifolia* is the only species found during our surveys that is listed as threatened by the Wisconsin Department of Natural Resources. We found populations at Sterling Barrens, Fish Lake, Crex Meadows, and Namekagon Barrens. The species appears to respond well to management carried out at these sites. Photo by Richard W. Haug.

Asclepias ovalifolia (dwarf milkweed) is a threatened species in Wisconsin (Figure 14). It also appears to be strongly represented at the southern sites of our study. We documented populations at Sterling Barrens, Fish Lake, Crex Meadows and the Namekagon Barrens. Anecdotally, we observed increases in flowering stems and follicle development following prescribed site management (e.g., fire and tree removal). More than ten populations of *Dalea villosa* (silky prairie clover) (Figure 15), are found at Sterling Barrens and Fish Lake. Several of these populations are comprised of hundreds of individuals.

Two other species listed as special concern, *Packera plattensis* (prairie ragwort) and *Phemeranthus rugospermus* (prairie fame flower), were observed only at Sterling Barrens. *Phemeranthus rugospermus* was previously known from the site and continues to persist in these barrens. This is the northernmost known site for the species in Wisconsin. The discovery of *Packera plattensis* also represents a new county record and range extension for the species in the state (Wisconsin Department of Natural Resources 2021a). This is a species more common to the prairies south and west of our survey area. It should be noted that identification of *Packera paupercula* and *P. plattensis* in northwestern Wisconsin is difficult and confounded by the tendency of *P. paupercula* to exist as a tetraploid in the



FIGURE 15. *Dalea villosa* is listed as special concern by the Wisconsin Department of Natural Resources. This western species reaches the eastern edge of its range in western Wisconsin. Many large populations were documented at Sterling Barrens and Fish Lake. Photo by Richard W. Haug.

barrens of this region. It occasionally displays a few characteristics more commonly associated with *P. plattensis* (Mahoney and Kowal 2008; Mahoney, personal communication 2022).

An interesting discovery made at Crex Meadows and Fish Lake was *Scleria triglomerata* (whip nutrush). This species is found in the oak/jack pine barrens of these sites in nearly indiscernible depressions within the barrens landscape. Associates included *Bromus kalmii*, *Hieracium umbellatum*, *Juncus* sp., *Lespedeza capitata*, *Pedicularis canadensis*, *Solidago* spp., and *Sorghastrum nutans*. We found two populations at Fish Lake and one population at Crex Meadows. *Symphotrichum robynsonianum* (long-leaved aster) was found only at one small location at Crex Meadow in a population consisting of about a dozen individuals. This aster has unusually long leaves and was growing on the edge of a remnant barren stand of jack pine and aspen.

Coreopsis lanceolata (sand coreopsis) was located at Moquah Barrens at the edge of a sandy road in the barrens, possibly an escapee or part of an earlier seeding or restoration activity at the site. *Sceptridium rugulosum* (rugulose grape fern) was located at three sites: Namekagon Barrens in 2020, Douglas County in 1991, and Moquah Barrens in 1929. The latter two specimens were growing in moist sandy soils, one near a relict lake and the other in an open grassy field. The 2020 collection was found in open sandy barrens with flat to gently rolling topography growing in association with *Arctostaphylos uva-ursi*, *Comptonia peregrina*, and *Rosa* sp.

DISCUSSION

The barren communities of the Northwest Sands Ecological Landscape represent a diverse assemblage of species. Several trends are noted in the distribution of species along the latitudinal gradient of sites from northwestern Polk County in the south to north-central Bayfield County in the north. There is a higher diversity of species in the southwestern sites in comparison to those in the northeast. The barrens of the southern sites are marked with a greater diversity of prairie species, while the barrens of the northern sites tend to have species more characteristic of northern dry forests and woodlands.

Management in the form of fire, robust scarification or tilling, and mechanical chopping, have been critical components in maintaining these sites as early successional barrens. Much of the recent expansion of barrens in the northwest sands is a direct result of two plans, the Wisconsin Sharp-tailed Grouse: A Comprehensive Management and Conservation Strategy (Fandel and Hull 2011) and the Northwest Sands Habitat Corridor Plan (Reetz et al. 2013). Fandel and Hull (2011) discuss the plight of the *Tympanuchus phasianellus* (Sharp-tailed Grouse) in Wisconsin. This is a species of greatest conservation need, and there was a desire to expand and protect high quality barrens habitat in the Northwest Sands. In an earlier study, Gregg (1987) found that fewer than 2000 birds existed in Wisconsin during a census survey of the early 1980s. Gregg (1987) recommended an aggressive landscape habitat management plan for barrens habitat throughout northwestern Wisconsin to prevent extirpation of the Sharp-tailed Grouse from the region. Since 1987, Sharp-tailed Grouse populations have fluctuated, and, in good years, some hunting has resumed. However, recent trends continue to challenge these birds. There was a 26% decrease in populations between 2020 and 2021 in the Northwest Sands, resulting in the cancellation of the hunting season of Sharp-tailed Grouse (Wisconsin Department of Natural Resources 2021b). Only Namekagon Barrens and the new Barnes Barrens have provided some stability and consistency for the Sharp-tailed Grouse.

The second plan, the Northwest Sands Habitat Corridor Plan (Reetz et al. 2013) recommends the creation of corridors to connect the eight sites of our study and other barren properties in the region. The potential habitat corridors, which contain fragmented forests of various growth stages, have been identified to reconnect currently managed barrens properties. These forests can be managed as rotating barrens, which would be made up of large blocks of forest that are harvested and regenerated in a systematic way. These corridors would provide critical habitat for wildlife to move between the larger managed barrens (Reetz et al. 2013). Expansion of this work continues at a rapid pace in Crex Meadows, Fish Lake, Namekagon Barrens, Barnes Barrens and a new area called Bass Lake Barrens that will link Barnes Barrens with Moquah Barrens (Bayfield County Forestry Department 2013; Wisconsin Department of Natural Resources 2015, 2016, 2017a, 2017b; USDA Forest Service 2009).

In the southern sites of our study, the importance of these communities for wildlife is only reinforced. In addition to providing habitat for numerous birds, reptiles, and mammals, the barrens are also habitat for many invertebrates. Perhaps one of the most significant is *Lycaeides melissa samuelis* (Karner blue butterfly).



FIGURE 16. *Lupinus perennis* is documented only at Sterling Barrens, Fish Lake, and Crex Meadows. Many large populations of this species are observed in the oak barrens and sand prairies of these sites. This species is the host plant for the federally endangered Karner Blue Butterfly. Photo by Richard W. Haug.

This federally endangered species is dependent on *Lupinus perennis* (wild lupine), which is commonly found in the southern sites (Figure 16). Maintaining the open savanna-like nature of the barrens is critical for maintaining a strong population of *L. perennis* and its obligate companion, the Karner blue butterfly.

In the northern sites, graminoids, oak scrub, and other woody shrubs continue to be the dominant features in the barrens. Anecdotally, these recent observations in tandem with over 20 years of visiting these sites, suggests a decline in some flowering forbs, such as *Asclepias tuberosa*, *Rudbeckia hirta*, *Lilium philadelphicum*, *Liatris aspera*, *Monarda fistulosa* and *Monarda punctata*. Future vegetative studies and observations could provide quantitative results of the changing landscape. If our suspicions are correct, these future studies would show that the barrens is experiencing a greater biotic homogenization while diminishing habitat values for insects, pollinators, birds and wildlife, as has been shown in other forest and non-forested ecosystems in Wisconsin. Future work could examine some further causes of habitat challenges in the barrens that may include deer herbivory, habitat fragmentation, management practices or lack thereof, a warming climate, anthropogenic disturbance, and mismatches in the synchronous relationship between flowering plants and pollinators.

Deer herbivory poses a serious threat to the proper functioning of these barrens ecosystems of the Northwest Sands Ecological Landscape. One of the first Wisconsin studies on the impact of deer was conducted by Alverson et. al. (1988). This study illustrated the negative impact of elevated *Odocoileus vir-*

giniatus (white-tailed deer) populations on the vegetation of northern Wisconsin. Over the ensuing 30 plus years the deer problem has intensified. Rooney (2009) describes the simplification and biotic homogenization of northern natural landscapes due to high deer densities browsing on forbs and woody vegetation in forested landscapes, which in turn favor graminoid species.

The increase in deer pressure on the vegetation coupled with decades-long changes in disturbance patterns (primarily fire suppression) may be related to an increase in the presence of *Carex pensylvanica* in the barrens. This species is normally considered a species of dry forests, but now is seen to be abundant in many areas of the barrens. In a floristic study conducted by Thomson (1945) in the barrens of the Brule River watershed, more than 127 species were documented, although *Carex pensylvanica* was not noted. Additionally, the work of Curtis (1959) lacks the inclusion of *C. pensylvanica* as a dominant, co-dominant, or associate species on his lists for pine barrens communities. In examining the northern sites of this study, we observed areas where monoculture stands of *C. pensylvanica* had formed. These dense pockets provide little opportunity for the establishment of other barrens species (Abrams et al. 1985). Long-term, this condition could further the degradation of sites, thereby reducing the diversity of plant species.

CONCLUSION

Our documentation of the flora of the region will provide data that adds to the vast body of knowledge of the region. The floristic quality assessments can serve as a baseline in strategic management plans (Magurran et al. 2010). They can be used to re-evaluate the flora at regular intervals in the future (e.g., once every 5 to 10 years). Lower values may indicate some changes in the environmental conditions on the sites that could influence future management decisions to maintain or increase floristic quality. Surveying after the implementation of management strategies would be highly beneficial to document the resurgence and expansion of barrens species that may be dormant or in the seed bank. Additionally, these surveys should target rare species listed by the state. It will be beneficial to document their responses to management and incorporate this information into conservation efforts in the future.

The expansion of the barrens on the landscape will allow plant populations to expand their narrow ranges of present day. It appears that there is a suite of plants (e.g., *Allium stellatum*, *Asclepias ovalifolia*, and others) that may lay dormant in the shaded forest of the region that will be expressed once trees are harvested. As continued restoration activities proceed throughout the Northwest Sands Ecological Landscape, future floristic studies will continue to expand our understandings of these ecosystems.

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APPENDIX 1. List of species found at the barrens sites. The list is organized by major plant group (pteridophytes and lycophytes, gymnosperms, dicots, and monocots), then alphabetically by family, genus, and species. An asterisk indicates an introduced species. The collection numbers that follow each species name indicate the lead collector by a prefix: A = Anderson; F = Feist; H = Hlima; Hg = Haug; M = Marcum; P = Philippe; and W = Wetter. Nomenclature follows Voss and Reznicek (2012) or, for several western ranging species not included in that work, Flora of North America (1993+). The survey sites are denoted by the following column headers: S = Sterling Barrens; F = Fish Lake; C = Crex Meadows; N = Namekagon Barrens; D = Douglas County; Mt = Motts Ravine; B = Barnes Barrens; and Mq = Moquah Barrens. A qualitative abundance estimate is given for each taxon at which it occurs with a letter representation as follows: A = Abundant (plants are dominant and found throughout much of the site); C = Common (plants are found in high numbers but may be patchy or dominant in local patches); O = Occasional (plants are sporadic at the site and mostly present as scattered individuals); and R = Rare (only a few plants observed, or local and restricted to small areas of the site). A dagger (†) superscript on these codes is used to denote an observed species that we failed to document with a specimen.

Taxon	S	F	C	N	D	Mt	B	Mq
PTERIDOPHYTES AND LYCOPHYTES								
DENNSTAEDIACEAE								
<i>Pteridium aquilinum</i> (L.) Kuhn (bracken fern); A3219, A3252, A3304, A3491, F7455, H6248, H6290, H6697, W1507	C	C	C	A	C	C	A	C
EQUISETACEAE								
<i>Equisetum hyemale</i> L. (scouring rush); H-53			R					R
<i>Equisetum laevigatum</i> A. Braun (smooth scouring rush); A3213, H5005			R					R
<i>Equisetum × ferrissii</i> Clute (Ferriss' horsetail); A3576, Hg305		O	R					R
LYCOPODIACEAE								
<i>Dendrolycopodium hickeyi</i> (W.H. Wagner, Beitel & R.C. Moran) A. Haines (Hickey's clubmoss); H4992, H6832								R
<i>Diphasiastrum digitatum</i> (A. Braun) Holub (southern ground cedar); H5442, H6053, H6661, H7056				R			R	R
<i>Lycopodium clavatum</i> L. (running club-moss); A3311, H5383							R	
OPHIOGLOSSACEAE								
<i>Botrychium matricarifolium</i> (Döll) A. Braun (matricary grape fern); A2782		R						
<i>Botrychium simplex</i> E. Hitchc. (least moonwort); A2760, A2783		R						
<i>Botrychium tenebrosus</i> A.A. Eaton (shade moonwort); A3089		R						
<i>Sceptridium dissectum</i> (Spreng.) Lyon (cut-leaved grape fern); H6083, H6107								R
<i>Sceptridium multifidum</i> (S.G. Gmel.) M. Nishida (leather-leaf grape fern); A2958, A2971, A2978, A2981, A3739, H151, H5433, H5452, W1541	R	R	R	O	R			
<i>Sceptridium rugulosum</i> (W.H. Wagner) Skoda (rugulose grape fern); A3342, Brakke (s.n.), Wilson (1712)				R	R			R

(Continued on next page)

APPENDIX 1. (Continued)

Taxon	S	F	C	N	D	Mt	B	Mq
SELAGINELLACEAE								
<i>Selaginella rupestris</i> (L.) Spring (dwarf spike moss); A2897, A2974, A2983, A3046, A4084, F7151, H4722, W1582	O	O	O	O	R			
GYMNOSPERMS								
CUPRESSACEAE								
<i>Juniperus communis</i> L. var. <i>depressa</i> Pursh (common juniper); H5064					R			
<i>Juniperus virginiana</i> L. (eastern red cedar); A2947	O							
PINACEAE								
<i>Abies balsamea</i> (L.) Mill. (balsam fir); H5437							R	
<i>Pinus banksiana</i> Lamb. (jack pine); A2952, A2955, A2963, A2966, A2975, A4076, F7039, H4581, H6047, H6165, H6619, M6691	C	C	C	C	C	C	C	C
<i>Pinus resinosa</i> Aiton (red pine); A2982, A3290, A3562, F7051, H6052, H6620, P43916		O	O	O	O	O	O	O
<i>Pinus strobus</i> L. (white pine); A2965, H4600, H6051, H6286, H6562		R	O	O	O	O	O	O
DICOTS								
AMARANTHACEAE								
<i>Chenopodium album</i> L. (lamb's quarters); A3555, A3575, H4568, H6375, H6577, H6589	R	R	R†	C	O	R†	R	R†
<i>Chenopodium pratericola</i> Rydb. (desert goosefoot); M7449		R						
<i>Chenopodium simplex</i> (Torr.) Raf. (maple-leaved goosefoot); A4345	R							
<i>Cyclopoma atriplicifolium</i> (Spreng.) J.M.Coult. (winged pigweed); A3379, H6373			R	R				
<i>Froelichia floridana</i> (Nutt.) Moq. (common cotton-weed); H6299, H152, H6486, H6486, W1481		R	R	R		R		
* <i>Froelichia gracilis</i> (Hook.) Moq. (cotton-weed); A2793, A3574, A4247, H5821, H6388, H6615	O	O	O	R				
ANACARDIACEAE								
<i>Rhus glabra</i> L. (smooth sumac); A3242, A3612, A4181, F7426, F7477, H7019	C	C	C					
<i>Rhus typhina</i> L. (staghorn sumac); H4168, H4548, H5021			O					
<i>Toxicodendron rybergii</i> (Rydb.) Greene (western poison ivy); A3153, A3688, A3506, A3567	O	O	O		R†			R†
APIACEAE								
* <i>Daucus carota</i> L. (Queen Anne's Lace); H5749			R					
<i>Zizia aptera</i> (A.Gray) Fernald (heart-leaved golden alexanders); A3064, A3138, A3483, A3622, A4249, H4904, H6859		O	R	R			R	

APOCYNACEAE									
<i>Apocynum androsaemifolium</i> L. (spreading dogbane); A3181, A3258, A3315, A4100, H4046, H4236, H4381, H4425, H4652	O	O	O	O	C	C	C	C	C
<i>Apocynum cannabinum</i> L. (Indian hemp); A4118, F7144, F7158, H4537, H5060	R	R	R	R	R				
<i>Asclepias ovalifolia</i> L. (poke milkweed); H4491									
<i>Asclepias exaltata</i> L. (dwarf milkweed); A2754, A3146, A4051, A4060, A4177, F7181, F7238, F7472, H4227, H4246, H4378, H4476, H4531	R	O	O	R	R				R
<i>Asclepias syriaca</i> L. (common milkweed); A3247, F7479, H4458, H6380, H6586, M7437	O	O	O	O	O				
<i>Asclepias tuberosa</i> L. (butterfly milkweed); A2941, A3139, A3221, F7232, F7424, H4218, H4369, H5327, H5649, H6340, W1489	O	O	O	C	O				
<i>Asclepias viridiflora</i> Raf. (green-flowered milkweed); A2903, H3100	O	R							
AQUIFOLIACEAE									
<i>Ilex verticillata</i> (L.) A. Gray (winterberry); A4416, F7157	R	R							
ARALIACEAE									
<i>Aralia hispida</i> Vent. (bristly sarsaparilla); A3566, H5048, Bruederle (s.n.)			R					R	R
ASTERACEAE									
<i>Achillea millefolium</i> L. (common yarrow); A3226, F7169, F7436, H4352, H4385, H4430, H5634, H6272, H6292, M7454,	O	O	O	C	C	O	C	O	O
<i>Ambrosia artemisiifolia</i> L. (common ragweed); A2915, A3397, F7429, H4061, H4547, H4550, H4619, H6326, H6389, H7057, W1497	O	O	O	C	O	R		R	
<i>Ambrosia psilostachya</i> DC. (western ragweed); A2899, A4236, F7399, H4692, H4724, M7439, W1579	O	O	O	C	O	R		R	
<i>Anaphalis margaritacea</i> (L.) Benth. (pearly everlasting); A3309, A3387, H6579	O	O	O	R				O	O†
<i>Antennaria howellii</i> Greene subsp. <i>canadensis</i> (Greene) Bayer (Canadian pussy-toes); A3057, H5453			O			R		R	
<i>Antennaria howellii</i> Greene subsp. <i>neodioica</i> (Greene) Bayer (field pussy-toes); A3055, A3059, A3072, H4956, H5801, H6089, H6287	R	O	O	O	O	O	O	R†	O
<i>Antennaria howellii</i> Greene subsp. <i>petaloidea</i> (Fernald) Bayer (small pussy-toes); A3032, A3053			O						
<i>Antennaria neglecta</i> Greene (cat's-foot); A3015, A3485, H4358, H4394, H4755, H4786, H4821, H4881, H4882, H5266		R	R	R	R	R	R	R	R
<i>Antennaria parlinii</i> Fernald (Parlin's pussy-toes); A3025, A3054, A3061, A3498, A3876, H4343, H4395, H4753, H4783, H4585, H4820, H4889, H4961, H5251, H6091, M6693	R	O	O	C	C	C	C	C	C
<i>Artemisia campestris</i> L. subsp. <i>caudata</i> (Michx.) Hall & Clements (field sawwort); A2894, F7395, H5204, H6328, W1482	C	C	C	O	C			C	
<i>Artemisia ludoviciana</i> Nutt. (prairie sage); A2933, F7423, H4508, H5206, W1486	O	O	O	O	C			C	
<i>Artemisia serrata</i> Nutt. (saw-tooth wormwood); A2928	R								

(Continued on next page)

APPENDIX 1. (Continued)

Taxon	S	F	C	N	D	Mt	B	Mq
<i>Solidago juncea</i> Aiton (early goldenrod); A2906, A3273, A3299, A4237, A4195, H4468, H4477, H4518, H4660, H5193, H5269, H6315, H4617, P43895	O	O†	O	A	O	O	O	O
<i>Solidago missouriensis</i> Nutt. (Missouri goldenrod); A2898, F7431, W1518	O	O	O					
<i>Solidago nemoralis</i> Aiton (gray goldenrod); A2893, A3331, A4431, F7403, H4184, H4239, H4520, H4571, H4595, H4625, H4648, H5279, M7460, P43894	C	C	C	A	C	C	C	C
<i>Solidago ptarmicoides</i> (Torr. & A.Gray) B.Boivin (upland white goldenrod); A3298, A3333, A3602, F7440, H4094, H4558, H4735, H5293, W1534	R	O	O	C	O	O	R†	R†
<i>Solidago rigida</i> L. (rigid goldenrod); A2914, F7421, H5277, W1531	R	R	R					
<i>Solidago speciosa</i> Nutt. (showy goldenrod); A2814, A2890, A2908, A3282, A3283, A4180, A4430, F7412, H3092, H4202, H4469, H4510, H4557, H4594, H4624, H4651, H4665, H4733, H5037, H5208,	C	C	C	C	O	O	C†	O
<i>Symphoricarichum ciliolatum</i> (Lindl.) A.Löve & D.Löve (Lindley's aster); H5292, H6614, H4650, H5260, H5268, H6572, H7048			R	O	O	O	O	C
<i>Symphoricarichum laeve</i> (L.) A.Löve & D.Löve (smooth aster); A3328, A4234, H4422, H4465, H4516, H4560, H4583, H5038, H6265, M6740, P43912				O	R	O	O	C
<i>Symphoricarichum lanceolatum</i> (Willd.) G.L. Nesom var. <i>hesperium</i> (lined aster); A3364, A3366, A3374, A3742, H4629, H4736, H4737, H5273, H5274, H5286, H7138	R	R	R	R	R	R	R	R
<i>Symphoricarichum lanceolatum</i> (Willd.) G.L. Nesom var. <i>lanceolatum</i> (lined aster); H4188, H4266, H6563, H6584			R	O	R	R	R	R
<i>Symphoricarichum oolentangiense</i> (Riddell) G.L. Nesom (azure aster); A2911, A3712, A3770, A4412, A4433, F7465, H4186, H4238, H4472, H4492, H4565, H4616, H4626, H4664, H4723, H5188, H5198, H5199, H5272, H6573, H5827, M7444, P43889, W1539	A	A	A	C	A	A	A	C
<i>Symphoricarichum pilosum</i> (Willd.) G.L. Nesom (awl aster); H4631, H5267, H6583			R				R	
<i>Symphoricarichum praealtum</i> (Poir.) G.L. Nesom (veiny lined aster); F7474			R				R	
<i>Symphoricarichum robynianum</i> (J.Rousseau) Brouillet & Labrecque (Robyn's aster); A2820, F7474.1, Hg167, Hg168, Hg169			R				R	
<i>Symphoricarichum sericeum</i> (Vent.) G.L. Nesom (silky aster); A2936, A3740, A4415, F7444, H4630, H5278, H3091	R	R	R				R	
<i>Symphoricarichum urophyllum</i> (DC.) G.L. Nesom (arrow-leaved aster); A2930, A2938, A3365, A3371, A4411, A4413, H4170, H4481, H4615, H5280	O	O	O	O			R	R
* <i>Tanacetum vulgare</i> L. (common tansy); H5190, H6344								
* <i>Taraxacum erythrospermum</i> Besser (red-seeded dandelion); A3882	R							

APPENDIX 1. (Continued)

Taxon	S	F	C	N	D	Mt	B	Mq
CARYOPHYLLACEAE								
* <i>Cerastium fontanum</i> Baumg. (common mouse-ear chickweed); F7263			R					
* <i>Scleranthus annuus</i> L. (annual knawel); A4092, A4230, H5056, H5447, H6569, M6756				O	R	R	R	O
* <i>Silene antirrhina</i> L. (sleepy catchfly); A3121, A3140, A3527, A3554, F7425, F7463, H4487, H6383	O	O	O	O				
* <i>Silene latifolia</i> Poir. (bladder campion); A3201, A3531, F7453, H4360, H4399, H6390, H6408	R	O	O	O	O	O†	O	
* <i>Silene vulgaris</i> (Moench) Garcke (bladder campion); H4396, H5061					O			
* <i>Stellaria graminea</i> L. (common stitchwort); A3910	R							
* <i>Stellaria longifolia</i> Willd. (long-leaved stitchwort); A3911, H6688	R							
CELASTRACEAE								
* <i>Celastrus scandens</i> L. (American bittersweet); F7250, H4370	O†		O					
CISTACEAE								
* <i>Crocyanthemum bicknellii</i> (Fernald) Janch. (Bicknell's rock-rose); A2907, A3571, A3272, F7407, F7448, F7449, H3102, H4085, H4171, H4322, H4452, H4453, H4470, H4474, H4493, H4957, H5046, H6270, M6732, M7453, W1509, W1529	C	C	C	C	C	C	C	C
* <i>Crocyanthemum canadense</i> (L.) Britton (Canada rock-rose); A2761, A3563, F7176, H4090, H4182, H4415, H5946, H4668, H6336, H6392, H6567, H6876, H6885, P43902, W1492	O	C	O	O	O	O	R	O
* <i>Hudsonia tomentosa</i> Nutt. (beach heather); A2957, A2967, A3086, A3500, H4578, H5254, H5257, H5575		O		R				O
* <i>Lechea intermedia</i> Britton (pinweed); A2892, A3253, A3284, A4229, F7470, F7519, H70, H4582, H5187, H5258, H5952, H4659, H4671, H6607, H6621, H6639, H7134, H7200, P43921	C	C	O	O	O	O	O	O
* <i>Lechea stricta</i> Britton (bushy pinweed); A3598, H-70, H3109, H5066, W1510	R	O	R				R	
CONVOLVULACEAE								
* <i>Calystegia sepium</i> (L.) R. Br. (hedge bindweed); H4447, H5751			O					
* <i>Calystegia spithamea</i> (L.) Pursh (low bindweed); A3133, A4080, F7164, H4359, H4376, H4420, H4963, H5607, H5632, M6751	R	O	C	C	C	C	O	O
* <i>Convolvulus arvensis</i> L. (field bindweed); Taylor (147)					R			
CORNACEAE								
* <i>Cornus foemina</i> Mill. subsp. <i>racemosa</i> (Lam.) J. S. Wilson (gray dogwood); A3169, A3363, A4095, H4598, H6877	O	O	O		O			
DIERVILLACEAE								
* <i>Diervilla lonicera</i> Mill. (bush honeysuckle); A3305, A4087, A4108, F7251, F7476, H4355, H4575, H4962, H5289, H5609, H5677, H6262, P43908	R		O	C	C	O	O	C

ERICACEAE									
<i>Arctostaphylos uva-ursi</i> (L.) Spreng. (bearberry); A2956, A2960, A2973, A3014, A3307, A3613, H4515, H4570, H4588, H4754, H6487, H6659, P44026	R	R	R	R	R	R	R	R	C
<i>Chimaphila umbellata</i> (L.) W.P.C. Barton (pipsissewa); H6366, H4781									
<i>Epigaea repens</i> L. (trailing arbutus); H4998, H5385, H5435, H6048, H6088, H6847									
<i>Gaultheria procumbens</i> L. (wintergreen); A2968, H4756, H5261, H5384, H6367, M6679	R								
<i>Gaylussacia baccata</i> (Wangenh.) K. Koch (black huckleberry); A3194, A3259, F7160, F7224									
<i>Vaccinium angustifolium</i> Aiton (low blueberry); A2749, A3073, F7049, H4086, H4339, H4466, H4812, H4874, H4875, H5823, H6638, M6680	C	C	C	A	C	C	C	C	C
EUPHORBIACEAE									
<i>Euphorbia corollata</i> L. (flowering spurge); A2787, A3167, H3093, W1488, W1532	O	O	O	O	O	O	O	O	
* <i>Euphorbia cyparissias</i> L. (cypress spurge); A2840, H4403, H4879, H5019, H5619	R								
<i>Euphorbia geyeri</i> Engelm. (Geyer's sand-mat); A2737, A2904, A3248, A3346, H4720, W1573									
<i>Euphorbia glyptosperma</i> Engelm. (rib-seed sand-mat); A3636, A4179, A4228, A4384, F7447, H4163, H6333, W1525	R	O	R	R					
<i>Euphorbia maculata</i> L. (spotted sand-mat); A3330, H5263, H5055, H6018, H6346, H6404, H6571, W1522, Richardson (3587)	R	R	R	R	R	R	R	C	R
* <i>Euphorbia virgata</i> Waldst. & Kit. (leafy spurge); A3192, H6129, H6321									
FABACEAE									
<i>Amorpha canescens</i> Pursh (lead plant); A2888, A4176, F7409, H4217, H4222, H4460, W1485	C	C	O	O					
<i>Amphicarpaea bracteata</i> (L.) Fernald (hog peanut); H5284									
<i>Asragalus canadensis</i> L. (Canada milkvetch); A3593	R								R†
<i>Dalea candida</i> Michx. ex Willd. (white prairie clover); A3228, A3569, A4259, H3097, H6279, W1501	O	O	R						
<i>Dalea purpurea</i> Vent. (purple prairie clover); A2880, A4256, F7428, H3095, H4457	O	O	O						
<i>Dalea villosa</i> (Nutt.) Spreng. (silky prairie clover); A2886, A4372, H4160, W1572	C	C	C						
<i>Desmodium canadense</i> (L.) DC. (showy tick-trefoil); A3610, H4446, H4462									
* <i>Kummerowia stipulacea</i> (Maxim.) Makino (Korean bush clover); H150, W1521	R	R	R						
<i>Lathyrus venosus</i> Willd. (veiny pea); A3164, A4053, F7161, F7244, H4235, H4528	O	O	O			R†			R
<i>Lespedeza capitata</i> Michx. (round headed bush-clover); A2932, A3493, F7398, H4161, M7438, W1493	C	O	O	R					O
* <i>Lotus corniculatus</i> L. (bird's foot trefoil); A3124, A3578, A4056, H4436, H4559, H6570, H6894									
<i>Lupinus perennis</i> L. (wild lupine); A2753, A3066, F7179, F7236, F7427, H4233, H4375	C	C	O						
* <i>Melilotus albus</i> Medik. (white sweet clover); A3680, F6283, H6330, H6347									
* <i>Robinia pseudoacacia</i> L. (black locust); H4672, H5059									
* <i>Securigera varia</i> (L.) Lassen (crown vetch); A3584, A4068									

(Continued on next page)

APPENDIX 1. (Continued)

Taxon	S	F	C	N	D	Mt	B	Mq
* <i>Trifolium arvense</i> L. (rabbit-foot clover); A3679, F7430, H6282, H6489, H6564		O	O	C	C			
* <i>Trifolium aureum</i> Pollich (yellow hop clover); F7168, H6131, H6281		R	O					
* <i>Trifolium pratense</i> L. (red clover); A3557, F7174, H4404	R	O	O†	O	O			
* <i>Trifolium repens</i> L. (white clover); F7170, H4393		O		R†	O			
<i>Vicia americana</i> Willd. (American vetch); A3577, A4038	R	O						
* <i>Vicia cracca</i> L. (cow vetch); H4267, H4730		O	O					
* <i>Vicia villosa</i> Roth (hairy vetch); F7246, H4319, H4320, H5028, H5569		R	O					
FAGACEAE								
<i>Quercus alba</i> L. (white oak); A4116	R							
<i>Quercus ellipsoidalis</i> E. J. Hill (Hill's oak); A2751, A3005, A3268, A3320, A3488, A3497, F7044, F7045, F7468, H4335, H6094, H6289, H6317, W1574	A	A	A	A	A	A	A	A
<i>Quercus macrocarpa</i> Michx. (bur oak); A2954, A2961, A2972, A3319, F7046, F7450, H4334, H6288, H6329, W1502	A	A	A	A	C	C	C	R
<i>Quercus rubra</i> L. (red oak); H6253, H6849								
GENTIANACEAE								
<i>Gentiana andrewsii</i> Griseb. (bottle gentian); Hg393	R							
<i>Gentiana puberulenta</i> J.S.Pringle (downy gentian); Hg392	R		R†					
GERANIACEAE								
<i>Geranium bicknellii</i> Britton (Bicknell's geranium); H4759, H4909, H4914						R	R	R†
HYPERICACEAE								
* <i>Hypericum perforatum</i> L. (common St. John's wort); A3324, H4437, H4780, H4913, H6284, H6337					O	O	O	O
LAMIACEAE								
<i>Agastache foeniculum</i> (Pursh) Kuntze (fragrant giant hyssop); A3227, A4258, F7460, H4459, H4732, H5754, H5942, H6417, W1504	C	C	C	O				
<i>Hedeoma hispida</i> Pursh (rough false pennyroyal); A3122, A3525, H5576	R	R						
<i>Monarda fistulosa</i> L. (bergamot); A3246, F7466, H4216, H4593, H5727, H6368, H6339, H6414, W1513	C	C	C	C	C	C	O	O
<i>Monarda punctata</i> L. (dotted horsemint); A3237, A3616, H4234, H4185, H5951, H6381		O	O	R				
<i>Prunella vulgaris</i> L. (heal-all); H4441								
<i>Pycnanthemum virginianum</i> (L.) Durand & Jackson (Virginia mountain mint); A3367, Hg396		R	R					
<i>Scutellaria parvula</i> Michx. var. <i>leonardii</i> (Epling) Fernald (small skull cap); A3528, A3145, H7016	R	R						
<i>Stachys arenicola</i> Britton (hedge-nettle); A2326, A3218, A3573, F7462, F7516, H442, H4494, H6334, H5726, H5833, H6385	O	O	O	C	C	C	C	R†

APPENDIX 1. (Continued)

Taxon	S	F	C	N	D	Mt	B	Mq
PAPAVERACEAE								
<i>Capsoides sempervirens</i> (L.) Borkh. (pale corydalis); H4912, H5631, H6099, Mahoney (110), Taylor (143)				R	R	R	R	
PLANTAGINACEAE								
* <i>Linaria vulgaris</i> Mill. (butter and eggs); A3236, H6597, H5829, W1576	R	R	R	R			O	O
<i>Nuttallanthus canadensis</i> (L.) D.A.Sutton (annual toadflax); A3087, A3196, H5580		R	R	R†				
<i>Penstemon gracilis</i> Nutt. (lilac penstemon); A3123, A3148, H4228, H5009, H6136	O	O	O					
<i>Penstemon grandiflorus</i> Nutt. (large-flowered penstemon); A3150, A4058	O		R					
* <i>Plantago lanceolata</i> L. (English plantain); H6568								R
* <i>Plantago major</i> L. (broad-leaved plantain); H6606, H7051					R	R	O	
* <i>Plantago patagonica</i> Jacq. (woolly plantain); A3168, A3558, F7208, H6387, H6332, H5836, H6275	O	O	O	R	O		O	
<i>Plantago rugelii</i> Decne. (American plantain); A3556, A3579, H4488, H6276, H4656, H5835, H6351	R	O	O	R			O	O
<i>Veronicastrum virginicum</i> (L.) Farw. (Culver's root); A3210, A3361, H4208, H4535, H4734	O	O	O					
POLEMONIACEAE								
<i>Phlox pilosa</i> L. (prairie phlox); A2763, F7122, F7207, F7240, H4230, H4367, H4888, H5622, H5760, W1515	C	C	C	C				
POLYGALACEAE								
<i>Polygala paucifolia</i> Willd. (fringed polygala); H6653							R	
<i>Polygala polygama</i> Walter (racedem milkwort); A2784, A3144, A3158, A4090, F7166, F7415, H4096, H4224, H4486, H4996, H5034, H5054, H5209, H5670, M6737, M7459	O	O	O	C	O	O	O	O
<i>Polygala sanguinea</i> L. (field milkwort); A3368, H3094, H5016		R	O					
<i>Polygala senega</i> L. (Seneca snakeweed); A3132, H5614				R				
POLYGONACEAE								
* <i>Fallopia convolvulus</i> (L.) Á.L.Óve (black bindweed); A3611, A4109, F7442, H4101, H6298, H6379, H6557, H5834, H6863, M7462, P43914	R	O	O	O	O	O	O	
<i>Persicaria lapathifolia</i> (L.) Delabare (curly-top knotweed); H4104, H6416, H6610							O	
* <i>Persicaria maculosa</i> Gray (spotted lady's thumb); H6578								O
<i>Persicaria pensylvanica</i> (L.) M.Gomez (Pennsylvania knotweed); A4341	R							
<i>Polygonella articulata</i> (L.) Meisn. (coastal joint-weed); A2826, A2929, A2738, A3347, A4432, H4181, H4577, H5262, H5298, H6553, H6590, Hg339, P43887	O	O	O	C	O	O	O	O
* <i>Polygonum aviculare</i> L. (common knotweed); A3627, A4342	R		R					

* <i>Rumex acetosella</i> L. (sheep sorrel); A3297, A3512, A4050, A4093, F7173, F7233, F7456, H4433, H6850, H6851, H6895	R	O	O	R†	R	O	R	R	R
* <i>Rumex crispus</i> L. (curly dock); H5830									R
RANUNCULACEAE									
<i>Anemone cylindrica</i> A. Gray (thimbleweed); A3128, A3149, F7178, F7248, F7406, H4231, H4449, H4556, H4640, H5030, H5613, H5616, M7441, W1484	O	O	O	C	O	O			
<i>Anemone patens</i> (L.) Mill. (pasqueflower); A2829, A2835, A2980	O	O	R	R					
<i>Anemone quinquefolia</i> L. (wood anemone); A2750, A3003, H4813, H6085, H6636, H6691, H6843, M6682	R	O	O†	O	O	R	O	O	O
<i>Aquilegia canadensis</i> L. (red columbine); A3062, A3077, A3504, F7163, H5615, H5674, H6128	O	O	O	R					O
<i>Delphinium carolinianum</i> Walter subsp. <i>virescens</i> (Nutt.) R. E. Brooks (prairie larkspur); A3152, H3089, H4225	O	R	R						
<i>Ranunculus rhomboides</i> Goldie (prairie buttercup); A2743, A2844, A2984, A3007, F7038, H4374, H5610, H6033, H6036	C	O	O	R					
<i>Thalictrum dasycarpum</i> Fisch. & Avé-Lall. (purple meadow-rue); A3216, A3580	R	R							
RHAMNACEAE									
<i>Ceanothus americanus</i> L. (New Jersey tea); A2937, A3183, A4097, A4178, A4240, F7438, H4220, H6880, H7018, H7135, W1544	O	O	O	R	R	R			R
<i>Ceanothus herbaceus</i> Raf. (inland New Jersey tea); A2764, A3126, A3193, A4065, H3708, H4126, H4408, H4489, H4572, H4895, H4955, H5031, H5612, H6403, P43911, W1511, Spickerman (0017)	C	C	O	C	R	O	R	O	R
ROSACEAE									
<i>Amelanchier interior</i> Nielsen (inland Juneberry); A2752, A3006, A3008, A3012, F7091, H6098, H6323, H6662, H4816	O	O	O	O	O	O	O	O	O
<i>Amelanchier spicata</i> (Lam.) K. Koch (dwarf serviceberry); A2746, A3004, A3009, F7037, F7117, F7252, H4333, H4384, H4380, H4646, H4878, H4811, H6090, H6259, H6656, M6697	O	O	O	A	O	C	C	C	C
<i>Crataegus macrocarpa</i> Ashe (big-fruit hawthorn); H5253									R
<i>Dryocallis arguta</i> (Pursh) Rydb. (prairie cinquefoil); A3220, A3249, A4232, H4215, H4221, H4392, M6752, P43920	O	O	O	O	O	O	O	O	O
<i>Fragaria vesca</i> L. (woodland strawberry); F7040, H4899, H7055			R	C†					O
<i>Fragaria virginiana</i> Mill (wild strawberry); A2740, A2841, A3070, A3492, H4388, H4818, H4871, H6082, H6640, H6858, M6685	O	O	O	A	O	O	C	C	C
<i>Geum fragaroides</i> (Michx.) Smedmark (barren strawberry); H5438, H6096, H6354									O
<i>Geum triflorum</i> Pursh (prairie smoke); A4112, F7120	R	R							O

(Continued on next page)

APPENDIX 1. (Continued)

Taxon	S	F	C	N	D	Mt	B	Mq
* <i>Potentilla argentea</i> L. (silvery cinquefoil); A3180, A3185, A3251, H4349, H4405, H4484, H4645, H4952, H5646, H6345, H6411	O	O	O	O	O	O	O	O
<i>Potentilla norvegica</i> L. (rough cinquefoil); A3156, A3214, A3625, H4432, H5647, H6293, H6325	O	O†	O	C	O	C	O†	C
* <i>Potentilla recta</i> L. (rough-fruited cinquefoil); A3198, F7185, H4642, H6280, H6338, W1537	R	O	O	O	R			
<i>Potentilla simplex</i> Michx. (common cinquefoil); A2778, A3079, F7145, F7171, F7459, H4368, H5605	O	O	O	C				
<i>Prunus americana</i> Marshall (American plum); F7041, F7052		R						
<i>Prunus pensylvanica</i> L.f. (pin cherry); A2741, A3276, A3878, H4379, H4511, H6374, H6654	O	O	O†	C	R		O	O
<i>Prunus pumila</i> L. (sand cherry); A3530, A3270, F7124, H4345, H4569, H4592, H4877, H5329, H5333, H5962, H6249, H6657, H6675, M6678, M7124, W1500	C	C	C	C	O	O	C	C
<i>Prunus serotina</i> Ehrh. (black cherry); A3278, A3522, H4526, H4647, H4666, H6252, H6846	R		O†	O†	O	O	O	O
<i>Prunus virginiana</i> L. (chokecherry); A2949, A3489, F7123, H4336, H4876, H5297, H6095, H6857, M6698, W1538	C	C	C	C	O	O	R	O
<i>Rosa acicularis</i> Lindl. (prickly rose); A3129, A3177, A4042, F7235, F7411, H4207, H4377, H4532, H5039, H5635, H6319, H6592, H6841, H7201, W1494	O	O	O	C	O	C	C	C
<i>Rosa arkansana</i> Porter (prairie rose); A2791, A3197, A3594, F7467, H4203, H7149, M7458	O	O	O	O	O			
<i>Rosa blanda</i> Aiton (smooth rose); A2484, A2487, F7229, H4348, H4654, H5195, H5608, H6839, W1494		O	O	C	O	O	O	O
<i>Rosa carolina</i> L. (Carolina rose); H4089, H4371, H4406, H4407, H4653, H4658, H5728, H6269, H6372, H6898, H7017, H7045, H7050, M6747		O	O	O	C	O	C	
<i>Rosa woodsii</i> Lindl. (western rose); H5032				O				
<i>Rubus allegheniensis</i> Porter (blackberry); A3245, H4662, H6256, H6371, H6407, H6349	O		C	C		O	C	O
<i>Rubus flagellaris</i> Willd. (common dewberry); A2765, A2781, A4046, A4194, A4245, H5637, H5671, H6127, H6676, H6694, H6842, M6767, P43903	O	O†	O	O	C	C	C	C
<i>Rubus pensilvanicus</i> Poir. (blackberry); A4057		R						
<i>Rubus setosus</i> Bigelow (bristly blackberry); A4350, A4071	O	O						
<i>Rubus strigosus</i> Michx. (red raspberry); A3261, A4111, H6415, H6587	O	O	O†	O†		C	C	O†
<i>Sibbaldiaopsis tridentata</i> (Aiton) Rydb. (shrubby five-fingers); A2489, A3495, H4092, H4434, H4514, H4586, H4752, H4997, H5639, H6273, M6736		R		C	O	C	C	C
* <i>Sorbaria sorbifolia</i> (L.) A. Braun (false spiraea); M7463								
<i>Spiraea alba</i> Du Roi (meadowsweet); A2913, A3631, A4175, F7475, H4573, H6382	O	O	O	O	O			
RUBIACEAE								
<i>Galium boreale</i> L. (northern bedstraw); A3134, A3170, A4063, F7180, F7241, F7457, H4200, H4226, H4372, H4382, H5648, H6384, W1514	C	C	C	C	O	O	O†	

<i>Houstonia longifolia</i> Gaertn. (long-leaved bluets); A3085, A3157, A3211, A4067, A4079, H4199, H4237, H4249, H4364, H4397, H4643, H4896, H5036, H5628, P43915	O	O	O	O	C	O	O	O	R [†]
SALICACEAE									
<i>Populus grandidentata</i> Michx. (big-tooth aspen); A3279, A3490, A3508, H6554	O	O	O	R	O				O
<i>Populus tremuloides</i> Michx. (trembling aspen); A2951, A2953, A3267, A3348, A3499, F7482, H5528, H6257, H6297, H6320	O	O	C	C	C	O	O	O	O
<i>Salix discolor</i> Muhl. (pussey willow); A2830, A2831, F7088, H4342	O	O	O						O
<i>Salix humilis</i> Marshall (prairie willow); A2964, A2976, A2834, A3166, A3200, A3266, F7116, F7441, H4340, H4757, H6045, H6050, H6658, M6699	C	C	C	A	C	C	C	C	C
SANTALACEAE									
<i>Comandra umbellata</i> (L.) Nutt. (bastard toadflax); A3065, A3063, F7048, F7126, H4344, H4429, H4815, H4869, H6883	O	O	O	C	O	O	O	O	O
SAPINDACEAE									
<i>Acer negundo</i> L. (box elder); A2950, F7042	R	R							
<i>Acer rubrum</i> L. (red maple); A2948, A4070, H5436, H6046, H6364, H6845, H6898, H6986	O	R	O	R	O	O	O	O	R
SAXIFRAGACEAE									
<i>Heuchera richardsonii</i> R. Br. (prairie alum root); A3125, A3190, A3895, A4059, F7182, H4386, H4192, H4784, H5618, H6087, P43917	O	O	O	O	O	O	O	O	O
SCROPHULARIACEAE									
<i>Scrophularia lanceolata</i> Small (American figwort); A3174, F7143, H3111	R	O	O						
* <i>Verbascum thapsus</i> L. (common mullein); A3595, H29, H5042, H6300, H6331, H6359, H6369, W1499	O	O	O	O	O	O	O	O	O
SOLANACEAE									
<i>Physalis heterophylla</i> Nees. (clammy ground-cherry); A2785, A2935, H4627, F7183	O	O	R						
<i>Physalis virginiana</i> Mill. (lance-leaved ground-cherry); A2786, A3163, A4083, F7146, F7177, F7418, H4242, H4497, H5203, H6130, M6750, W1535	O	O	O	O	O	O	R		
<i>Solanum pycnanthum</i> Dunal (black nightshade); A4347, H4270	R	R							
VALERIANACEAE									
* <i>Valeriana officinalis</i> L. (garden valerian); H7210									R
VERBENACEAE									
<i>Verbena bracteata</i> Lag. & Rodr. (creeping vervain); A3526, A3564, H6277	R	R	R						
<i>Verbena hastata</i> L. (blue vervain); A3581, A4346	R	R							
VIOLACEAE									
<i>Viola adunca</i> Sm. (hook-spur violet); A3027, A3494, H4814, H5444, H4587, H4785, H4872, H4900, M6681	O	A	O	C	C	C	C	C	C

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APPENDIX 1. (Continued)

Taxon	S	F	C	N	D	Mt	B	Mq
<i>Viola pedata</i> L. (bird's-foot violet); A2742, A3074, F7055, F7420, H4341, H4347, H4809, H4887, H4907, H5035, H5294, M6689	C	C	C	A		R	R	
<i>Viola pedatifida</i> G. Don (prairie violet); A3067, A3916, F7095, H4243, H5496, H6690	O	R	O	O				
<i>Viola sagittata</i> Aiton (arrow-leaved violet); F7092		O						
MONOCOTS								
ALLIACEAE								
<i>Allium stellatum</i> Ker Gawl. (prairie onion); A2330, A2331, A2335, A2336, A4257, A4260, A4364, F7396, H3090, H4172, W1516	R	O	O					
ASPARAGACEAE								
* <i>Asparagus officinalis</i> L. (asparagus); F7230, H5288			O					
COMMELINACEAE								
<i>Tradescantia occidentalis</i> (Britton) Smyth (prairie spiderwort); A3160, F7212, F7432, H4219, H4229, H4718, M7440, W1540	C	O	O					
CONVALLARIACEAE								
<i>Maianthemum canadense</i> Desf. (Canada mayflower); A2748, A3083, A3496, F7165, H4361, H4954, H6097, H6251, H6285	R	O	O†	O	O	O	C	O
<i>Maianthemum racemosum</i> (L.) Link (false Solomon's seal); H4623			R					
<i>Maianthemum stellatum</i> (L.) Link (starry false Solomon's seal); A2757, A3058, A3071, A3136, A3503, F7483, H4373, H4898, H5006, H6886, W1577	O	O	O	C	O	O	O†	O†
<i>Polygonatum biflorum</i> (Walter) Elliott (giant Solomon's seal); A3075, A4064, F7484, H5281, H6119, W1530	O	O	O					
<i>Uvularia sessilifolia</i> L. (sessile bellwort); A2747, A3031, A3880, A4243, H4496, H4868, H5526, H6260, H6356	R	O	O	R	O		C	O
CYPERACEAE								
<i>Bulbostylis capillaris</i> (L.) C. B. Clarke (hair sedge); A2486, H6420						O		
<i>Carex adusta</i> Boott (brown oval sedge); H4908, H5527, H6875			R				R	
<i>Carex bicknellii</i> Britton (Bicknell's oval sedge); Hg942								
<i>Carex breviar</i> (Dewey) Maek. (fescue sedge); A3524, A4044	R							
<i>Carex foenea</i> Willd. (bronze-headed oval sedge); H6122		R						
<i>Carex houghtoniana</i> Dewey (Houghton's sedge); H6867								R
<i>Carex muhlenbergii</i> Willd. (Muhlenberg's sedge); A3084, H5012, M6753	R		R				R	
<i>Carex pellita</i> Willd. (broad-leaved woolly sedge); A3078, F7154, H5571, H6687, Hg255	R	O						

<i>Carex pensylvanica</i> Lam. (common oak sedge); A3033, A3035, A3137, A3143, A3178, A4047, A4048, H6093, H4883, H4906, H5053, H6086, M6684	C	C	C	C	A	C	O	C	A
<i>Carex richardsonii</i> R.Br. (Richardson's sedge); A2647, A2977, A3010, A3013, A3026, A3914, H5434, Hg261	R	R	R	R	R	R			R
<i>Carex scoparia</i> Willd. (broom sedge); H4485									
<i>Carex siccata</i> Dewey (dry-spiked sedge); A3080, F7152, F7231, F7414, H4338, H4365, H4894, H5047, H5644, H6100, H6696, H6860	C	C	C	C	O	R			R
<i>Carex tonsa</i> (Fernald) E. P. Bicknell var. <i>tonsa</i> (shaved sedge); A3302, A3034, F7043, H5441, H6014, H6031, H4782, H4911, Hg516, M6683, Tans (667)	R	R	O	C	O				O
<i>Cyperus houghtonii</i> Torr. (Houghton's nut sedge); A3322, A3329, F7416, H4205, H4483, H4495, H4639, H5044, H5201, H5838, H5841, H5938, H5949, H6377, H6602, M7446, P43893	O	O	O	C	O				O
<i>Cyperus lupulinus</i> (Spreng.) Mareks (Great Plains flat sedge); A3353, A4250, H3124, H4490, H5758, F7451, H5018, M7445, W1527	O	O	O	R					
<i>Cyperus schweinitzii</i> Torr. (Great Plains sand sedge); A2794, A2887, A3238, A3241, A4251, F7434, H4193, H4209, H4451, H4691, H4726, W1517, W1581	C	O	O	R					
<i>Cyperus strigosus</i> L. (false nut sedge); H4167	R	R							
<i>Scleria triglomerata</i> Michx. (stone-rush); A3369, A3405, H5577	R								
HYPOXIDACEAE									
<i>Hypoxis hirsuta</i> (L.) Coville (yellow-star grass); A3518, H6686									
IRIDACEAE									
<i>Sisyrinchium campestre</i> E. P. Bicknell (prairie blue-eyed grass); A3050, A3060, A3068, A3484, A3505, A3917, H6133, F7242	O	O	O						
<i>Sisyrinchium montanum</i> Greene (mountain blue-eyed grass); F7128, H4400, H4892, H5620, H5623, H4960	R				C	R			
JUNCACEAE									
<i>Juncus greenii</i> Oakes & Tuck. (Greene's rush); H3103, H4454, H4744, H4746	R	R							
<i>Juncus tenuis</i> Willd. (path rush); H5017, H6987, H6352, H7205, Hg296	O	O							O
<i>Luzula multiflora</i> (Ehrh.) Lej. (common woodrush); A3048	R	R							
LILIACEAE									
<i>Lilium philadelphicum</i> L. (wood lily); A3323, A3583, H4463, H4995, H5291, H5408, H6254, H6322, M6735	R	R	O	O	R				R
ORCHIDACEAE									
<i>Liparis loeselii</i> (L.) Rich. (Loesel's twayblade); A3356, Hg397	R								
<i>Spiranthes cernua</i> (L.) Rich. (sphinx ladies' tresses); H4675, Hg394	R	R							
<i>Spiranthes lacera</i> (Raf.) Raf. (northern lady's tresses); H4093								R	R†

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APPENDIX 1. (Continued)

Taxon	S	F	C	N	D	Mt	B	Mq
POACEAE								
* <i>Agrostis gigantea</i> Roth (red top); A4113, Hansen (2061)	R							O
<i>Agrostis hyemalis</i> (Walter) Britton, Sterns & Poggenb. (winter bent grass); H5840, H6852							R	
<i>Agrostis scabra</i> Willd. (rough bent grass); A2485, A3179, A3186, A3263, A3596, A3634, A4085, A4102, A4231, H3101, H4401, H5013, H5050, H5313, H5964, M6754	C	C	C	C	C	C	O	O
<i>Andropogon gerardii</i> Vitman (big blue-stem); A2901, A3291, A3708, F7397, H4555, H6294, H6365, H6274, M7447, P43888, W1506	A	A	A	A	A	A	A	A
<i>Anthoxanthum hirtum</i> (Schrank) Y.Schouten & Veldkamp (sweet grass); A3482, A3879, F7100	R	R						
<i>Aristida basiramea</i> Vasey (fork tip three-awn grass); A2943, A2944, A2945, A3321, A3696, A3707, H34, H5295, H6560, Hg382, P43890	O	O	O	O	O	O	O	O
<i>Aristida tuberculosa</i> Nutt. (beach three-awn grass); A2927, A3345, A3358	O	R						
* <i>Avena sativa</i> L. (oats); H4584								R
<i>Avenella flexuosa</i> (L.) Drejer (crinkled hair grass); A3288, A3303	O							O
<i>Bouteloua curtipendula</i> (Michx.) Torr. (side-oats grama grass); A2882	O							
<i>Bouteloua hirsuta</i> Lag. (hairy grama); A2883	O							
* <i>Bromus inermis</i> Leyss. (smooth brome); A3116, A3172, A3286, H4363, H6856	O	O	O	O	O		R	O
<i>Bromus kalmii</i> A. Gray (Kalm's brome); A2490, A2931, A3223, A3257, A3292, A3317, A3738, A4110, F7464, H4525, H4553, H5945, M6739, W1487	O	O	O	C	O	O	O	O
* <i>Bromus tectorum</i> L. (cheat grass); A3519	R	R						
<i>Calamovilfa longifolia</i> (Hook.) Scribn. (prairie sand reed); A2879, A4409, H4727	O	O	O	O	O			R
<i>Cenchrus longispinus</i> (Hack.) Fernald (sandbur); A2891, A3285, A3617, H5753, M7456, W1526	O	O	O	O				
<i>Danthonia spicata</i> (L.) Roem. & Schult. (poverty oat grass); A3118, A3171, A3264, A3711, A4045, A4089, A4104, H4418, H4455, H4475, H4641, H5051, H6873, M6731, M6741, M6742	C	C	C	A	C	C	C	C
<i>Dichanthium acuminatum</i> (Sw.) Gould & C. A. Clark var. <i>fasciculatum</i> (Sw.) Gould & C. A. Clark (hairy panic grass); A2780, A3141, A3159, A4086, A4099, F7408, F7461, H4248, H5302, H6133, H6855, H6896	C	C	C	C	C	O	O	O
<i>Dichanthium columbianum</i> (Scribn.) Freckmann (puberulent panic grass); F7237, F7485			R					
<i>Dichanthium depauperatum</i> (Muhl.) Gould (poverty panic grass); A2869, A3176, A4078, H4247, H4482, H5626, H5642, Hg250, M6755	C	O	O	O	O			R
<i>Dichanthium linearifolium</i> (Britton) Gould (linear-leaved panic grass); H5000, H5625								
<i>Dichanthium meridionale</i> (Ashe) Freckmann (slender panic grass); M6748								
<i>Dichanthium oligosanthes</i> (Schult.) Gould var. <i>scribnerianum</i> (Nash) Gould (Scribner's panic grass); A3117, A3151, A4039, F7150, F7156, F7184, H4456, M7451	O	O	O	O				

<i>Dichanthelium perlongum</i> (Nash) Freckmann (long-stalked panic grass); A2868, A3147, A3521, F7234, H5065, H6134, H6833, H6882	C	O	O	O	R
<i>Dichanthelium villosissimum</i> (Nash) Freckmann var. <i>praecoccium</i> (Hitchc. and Chase) Freckmann (prairie panic grass); Mauritz (s.n.), Westad (s.n.)				R	
<i>Dichanthelium xanthophysum</i> (A. Gray) Freckmann (pale panic grass); H4428, H4524, H5301, H6409, H4669				R†	R O O
* <i>Digitaria ischaemum</i> (Schreb.) Muhl. (smooth crab grass); H-4, H-5, H4644, H4725, H5296, H6591, H6599, H7146, P43892	O	O	R	O	O O
* <i>Digitaria sanguinalis</i> (L.) Scop. (hairy crab grass); A3354, H5831					R R
<i>Echinochloa muricata</i> (P.Beauv.) Fernald (American barnyard grass); H6419, H6594	R				
<i>Elymus canadensis</i> L. (Canada wild rye); A2912, A3619					
* <i>Elymus repens</i> (L.) Gould (quackgrass); A3142, A3173, A3565, H4240, H5001, H5755, H4637, H6295, H6872	O	O	O	C	O C O
<i>Elymus trachycaulus</i> (Link) Gould (slender wheat grass); A3295, A4343, H4502, H4513, H6271, H6413	R				R R R
<i>Eragrostis pectinacea</i> (Michx.) Nees (tufted love grass); A3287, A4246, A4252, F7445, H6604	O	O	O	R	R C
<i>Eragrostis spectabilis</i> (Pursh) Steud. (purple love-grass); A2889, A3599, F7401, H78, M7452	O	O	O		
* <i>Festuca rubra</i> L. (red fescue); A4088, A4114, H7148, Hansen (2042)	R				O R
<i>Festuca saximontana</i> Rydb. (Rocky Mountain fescue); A3501, A3520, H6370, M6692	R				
* <i>Festuca trachyphylla</i> (Hack.) Krajina (hard fescue); H6695					R
<i>Hesperostipa spartea</i> (Trin.) Barkworth (porcupine grass); A3162, A4066, F7153, F7247, F7471, H6140	C	C			
<i>Koeleria macrantha</i> (Ledeb.) Schult. (June grass); A3135, A3161, A4082, F7149, F7249, H4194, H5645, H4567, H4958, H4994, H5189, H6854, P44010	C	C	C	C	O O O
<i>Muhlenbergia glomerata</i> (Willd.) Trin. (marsh muhly); H4195, H4554, H5200, H5252, H5950, H6268, Hg103, P43913	O				O O O O
<i>Oryzopsis asperifolia</i> Michx. (rough-leaved rice grass); H6678, H4905, H6844, M6688	R	R	R	O	R O† O C
<i>Panicum capillare</i> L. (witchgrass); A3240, A3615, H4197, H6378, H4638, W1505, W1578	O	O	O		R
<i>Panicum virgatum</i> L. (switch grass); A2884, F7473, H4728, H5244, H7147, M7442	O	O	O		R O†
* <i>Phleum pratense</i> L. (timothy); A3912	R				
<i>Piptatheropsis pungens</i> (Spreng.) Romasch., P. M. Peterson & R. J. Soreng (mountain rice grass); A3271, A4055, A4101, H4522, H4670, H4903, H4916, H5309, H5825, H5941, H6101, H6660, M6694, Sulman (615)	R	R	R	R	R R R C R
* <i>Poa compressa</i> L. (Canada bluegrass); A3187, A3195, A3709, A4091, F7452, H4350, H4880, H5640, H5832, H6394, H6829, H6897, Hg118	O	O	C	O	O O O
* <i>Poa pratensis</i> L. (Kentucky bluegrass); A3030, A3051, A3502, H6296, M6690	C	C			C O O†

(Continued on next page)

APPENDIX 1. (Continued)

Taxon	S	F	C	N	D	Mt	B	Mq
<i>Schizachne purpurascens</i> (Torr.) Swallen (false melic-grass); A3523, F7127, H4075, H4402, H4902, H4915, H5621, H6838, H6853, H7054	R	O	O†	R	R	R	O	R
<i>Schizachyrium scoparium</i> (Michx.) Nash (little bluestem); A2934, A3274, A3335, A3706, F7402, H4561, H6488, H6555, H6596, M7457, P43896, W1490	A	A	A	A	A	A	C	C
* <i>Setaria faberi</i> Herrm. (giant foxtail); H6490, H6609								
* <i>Setaria pumila</i> (Poir.) Roem. & Schult. (yellow foxtail); H5282, H6418, H6608, M7455, W1543		R	O				O	
* <i>Setaria viridis</i> (L.) P.Beauv. (green bristle grass); H4244				R				
<i>Sorghastrum nutans</i> (L.) Nash (Indian grass); A2885, A3327, A4410, F7419, H4162, H4620, H4634, H5207, M7436, P43922, W1508, W1546	C	C	C	C		R	R	
<i>Spartina pectinata</i> Link (prairie cord grass); H4549			R					
<i>Sporobolus cryptandrus</i> (Torr.) A.Gray (sand drop-seed); A2739, A2795, A3250, A3614, A3618, A4196, W1571	O	O	O				R	R
<i>Vulpia octoflora</i> (Walter) Rydb. (six-weeks fescue); A2779, A3049, A4103		R	R	R				
SMILACACEAE								
<i>Smilax hispida</i> Raf. (bristly green brier); H5808			R					
<i>Smilax lasioneura</i> Hook. (common carrion flower); H5020			R					