OLD MILL PARK

NATURAL RESOURCE MANAGEMENT PLAN

Prepared for:
The City of Hastings

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EXECUTIVE SUMMARY

Old Mill Park is located in and owned by the City of Hastings, Minnesota. Even though the park is small, it offers important wildlife habitat and connectivity along the corridor of the Vermillion River, and more than half of the property lies within an area that was designated high biodiversity by the Minnesota Department of Natural Resources (DNR). Four populations of the rare and threatened kittentail (*Besseya bullii*) that require extra protection are also growing on the property.

Historically, the park was dominated by oak savanna, but due to the lack of natural fires some areas have turned into woodland, and the current savanna is overgrown and in relatively poor condition. The present-day land cover is: 4.9 acres oak savanna, 3.9 acres of oak woodland, and 1.2 acres of mowed turf. The parking lot, concrete trail, and the Old Mill ruins together make 0.5 acres. Of the many invasive species that have infested the park, smooth brome (*Bromus inermis*) is the dominant understory species in the majority of the savanna, and common buckthorn (*Rhamnus cathartica*) can be found in the shrub-layer throughout the entire property.

The primary goal of this project is to restore the savanna and woodland to plant communities typical of intact remnants or the DNR Natural Plant Communities. This document describes recommendations, methods, and approximate costs for enhancing the ecological health of the entire property, and restoring the native vegetation. The activities include the removal of invasive exotic and native species, the re-introduction of fire, and the enhancement of the native plant communities by seeding and planting.

INTRODUCTION

Old Mill Park has been the property of the City of Hastings, Dakota County, since 1925. It is located in the south of Hastings and bordered by the Vermillion River in the east and south, by 18th St E and a small private property with comparable vegetation in the north and west. To the north is a housing development. The site has altogether 10.5 acres, which includes oak savanna, oak woodland, and some steep woody bluffs leading down to the Vermillion River. In 1958 the park was designated a Minnesota Historic Site as it features the ruins of the old Ramsey Mill. This Natural Resource Management plan presents the site analysis and recommended activities for the existing oak savanna and oak woodland.

Before European settlement, 11 million hectares of land in the Midwest of the United States were covered by oak savanna. Currently, less than 1% of that is still intact (Nuzzo 1986) and most remnants are dry, nutrient-poor oak barrens that have been pastured at some time in the past (Nielsen et al. 2003). For example, Curtis (1971) describes that in the entire state of Wisconsin no single oak savanna was found that was not pastured. Despite this, there is still a lot of diversity (Abella et al. 2004), often reflecting hydrologic gradients within sites (Apfelbaum et al. 1991). For a full description on the characteristics of oak savannas before European settlement, see **Appendix A**.

The main reasons for oak savanna degradation and woody plant encroachment were originally logging and livestock grazing, later supplemented by fire suppression (starting in the 1930s), drainage for development, and climate change (Brudvig et al. 2007, Apfelbaum et al. 1991, Wolf 2004, Brudvig et al. 2005). Livestock damage includes over-grazing and trampling. Fire suppression allows for the development of a brushy understory that crowds out herbaceous species. It also enables trees intolerant of fire to invade the site (e.g. *Ulmus americana*, *Fraxinus pennsylvanica*, *Carya ovata*, *Acer negundo*) (Wolf 2006). After a continuous fire-free period, those woody encroachers increase the overstory density and savannas usually convert into woodlands (Brudvig et al. 2007, Abella et al. 2004, Wolf 2004, Brudvig et al. 2011). One of the main threats to savanna ecosystems since the 1990s has been the invasion of exotic invasive species that replace native species and prevent the development of a higher crown layer (Apfelbaum et al. 1991, Maloney 1997).

Prior to European settlement the majority of the Old Mill Park was composed of dry oak savanna of the sand-gravel sub-type. But as with the majority of oak savannas in the Midwest, the lack of fire and the encroachment of woody and invasive species have heavily degraded the existing savanna and parts of it are now classified as oak woodland. The two main invasive species threatening the park are common buckthorn and smooth brome. This plan was developed to:

- Evaluate the existing condition of the vegetation in reference to pre-settlement conditions
- Identify target native plant communities and restoration goals (re-establish oak savanna comparable to pre-settlement conditions)
- Identify methods for improving the wildlife habitat value of the property

BACKGROUND AND SIGNIFICANCE OF THE SITE

PARCEL INFORMATION

Owner, property address
City of Hastings
800 18th St E
Hastings, Dakota County, MN 55033
Dakota County

Township, range, section: T115N, R17W, 34

Watershed:
Major watershed: Mississippi River
Sub-watershed: The entire site is within the Vermillion River sub-watershed (No. 38025)

Watershed Management Organization: Vermillion River Watershed Joint Powers Organization (VRWJPO)

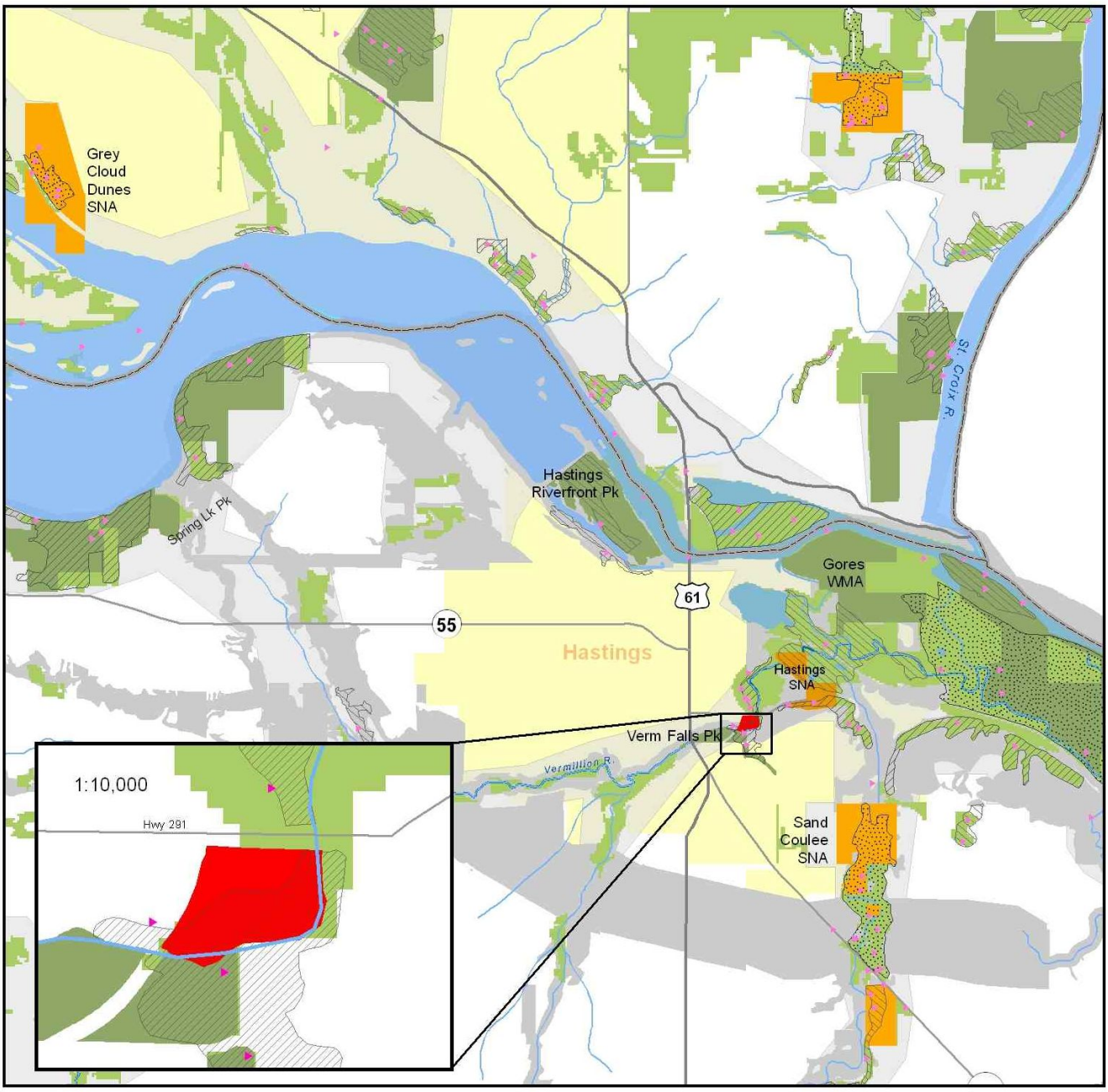
Element Occurrences: Native Plant Communities: Dry Oak Savanna – Sand gravel subtype
Rare Plant Species: Kittentail (*Besseya bullii)* – Threatened

LANDSCAPE CONTEXT

Proximity to established greenways
To protect the most important sites and designate them for permanent protection and/or natural resource restoration, several greenway corridor-planning efforts have occurred. Old Mills Park falls within two greenways - the Metro Conservation Corridors, a regional land protection plan of the Department of Natural Resources (DNR) (**Map 1**) and the Mississippi Greenway Plan (which was a collaboration among several municipalities around Hastings). This park is part of a chain of ecologically significant areas that includes Hastings SNA to the east, the Hastings Sand Coulee SNA to the south and Gores Pool WMA to the east.

Ecological significance and wildlife value
More than half of the park lies within an area that was designated high biodiversity by the DNR (**Map 1)**. Four populations of the threatened kittentails (*Besseya bullii*) can also be found here. Even though the park is small and is located within an area of urban development, it offers important wildlife habitat and connectivity along the corridor of the Vermillion River. It is directly adjacent to Vermillion Falls Park to the south and Hastings SNA is ¼ mile to the east, with the Vermillion River Bottoms beyond. The Sand Coulee SNA is less than one mile to the south, Gores Pool WMA is about 1 miles to the northeast, and Hastings Riverfront Park is about 1.5 miles to the north. This area is very biologically diverse and Old Mill Park is an important link among these areas. Further, the site is significant for its proximity to the Mississippi River, a globally significant bird migration corridor. Old Mill Park contributes to a much larger natural area complex and the important habitat it provides.

Map 1. Landscape Context



Sources: DNR data deli online data, DNR Natural Heritage database.

Rare natural features
Outstanding biodiversity
High biodiversity
Moderate biodiversity
Old Mill Park
Parks, WMAs
Scientific & Natural Areas
Ecologically significant areas (DNR)
Mississippi Greenway Plan
Metro Conservation Corridors

N
1:72,500
2 1 0 Miles

Dominant land use within one mile
Within one mile of Old Mill Park the main land use is urban residential (the city of Hastings). The park is located directly south of 18th Street/Hwy 291, and Hwy 61 and County Road 55 are both less than a mile away. To the northeast of the site, the Hastings SNA and several parks and sites of ecological significance are located.

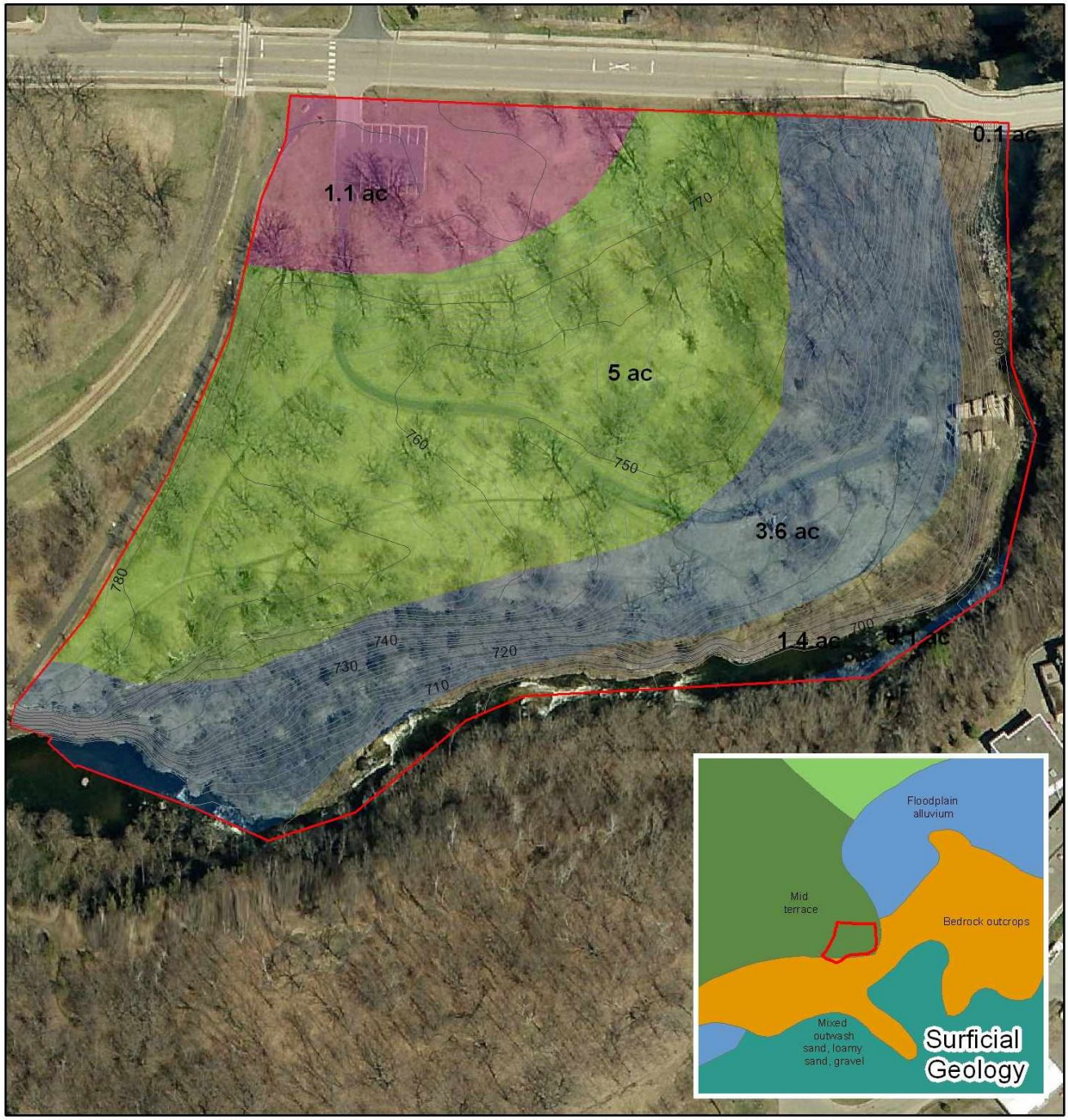
SITE GEOLOGY

Geologic formation and bedrock
Glaciers covered the majority of Minnesota several times during the Quarternary Ice Age. The movement of large ice sheets shaped the current landscape in Minnesota and influenced topography, soils, and the types of plants that are growing in the area. In Dakota County, soils mainly formed in glacial till and glacial outwash. Some of the soils formed through weathering of bedrock and alluvium, influenced by and influencing the original vegetation of tall-grass prairie and mixed deciduous forests. In the eastern part of Dakota County the soils are mostly well drained with many level or gently sloping outwash plains. Some short, steep escarpments separate terraces along the Mississippi River.

Old Mill Park is underlain by Prairie du Chien bedrock, which formed when shallow seas that covered southeastern Minnesota in the early Paleozoic Age (between 600 and 400 million years ago) deposited marine sedimentary rocks. The lower layers of sandstone and shale of the Prairie du Chien are now major aquifers in Dakota County and a primary source of drinking water. Most of the glacial till in uplands was deposited in the Wisconsin Glaciation, which ended around 10,000 years ago. It consists of loamy unsorted sediments, overlain by younger sediments and organic material (Dakota County Soil Survey, Dakota County Geologic Survey). The depth of soils over the bedrock ranges from 8 to 60 inches.

Soil and Topography
The majority of the soils in Old Mill Park are loams and silt loams (**Map 2**). In the gently sloping northwest corner of the property, 1.1 acres are covered with deep, well drained, and moderately permeable Port Byron silt loam, which formed on deep loess soil. The 5 acres adjacent to this parcel in the south are moderately steep with a slope of 6-12% and dominated by soils of the Rockton series. These soils formed in glacial drift underlain by limestone bedrock and are moderately deep and well drained.

Map 2. Geology and Soils



ources: Dakota County: 2011 aerial, 2 ft contours, 1980 Soil Conservation Service data. DNR data deli: surficial geology.

N

1:1,600

1 inch = 133 feet

0 100 200 Feet

Soil types

- 285B Port Byron silt loam, 2-6% slope
- 299C Rockton loam, 6-12% slope. Potentially erodible
- 880F Brodale rock-outcrop, 18-45% slope. Highly erodible
- Old Mill Park (modified bndry)

Furthest to the south and adjacent to the Vermillion River the terrain is steeper with a slope of between 18 and 45%. Here deep and excessively drained Brodale rock-outcrop soils are located, which formed on loamy colluvium and residuum from limestone bedrock. They cover 3.6 acres of the park.

The depth of the soils is 8 to 20 inches in the Brodale, 20-40 inches in the Rockton, and 36-60 inches in the Port Byron series.

Table 1: Soil Types, Old Mill Park

Soil code	Acres	Soil Name	Slope	Hydric	Water erodibility
285B	1.1	Port Byron Silt Loam	2-6%	N	M
299C	5	Rockton Loam	6-12%	N	M
880F	3.6	Brodale rock-outcrop	18-45%	N	H

The topography of the site is influenced by the Vermillion River, which created erosion and deposition at its edges and is responsible for the steep slopes along the bluffs, compared to the more moderate slopes in the upland. The upland has a number of elevation changes and the concrete path leading to the Old Mill Ruins is located along a natural vale. The oak woodland in the northeast of the park has slightly steeper slopes than the savanna. The site is well-vegetated and there is no visible erosion, except for the trail on the southern bluffs along the river. The elevation changes about 96 ft from a maximum of 782 ft in the southwest to 686 ft in the northeast.

RARE SPECIES

According to the DNR Natural Heritage Database, the native plant community on the site is dry oak savanna – sand gravel subtype (DNR biological survey). Dry oak savanna is one of the habitats that used to cover more than 5% of the 1890s landscape in Minnesota and have declined by more than 50% (DNR 2006). Today only remnants of oak savanna remain, which makes it a rare and precious ecosystem (Nuzzo 1986). Oak savannas host more than 93 species of greatest conservation need (SGCN), 36 of which are listed as endangered, threatened, or of special concern by the state. The majority of these are birds (48 species), followed by

Photo 1. Kittentail found in Old Mill Park (2012)

fish (12 species) and mollusks (9 species) (DNR 2006). It is important to manage the site to re-establish a healthy oak savanna community and increase habitat for the SGCN, including the red-headed woodpecker (*Melanerpes erythrocephalus*).

One rare species, Kittentail, a state threatened species, can be found in Old Mill Park. In spring 2012, four kittentail patches with 58 flowering plants were counted (**Photo 1**).

The following excerpt concerning kittentail is from the MN DNR website:
"Besseya bullii is primarily a species of oak savanna communities, though it also occurs in dry prairies and oak woodlands (including dry-mesic oak (maple) woodlands, dry-mesic oak-hickory woodlands, and dry-mesic pine-oak woodlands). Plants show a preference for partial to open light and upper slopes. Some populations exhibit a preference for less xeric north-facing slopes in prairie habitats. Soils are most often sandy to gravelly, well-drained soil derived from alluvium or limestone.

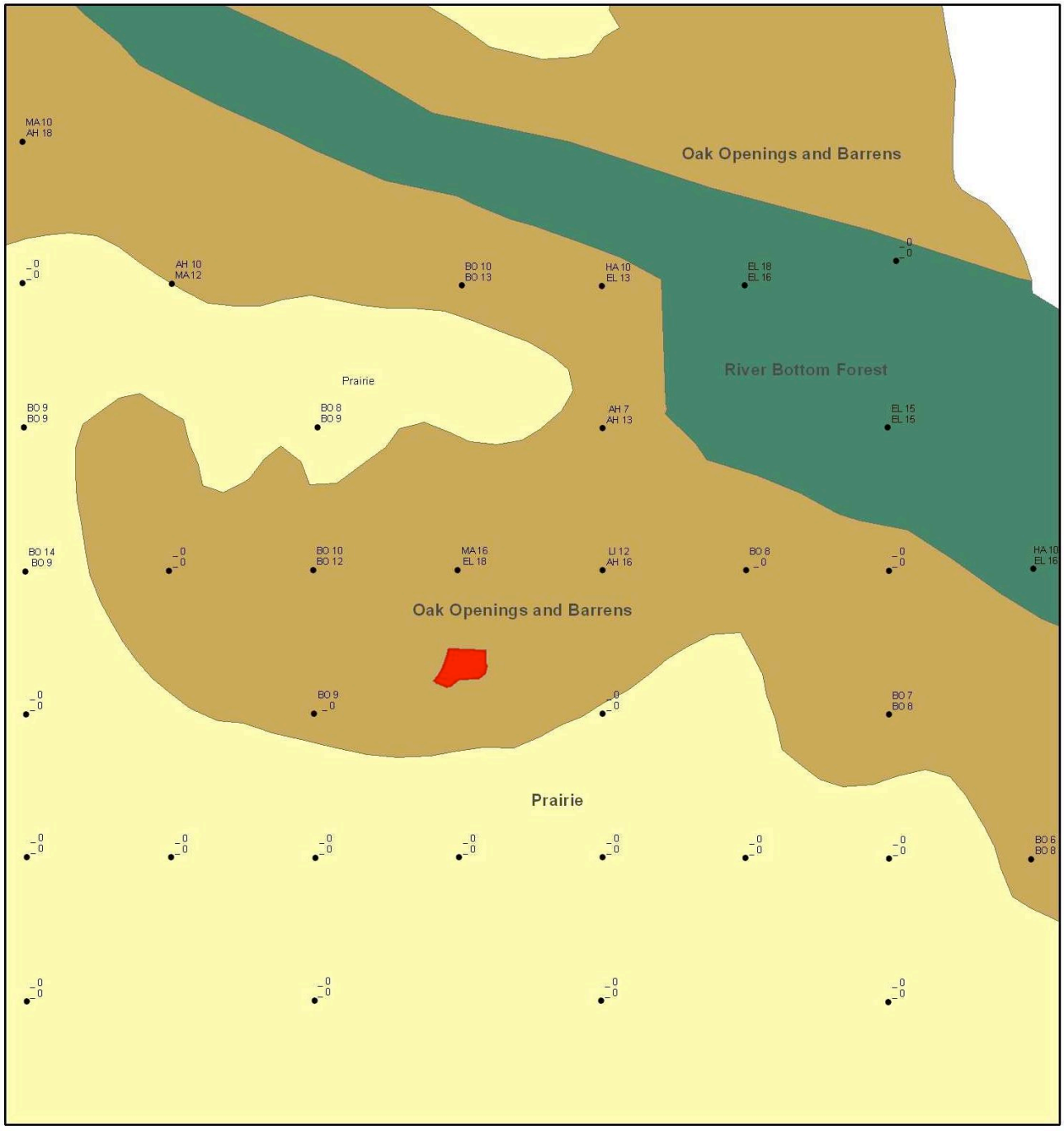
Besseya bullii has suffered a significant decline (throughout its range) because of habitat loss. Management techniques should be used to maintain or regain suitable habitat conditions. Active management does not appear to be as necessary at gravel prairie sites due to the xeric conditions and increased erosion. More intensive management may be required at savannas or wooded sites where species vigor is decreased. Management tools may include fire, which may be effective in reducing woody vegetation and encouraging flowering. However, careful timing of prescribed fires is critical. Fire should only be used in early spring before plants appear above ground, usually during late March or early April. Once the plants appear above ground, even 2.5-5.1 cm (1-2 in.), they can be severely damaged by fire. *Besseya bullii* occurs in isolated patches, which makes it conducive to protection from certain types of development, if protection of existing populations is incorporated into the early planning stages of development." Fire is important for management of kittentails and has historically been an important component of the mesic oak forest and associated maple-basswood forest. Additional survey work can be done to verify the presence/absence of the species. Substantial populations of kittentail are found in the City of Hastings Old Mill and Vermillion Falls Parks about a mile west of the SNA.

In addition, there are 6 other rare plant species records within one mile of the park. Most of them would not occur in the park, but their presence in the nearby landscape demonstrates the importance of the contiguous habitat.

HISTORIC VEGETATION

The best information available on plant communities present at the time of European settlement comes from the 1850's land surveyor notes, which recorded plant species at each one-mile node. A compilation of those notes into a map indicates that Old Mill Park was within the Oak Openings and Barrens region, today known as oak savanna (**Map 3**). These oak savannas were dominated by bur oak and maintained by fires. Within 1 mile of the site, ash, maple and elm could be found.

Map 3. Pre-Settlement Vegetation



Source: DNR data deli

Bearing trees: LI=Basswood, AH=Ash, MA=Maple, BO=Bur oak, EL=Elm

Old Mill Park

1:30,000

0 0.5 1 Miles

A comparison of more recent aerial photographs between 1937 and 1991 offers the opportunity to look at previous site conditions and at changes that occurred within 54 years (**Map 4**). Even though the site was not in its original state in1937, it shows some indication of what site conditions might have been before European settlement. In the 1930s urban development had not spread to 18th St W to the north of the site yet. The vegetation in the majority of the park was very sparse with an open canopy and trees often beyond 30 feet distance from each other. The sparse vegetation could have been a result of overgrazing or the severe drought in the 1930s during the 'Dust Bowl'. The open canopy indicates that the main vegetation type in the park used to be oak savanna. One patch in the west was a little denser and the entire eastern bluff and northeast area of the park had a more closed canopy than the rest of the park, suggesting that this area could have been oak woodland. Two visible trails formed a cross through the park, and there was noticeable erosion in the north of the site, which could have either been a result of overgrazing and drought or the removal of soil for construction.

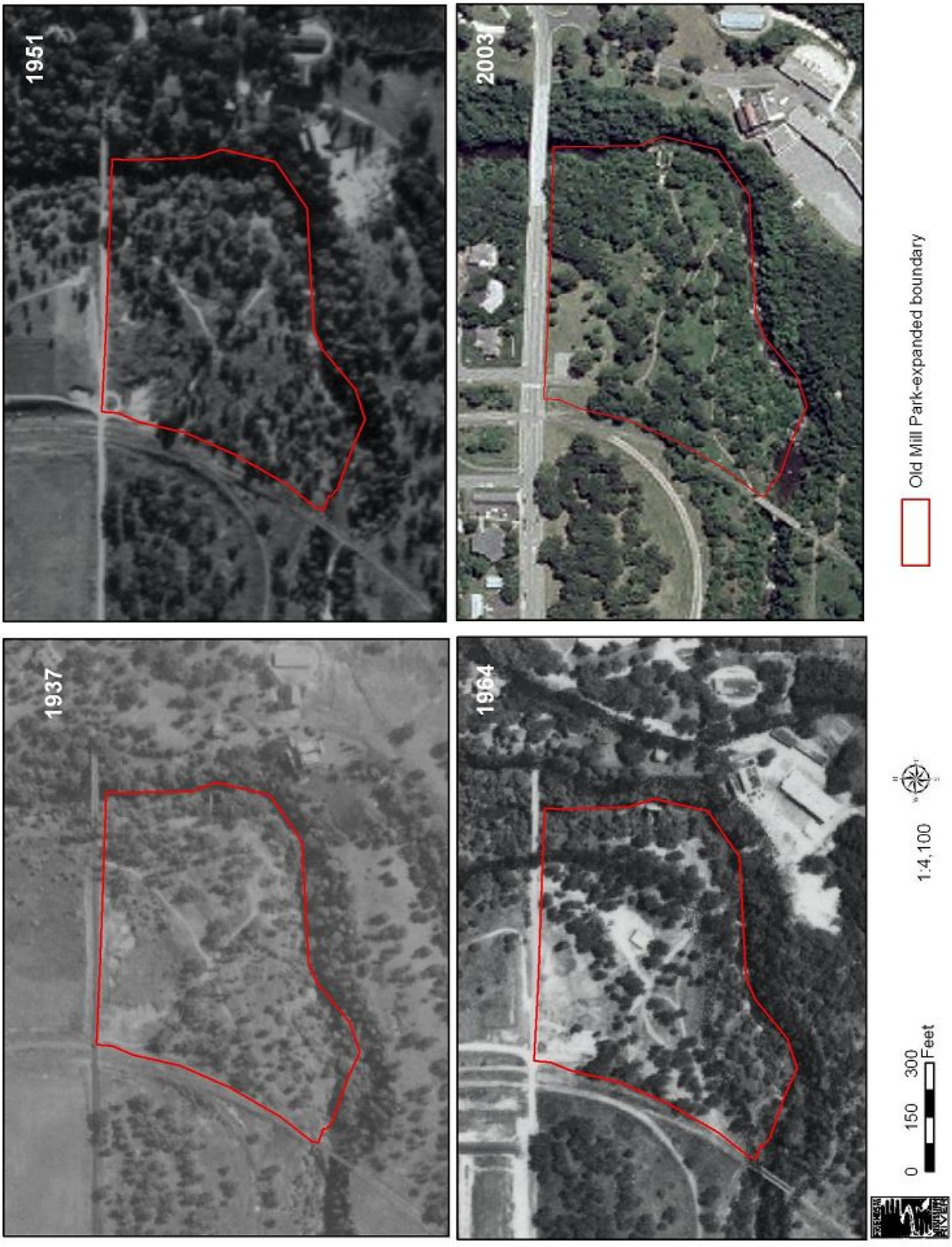
Based on the 1951 photograph there was still no urban development to the north of the site. The vegetation appeared quite similar to 1937 with an open canopy throughout and denser vegetation in the east and northeast. The patch that occurred more than average dense in the west in the 1937 picture seemed more open in 1951, which could have been caused by logging. In the northwest corner, there was a visible access to a trail leading down to the ruins. The heavy erosion in the north was not visible anymore.

Photos show that between 1951 and 1964 urban development occurred in the northwest and southeast of the site. The roads surrounding the park were more noticeable and seemed to be more heavily trafficked. The canopy was now denser in some areas, especially in the northeast and east. The vegetation change in the bluff area is hard to determine with this imagery because of shadows created by the canopy. The trail system was more developed and a shelter was found in the middle of the park. The vegetation around this shelter was removed for parking cars. The northern part of the property was mowed and the current parking lot was probably established in the far northwest corner. It seems as if the park was very heavily used. The mill ruins were not visible due to dense vegetation.

According to the 1964 and 2003 photos, urban development spread significantly in the north of the park. The vegetation was denser than at any other state in history, especially in the western part of the park, along the bluffs, and on the northeast slope. There was also a small tree line of sugar maple (*Acer saccharum*) along 18th St in the north, and the mow-line is clearly distinguishable. Around the Old Mill ruins the vegetation had been removed as they were now much more clearly visible. The 2003 photograph also shows that the vehicle access to Old Mill Park was restricted to the parking lot in the northwest corner, and the area around the shelter that used to function as a parking lot was overgrown with understory vegetation. Use of the park seems to have been reduced since 1964. Three trails were dominating the park: one leading from the parking lot to the ruins, one from the parking lot to the bridge over the Vermillion River, and one parallel to the bluffs in the south.

Generally, the trends show that the vegetation in 2003 was much denser than it used to be in the past, urban development spread significantly in the north and east of the property, that the park itself was less heavily used compared to the 1960s, and that there was an extensive mowed area in the northern section of the property.

Map 4. Historic Aerial Photographs



HISTORIC AND CURRENT LAND USE

Alexander Ramsey and Dr. Foster built the Ramsey Mill in 1856 as a gristmill. In 1877 Ramsey sold his interest to Governor Ramsey, who in 1867 formed a partnership with Theodore Gardner and Benjamin Caldwell. The company Gardner & Caldwell then operated the mill until in 1877 Ramsey sold the mill to Frederick Voigt, but the mill was still known as Ramsey Mill (Dakota County Historical Society 1974). On December 22, 1894 the mill burnt down, probably because of arson, and was never rebuilt (Kaplan *et al.* 1999).

Old Mill Park used to be called 'Tourist's Park' and was used as an informal camping area. King Midas Flour Co. owned the land before deeding it to the City of Hastings in 1925 (Hastings Gazette 1925). In 1940 Hastings celebrated the grand opening of Old Mill Park after the Hastings Boys 4-H Club created picnic grounds with tables, benches, and a fireplace. The park at that time also had a birch arch as an entrance and several signs leading through it. The Boys 4-H built steps leading down to natural springs close to the mill ruins, and they improved the road leading to the ruins. In the 1950's the Greater Hastings Association also did some maintenance. In 1958, the park was named 'Old Mill Park' and designated a Minnesota Historic Site with the old Ramsey Mill ruins as the main attraction. The city was planning to replace the old sign close to the ruins with a new one in 1997, including designation of the grasses and plants.

Currently, the park is mainly used by people interested in visiting the ruins, walking their dogs, or accessing the Vermillion River for fishing. There are several trails throughout the park, including a paved one leading down to the Old Mill ruins. One of the trails that is located in the southern part of the site along the bluffs is heavily used and severely eroded (see **Photos 2 and 3**). A large tube-formed gully has formed that clearly concentrates water after precipitation events. There is no evidence that this water is routing into the direction of the Vermillion River forming further gullies. Instead, the slope leads down the hill parallel to the Vermillion River from the west to the east, ending at the foot of the hill where the Old Mill is located. To prevent further erosion and concentration of water flows, it is necessary to fix this trail.

Photos 2 and 3. Eroded trail in Unit III.

ADJACANT LAND USE

The land use in the area adjacent to Old Mill Park is important because of its potential impact on the vegetation belonging to the site. The Vermillion River forms a natural barrier in the park's south and east. Its west is bordered by a bike trail and major impacts are unlikely here. The only area of potential concern is 18th Street right to the north of the site. This heavily used road is undoubtedly a source of road salt during the winter months. Salt accumulation occurs usually within 30-50 feet of roads and salt spray can lead to disfigurement, reduced growth, and even plant death. Bur oak is tolerant to salt spray and saline soils, and red oak is tolerant to saline soils (Virginia Tech 2009). The sugar maple trees planted near road are not considered salt-tolerant.

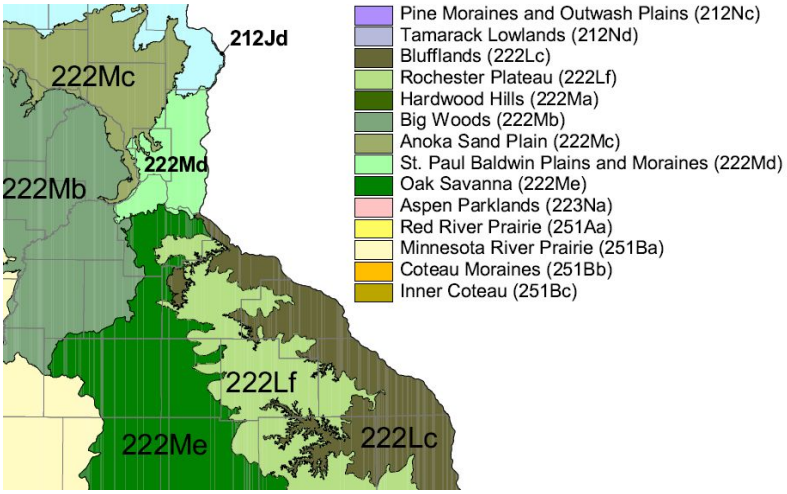
In the west of Old Mill Park beyond the bike trail lays a small private property that is owned by ConAgra. The vegetation composition of this private property is very similar to that of Old Mill Park and it would be preferable if this site was also restored to increase the landscape connectivity and to avoid the spread of invasive species. Because of the similarity of the sites, the guidelines in this restoration plan could be used to manage the ConAgra parcel. An effort should be put into cooperating with ConAgra and keeping the responsible representatives informed about the restoration efforts at Old Mill Park.

ECOLOGICAL RESTORATION AND MANAGEMENT RECOMMENDATIONS

EXISTING LAND COVER

According to the Field Guide to the Native Plant Communities of Minnesota, Eastern Broadleaf Forest Province (DNR 2005), Old Mill Park is located in the following ecological section: Eastern Broadleaf Forest Province, Minnesota and Northeast Iowa Morainal Section, St. Paul Baldwin Plains and Moraines (222 Md) subsection (**Map 5**).

The following native plant communities, as described in the Field Guide, can be found at the site: Ups14 – southern dry savanna, FDs37 – southern dry-mesic oak woodland.



Map 5: DNR Ecological Subsection of Southeast MN

The DNR developed a system called the Minnesota Land Cover System (MLCSS), which defines and classifies all types of land cover (DNR 2001). The MLCSS information was used as a basis for the site evaluation, conducted by the University of Minnesota in the spring and summer of 2012. The information that was recorded during this evaluation includes a list of plant species and their percentage cover in each vegetation layer (**Appendix B**), soil type, slopes, animal signs, human use, and ecological concerns, such as erosion, invasive species, recruitment, tree health, etc. The classifications were modified as needed, based on plant species observed, and the resulting land cover types are shown in **Map 6**. The land cover types are described in **Table 2** and the paragraphs below.

Map 6. Existing Land Cover

Data sources: MLCCS - DNR data deli; 2006 aerial (leaf on), 10-ft contours - Dakota County GIS

1:1,800

0 30 60 120 180 Feet

Modified park boundary

Features

- 1-Concrete slab
- 2-Caves/geologic features
- 3-Old mill ruins

- Impervious surface
- Dry oak savanna sand-gravel subtype
- Mowed turf/picnic grounds
- Former Savannah. Non-native grass with deciduous trees
- Oak woodland-brushland

Table 2: Existing Land Cover and Proposed Restoration

Existing land cover	Dominant soil types	Units	Ac	Target community
Mowed grassland/ lawn	Port Byron silt loam	1a	0.4	Mowed grassland/lawn
Mowed grassland/ lawn	Port Byron silt loam Rockton loam	1b	0.9	Southern dry savanna (UPs14*) /southern mesic prairie (UPs23)
Altered mesic oak woodland	Brodale rock-outcrop	2	1.7	Southern dry-mesic oak woodland (FDs37)
Altered mesic oak savanna (brome-infested)	Rockton loam Brodale rock-outcrop	3	4.5	Southern dry savanna (UPs14)
Oak savanna	Rockton loam	4	0.3	Southern dry savanna (UPs14)
Overgrown mesic oak savanna (buckthorn-infested)	Rockton loam	5	0.6	Southern dry savanna (UPs14)

*According to our species list the type of savanna is matching the UPs14 'Southern Dry Savanna' characteristics more closely than the UPs24 'Southern Mesic Savanna' characteristics. There is some overlap of both types of savanna in some areas of the site.

RESTORATION UNITS DESCRIPTIONS AND GOALS

The plant composition at Old Mill Park is not evenly distributed and there are clearly separate sections with different vegetation. Based on these differences and the affiliated varying restoration goals, we divided the site into five units (see **Map 7**). A detailed list with all plant species in each unit can be found in **Appendix B**.

Unit 1 (managed landscape)
An area of 1.3 acres around the parking lot, including west of the concrete trail leading down to the Old Mill ruins is maintained on a regular basis, which includes mowing, pruning, and general cleanup (**Photos 4 and 5**). Currently the area contains mainly Kentucky bluegrass (*Poa pratensis*), black medic (*Medicago lupulina)* and scattered trees, including two large cottonwood (*Populus deltoides*) trees, some sugar maple (*Acer saccharum*) along the road in the north, and a number of red oak (*Quercus rubra*) trees. Two picnic tables are located in this mowed area, one directly to the south of the parking lot and a second in its northeast.

Restoration Goals:

1. Maintain an area for active recreation, including picnicking
2. Within the active recreation area, restore a woody plant canopy typical of an oak savanna
3. Increase public awareness of oak savanna floras by planting a native garden at park entrance
4. Reduce the area frequently mowed and restore it to oak savanna, including the ground layer.

Photos 4 and 5. Mowed turf area in north part of property, signs at park entrance

Map 7. Management Units

Data sources: Contours, DNR data deli; 2011 aerial- Dakota County GIS

1:1,600

0 25 50 100 150 200 Feet

8/1/2012

Unpaved trails
10-ft contours

Management Goals
Lawn/picnic-Unit A
Oak savanna-Units1,III
Oak woodland-Unit II,VI
Savanna - existing remnant-Unit IV
Modified park boundary

Unit 2 (Southern Dry-Mesic Oak Woodland FDs37)

Photo 6. Oak woodland in East of property.

The 1.7 acres of dry-mesic oak woodland are located in the east of Old Mill Park, leading down to the Vermillion River. This unit has some slopes and is a little cooler and moister than the rest of the property, because of its eastern aspect and shade from a denser tree canopy. A small opening with full sun exposure can be found in the middle of the unit, right at the bottom of a slope. The overstory of the woodland is dominated by pin oak (*Quercus palustris*), red oak (*Quercus rubra*), and some large white oak (*Quercus alba*) (**Photo 6**). Black cherry (*Prunus serotina*) is very common in all layers and some native shrubs, such as prickly ash (*Zanthoxylum americanum*) and black raspberry (*Rubus occidentalis*) are also abundant. The groundlayer is relatively diverse with abundant Pennsylvania sedge and a large number of forbs; oak regeneration is, however, minimal, especially in the denser parts or the woodland. Common buckthorn has densely infested the woodland, and other invasive species are present, such as ground ivy (*Glechoma hederacea*) and sweet clover (*Meliolotus officinalis*).

Goals:

1. To regenerate a healthy oak woodland with natural oak regeneration typical for the FDs37 DNR Native Plant Communities (NPC)
2. To reduce all the invasive species present in the woodland

Unit 3 (brome infested savanna)

Photo 7. Brome infested savanna in center of the property.

The dry-mesic oak savanna in the 4.5 acres of Unit 3 is heavily infested with invasive smooth brome (**Photo 7**), and with common buckthorn in the shaded areas under the trees. In most of this section, smooth brome is forming a close to homogeneous layer that is only interrupted by some patches or individuals of native grasses, forbs, and vines. For example, there are patches of Virginia creeper (*Parthenocissus quinquefolia*) and woodbine (*Parthenocissus vitacea*), and especially the southern parts of the savanna contain large patches of poison ivy (*Toxicodendron rydbergii*). The invasive sweet clover can be found throughout this unit and some areas contain a dense layer of Kentucky bluegrass, especially those close to the lawn. The patchy overstory is dominated by bur oak (*Quercus macrocarpa*), red oak, and black cherry and there is

substantial tree regeneration. Three populations of the endangered kittentail (*Besseya bullii*) are growing in the far south of this unit.

A large part of this unit has relatively steep slopes, which will have to be considered during management activities. The concrete path that leads down to the Old Mill runs through this unit, and many of the trails along or leading to the Vermillion River are found here. One of the trails is heavily eroded.

Restoration goals:
1. restore a healthy dry-mesic oak savanna typical for UPs14 DNR NPC
2. reduce the cover of invasive species
3. ensure that the viability of the three kittentail populations is maintained
4. protect powerlines from growing trees
5. reduce compaction by removing the concrete patch
6. reduce erosion by stabilizing the eroded trail

Unit 4 (oak savanna patch with less brome and more native diversity)

This 0.3 acres unit is located within the southern section of Unit 3, but has a very different plant composition (**Photo 8**). The most conspicuous difference is the sparse infestation with smooth brome and Kentucky bluegrass and the dominance of the native Indian grass (*Sorghastrum nutans)* and the native Pennsylvania sedge (*Carex pennsylvanica*). Many invasive species that have infested other parts of the property are absent in Unit 4, including sweet clover, Tartarian honeysuckle, and common buckthorn. There are less forbs species than in Unit 3, but the shrub layer is much more extensive, hosting native species, such as smooth sumac (*Rhus glabra*), grey dogwood (*Cornus racemosa*) and American bittersweet (*Celastrus scanadens*). There is substantial tree regeneration: oak seedlings and saplings of several species can be found throughout the unit. Another common species in the sapling and seedling stage is American basswood (*Tilia americana*), a species associated with natural oak savannas.

Photo 8. Fairly intact oak savanna patch in the south of the property.

Restoration goals:
1. To restore a healthy and diverse dry-mesic oak savanna typical for UPs14 DNR NPC
2. To reduce all the invasive grasses

Unit 5 (buckthorn infested oak woodland)
This woodland has around 0.6 acres and extends from the north to the south along the bike trail in the west of the property (**Photo 9**). The woodland most likely used to be oak savanna before it was overgrown, as the bur oak trees in the overstory have an open-grown, very wide shape. This unit also has an extensive sub-canopy layer of smooth sumac (*Rhus glabra*) and common buckthorn. The majority of these buckthorn individuals are in a sapling stage and between 1.50 and 3m of size.

The understory in this area is fairly diverse with a number of native grasses and forbs, but the shady conditions prevent higher diversity and smooth brome is also present. Oak savannas in the Midwest are naturally patchy and contain a mosaic of more open and denser patches of oak trees. This unit is an example of the more densely grown patches.

Restoration Goals:

1. To regenerate an oak savanna plant community typical for the DNR UPs14 NPC
2. To support a healthy groundcover by reducing the competition of invasive species
3. To improve light conditions and control the spread of smooth sumac by reducing the existing sumac individuals

Existing Trees
In 2007, Andrew Gibbs conducted a tree inventory project at Old Mill Park and altogether recorded 164 trees. He measured the diameter at breast height (dbh) for hardwoods over 8'' and softwoods over 12'' and calculated an average dbh for the entire site of 6.006''. He found 12 tree species, close to half of which were bur oaks, followed by red oaks (*Quercus rubra*) and pin oak (*Quercus palustris*), a typical distribution in Midwest tallgrass savannas. A detailed list of all tree species in each unit can be found in **Appendix B**.

Photo 9. Oak woodland in west of property.

RESTORATION AND MANAGEMENT RECOMMENDATIONS

Restoration Goals For Entire Site

The primary objective for this site is to improve the composition of the plant communities throughout the property to better reflect the diversity, composition, and structure that would have been present at the time of European settlement and to improve the ecological services. The entire site has good potential for improvement as some areas are in a rather good state and there is still a substantial number of native species that offer a seed source for the desired plant community.

Services:

1. Provisioning Services:
    - Habitat for a diversity of native plant and animal species,
2. Regulatory Services:
    - Carbon storage,
    - Erosion control,
    - Retention and cycling of nutrients, sediments, and pollutants,
    - Development and enrichment of soils,
    - Local temperature moderation.
3. Cultural Services
    - Recreational opportunities for the public,
    - Aesthetics

Overall Site-Based Goals:

1. Create a species composition in the oak savanna and oak woodland that is typical for high quality remnants within 10 years
2. Create a mosaic of all types of communities natural to oak savannas
3. Retain the genetic material already present at the site
4. Reduce the cover of invasive perennial woody and grass species by 90% within 5 years
5. Reduce non-invasive species that are not naturally present in oak savannas and oak woodlands by 90% within 2 years
6. Increase the cover of native species no longer present at the site to 90% within 5 years
7. Encourage the spread of native species currently present at the site and increase their presence to 90% within 5 years
8. Reduce the amount of the mowed area to 25%
9. Increase the number of species and types of species on the site to reflect a natural oak savanna and oak woodland community (use of DNR standards) within 10 years
10. Increase the vigor of existing oak trees within 2-5 years
11. Re-introduce regular natural disturbances within 2 years
12. Minimize the extent of actively eroding areas on the site within 2 years
13. Manage vegetation to encourage use by oak savanna specialists
14. Manage vegetation to provide a corridor for forest song birds migration
15. Cooperate with ConAgra Foods Inc. and other neighbors to restore their property to reduce the seed source of invasive species and to increase the corridor within 2 years
16. Support smart and sustainable use of the site for park visitors within 2 years

Restoration process

The restoration process can be broken into three overall phases. Phase 1 would address the exotic and encroaching species problem, seed the units, and re-introduce fire. As the site is small, proposed activities can be organized throughout the property without the necessity to prioritize any units. Phase 2 of the restoration process would focus on following up the initial activities by continuous removal of invasive species, mowing, and interseeding if necessary. In phase 3, seedlings will be planted in some of the units and regular fires will be re-installed. For a general description on how to restore oak savannas in the Midwest see **Appendix C**.

Additional prescriptions for restoration activities are:

- Seek methods that have the least negative impact on the land and it inhabitants.
- For all tasks, seek viable options to avoid or minimize the use of chemicals. When chemicals are used, certified professionals should do it.
- When there are multiple options for effective chemicals, use the lowest toxicity and the one with the least soil residual.
- For planting or seeding, use native plant species whose genetic origin is as close as possible to the site, or within 100 miles if possible.

Additional detail on the restoration steps is provided below and a schedule of tasks and rough cost estimates is provided in **Table 3**. However, these details are meant as guidelines. The exact procedures are likely to be modified as the project develops. Species list for all the plant community restorations are provided in Appendix D.

Unit 1: managed landscape

Goals and recommendations:

1. To maintain an area for active recreation, including picnicking

Currently, an area of 1.3 acres in this unit is mowed turf grass. To achieve the goal of maintaining an area for active recreation, mowing and existing maintenance will be continued in 0.4 acres. Both of the picnic tables will be located in this mowed area.

2. Within the active recreation area, restore a woody plant canopy typical of an oak savanna

The large cottonwood and the sugar maple trees that are currently found in this part of the unit are not typical of an oak savanna canopy. As they grow older and die, we recommend that the trees will be replaced with tree saplings of species that are naturally part of oak savannas. These include *Quercus macrocarpa*, *Quercus rubra*, and *Quercus palustris*. Because the oak individuals that are already present at the site are genetically well adapted to the existing conditions, the aim is to use that genetic material as much as possible. To prepare for later plantings after the death of non-savanna canopy species, we propose collecting acorns and growing them in a nursery.

3. Increase public awareness of the oak savanna flora by planting a native garden at park entrance

At the parking lot, we recommend putting up a sign that explains some background about the site, the restoration activities and where the trails are leading. To the east of the parking lot a garden of native forbs and grass species will be planted to increase the public awareness of the oak savanna flora. Another sign should briefly introduce the garden, and each species in the garden should be marked (scientific and common names). A few suggested species are listed below.

Grasses:
- Pennsylvania sedge (*Carex pennsylvanica*)
- Indiangrass (*Sorghastrum nutans*)
- Switchgrass (*Panicum virgatum*)
- Little bluestem (*Schizachyrium scoparium)*
- Big bluestem (*Andropogon gerardii)*

Forbs:
- Common milkweed (*Asclepias syriaca)*
- Starry false Solomon's seal (*Smilacina stellata)*
- Wild geranium (*Geranium maculatum)*
- Northern bedstraw (*Galium boreale)*
- Leadplant (*Amorpha canescens)*
- Tall thimbleweed (*Anemone virginiana)*
- Pussytoes (*Antennaria* spp.)
- Sky blue aster (*Aster* oolentangiensis)
- Round-headed bushclover (*Lespedeza capitata)*
- Purple prairie clover (*Dalea purpurea)*
- Rough blazing star (*Liatris aspera)*
- Harebell *(Campanula rotundifolia)*
- Coreopsis *(Coreopsis palmata)*

Dealing with the history of the Old Mill ruins is beyond the scope of this project, but we recommend putting up an informative sign next to them.

4. To restore southern dry oak savanna (UPs14), including the ground layer, in the frequently mowed area

We recommend restoring around 75% of the currently mowed area to oak savanna and ceasing current maintenance and mowing. In the first phase, some of the red maple (*Acer rubrum*) trees, which are not typically found in an oak savanna, should be removed to make space for oak tree planting (*Quercus macrocarpa*, *Q. palustris*, or *Q. rubra*). To reduce compaction of the soil, the vehicles used for the removal should remain on the street as much as possible and the activity should be organized during the winter. To retain the genetic material already existing at the site, we proposed to collect acorns from all the oaks and commission a nursery to grow seedlings. As the success rate of growing seedlings from acorns is not very high, a large number (hundreds) of seeds should be collected.

During the second year of the first phase the site should be prepared for seeding. To be able to determine where the seed mixes will be spread, the daytime light and shade conditions will be evaluated and recorded. To get rid of the current turf vegetation, we recommend treating this area with glyphosate in the late spring, followed by discing to loosen the soil. Discing will also stimulate germination and growth of additional undesired plants and a second herbicide treatment can be applied when plants are 6 to 8 inches tall. The final herbicide application should occur in late fall, just prior to seeding. If needed, the site should be lightly harrowed to smooth the soil and create a suitable seedbed. The site should be broadcast seeded in late fall.

We propose the use of two different native seed mixes: One savanna mix that would contain species in need of shade and one prairie mix with only shade-intolerant species.

The standardized State Seed Mixes for the State of Minnesota can be used, or a custom mix can be designed for the site, based on native savanna or prairie communities found in the area. For partially shaded areas (woodland edge south and west) seed mix 36-211could be used, and for the sun-exposed areas (mesic prairie southeast), seed mix 35-641. For a detailed list of both mixes see **Appendix D**. Both seed mixes would be distributed through broadcasting in the fall, a few weeks after the second herbicide treatment, so that the seeds can overwinter in conditions that mimic natural conditions. For seeding, first the areas receiving daytime shade would be staked off with flags. The savanna mix would be spread in those areas, while the prairie mix would be spread in areas that don't receive any shade during the day. In the first year after seeding, we recommend mowing the site three times during the growing season to help with plant establishment. In the second year it should be mowed only once, and in the third year a spring burn should be organized.

In the second phase, oaks should be planted to support the creation of a natural oak savanna canopy. Two approaches could be combined: First a large number of acorns could be collected and directly placed into the soil. Second the seedlings that have been grown in the nursery could be planted. For this open area a canopy cover of <50% is recommended to avoid too much shade that can favor weedy species in the ground cover. The canopy diameter of a grown oak tree can be 85 feet to 135 feet (Dimensions Info 2012). These dimensions should be considered while planting and seeding.

In later phases the unit needs to be monitored and maintained. Invasive and weedy species should be removed on a yearly basis until the groundlayer is well established. It is important to reintroduce natural fires on a regular basis and to protect the oak seedlings until they have grown to a size large enough to withstand fire. As they die, the remaining canopy trees not typical for oak savannas should gradually be replaced with native oak species.

Unit 2: oak woodland

1. To improve the condition of the oak woodland, including promoting natural oak regeneration typical of the FDs37 DNR Native Plant Communities (NPC)

The lack of oak regeneration in the shady areas of the unit can partially be explained by the competition with exotic species, especially common buckthorn. The oak species that are present at the site are all moderately shade tolerant and need some light to germinate and establish, but buckthorn leaves out very early in the spring and reduces sun penetration throughout the woodland. In the first phase we therefore recommend the removal of all invasive species (see below). As fires are natural disturbances in oak woodlands, in later phases fire should be re-introduced on a regular basis. The burn frequency should be less often than in the savanna, around every 8-12 years.

2. To reduce all the invasive species present in the woodland

During the first phase in early fall, common buckthorn should be removed from the unit. Hand-pulling stems that are smaller than ½ inch in diameter can be done ONLY if it will not cause excessive soil disturbance, nor dislodge desirable native species. Larger stems can be cut and stumps treated with glyphosate. In early spring of the following year the leaves of re-sprouting small-diameter stems and new seedlings should be treated with herbicides as soon as they appear. A fall burn will be most effective for removing seedling plants. In later phases, buckthorn should continuously be pulled and treated with herbicide until most of it is eliminated from the unit.

The invasive non-native sweet clover is part of the woodland, but relatively rare. As it increases with fire, it is best to hand-pull it or spot mow it before it seeds out in the spring and before the site is burned. This procedure needs to be repeated during yearly maintenance as needed.

Smooth brome covers approximately 1-5% of this unit. As studies have shown that smooth brome is most successfully treated with herbicides (Willson *at al.* 1996 Anderson 1994), the majority of it will be targeted with glyphosate from backpack sprayers in the spring (Smith *et al.* 2010). It is important to avoid damage to native species during this treatment. In the late spring of the following year, a prescribed burn should be organized to kill off the remaining brome. The best results can be achieved after late May fires (Willson *at al.* 1996). In later phases we recommend further herbicide spot treatments as necessary.

Ground ivy (*Glechoma hederacea*) is very hard to control in woodlands because of the far-spread roots and the persistent seed banks. In the fall of the first year, we recommend pulling individuals with their roots when the soil is damp. We also recommend spot treatment with Super Trimec (glyphosate 2, 4-D in combination with dicamba and dichlorprop) in the fall after the first hard frost (U.S. Forest Service 2006, Hatterman-Valenti *et al.* 1996).

For more information about invasive species control see **Appendix E**.

Unit 3: brome infested savanna

1. To restore a healthy dry-mesic oak savanna typical for UPs14 DNR NPC

To restore this unit to a healthy oak savanna, in the first phase smooth brome and any woody encroachment need to be treated (see below). After the reduction of invasive species, the site should be seeded. As some of the slopes in this section are rather steep, it is important to prevent erosion and to avoid the waste of seeds due to downhill water, nutrient, or seed movement. After the first burn, we therefore recommend planting the short-lived annual Canada wild rye as a cover-crop. In the fall of that same year, we suggest using the same two seed mixes that have already been used in Unit 1 and broadcast seed them. Invasive species that might re-infest this unit should be removed and treated with herbicides on an ongoing basis. Fires should be organized regularly every 4-6 years (Wolf 2006).

2. To reduce the cover of invasive species

Smooth brome is uniformly covering 75-100% of this unit, reducing the amount of available resources for native species. In between the brome, native grasses and forbs are present, and it would be desirable to preserve these as much as possible. We propose to spot- treat the invasive grass with glyphosate from a backpack sprayer in the spring (Smith *et al.* 2010). If there are any areas with many desirable natives forbs, a grass-specific herbicide (e.g. sethoxydim) could be used. When the grass is dead, a prescribed burn should be done to remove the dead vegetation. The site will green-up again and can be treated once or twice more prior to seeding in late fall (late Oct/early Nov). The rootmass of the existing plants should be adequate to hold the soil, even after the plants are killed, so the soil should not be disced. The site can be seeded with a drill to avoid discing and to ensure good seed-soil contact. If a broadcast seeding is desired, the site will likely need to be burned prior to seeding for the best possible seed contact. Quick-growing cool-season grasses such as Canada wild rye should be included in the mix.

We recommend mowing the unit three times in the spring and summer of the first growing season. This will further reduce the brome cover and allow light to reach the native seedlings. In later phases, re-appearing brome should be spot-treated with herbicides during annual maintenance.

Tartarian honeysuckle is a non-native and very invasive shrub species. In honeysuckle thickets the soil usually doesn't receive any sun. The small number of honeysuckle shrubs in this unit should be cut and treated with glyphosate or tryclopyr in the fall. The foliage of new seedlings and any sprouts should be sprayed with herbicide in the spring of the following year. We recommend repeating this procedure during annual maintenance as needed. Common buckthorn and Siberian elm should be treated in the same way.

3. To ensure that the viability of the four kittentail populations is maintained
Kittentail populations statewide are threatened from habitat loss, including the succession of oak savannas into forests due to the absence of fires. The most important aspect in protecting the kittentail populations on the site is the provision and regeneration of suitable habitat and the prevention of succession and overgrowth. We recommend removing invasive species by pulling and by spot treatment with herbicides if necessary. Fires could also be re-introduced as kittentails are deep-rooted and able to survive and even respond positively to fires (Maloney 1997, Schneider 1993). But fires should not be too frequent. In a study in Illinois, kittentails disappeared from some plots that were burned once, while they occurred in other burned plots (Bowles *et al.* 1995), which means kittentails could react negatively to fire. Additionally, to prevent damage to the plants, prescribed burns should be timed before the kittentails appear above ground in the early spring, i.e. late March or early April (DNR 2012). As other section of this unit will be burned in late May to target smooth brome, the kittentail populations need to be protected during those fires.

To further protect the kittentail populations we recommend avoiding the development of any trails or other infrastructure in their vicinity.

4. To protect powerlines from growing trees
Under the powerline that extends from the north to the south of Unit 3, there are a number of black walnut trees that were most probably planted in the past. Black walnuts are not natural parts of oak savannas and they produce juglone, which can suppress the growth of other savanna species. We recommend removing those walnut trees in the late fall or winter of the first year. Re-sprouting should be avoided by immediate Garlon 3A treatment (Walter *et al.* 2004). Walnut seedlings will be hand-pulled. Pulling will continue through later maintenance phases.

5. To reduce compaction by removing the concrete patch
The concrete remnants of a shelter can be found in the east of this unit. We recommend tearing out the concrete to reduce the compaction under it and to create more space for vegetation to grow. Concrete saws and jack-hammers can be used to achieve this goal. After exposal to the air, the soil should be tilled and seeded with the same prairie species mix that will be used in Unit 1.

6. To reduce erosion by stabilizing the eroded trail
One of the trails parallel to the Vermillion River is heavily eroded. To reduce this erosion, we recommend closing the trail to further use, filling the trail with sandy loam from a

quarry and planting native species. If any of the eroded trails must be kept open, then installing water bars is advised as a way to prevent and control erosion. Park visitors can utilize the parallel trail further to the north in the direct vicinity of the eroded one.

Unit 4: savanna with less brome and more native diversity

1. To restore a healthy and diverse dry-mesic oak savanna typical for UPs14 DNR NPC

Compared to the savanna in Unit 3, the savanna in this unit is in good shape with only two invasive grasses present. The main priority here is to significantly reduce smooth brome and the Kentucky bluegrass (see below). After the phase 1 invasive species treatments, we recommend to re-introduce fire in the late spring of the third year. After the first fire, the site should be allowed to recover and evaluated for resurgence of native species. Results may be detected until the second growing season after the burn. Establishing vegetation study plots will help to monitor any change in cover. If the site does not respond to fire within a few years, it could be inter-seeded with the two native seed mixes that were already used in Unit 1 and 3. In later phases, if invasive and woody species are re-occurring at the site, we recommend spot-treatment with suitable herbicides with backpack sprayers. Fires should be used on a regular basis, every 6-8 years.

2. To reduce all the invasive grasses

Smooth brome covers up to 5% and Kentucky bluegrass between 5 and 25% of this unit. To avoid damage to adjacent forbs, grasses, and shrubs, we recommend foliar spot application with glyphosate in the spring of the second year. A burn in late spring of the next year will also target the species. In the following phases, spot treatments should be applied as necessary.

Unit 5: buckthorn infested oak woodland

Restoration Goals:

1. To regenerate an oak savanna plant community typical for the DNR UPs14 NPC

This unit is highly infested with common buckthorn and during the first phase, buckthorn and other invasive species should be removed (see below). In the second phase fire should be introduced to the site in the spring of the third year. We recommend inter-seeding with the savanna seed mix after the fire in the fall. In later phases, invasive species should continuously be removed and the site should be burned with a frequency of every 6-8 years.

2. To support a healthy groundcover by reducing the competition of invasive species

For recommendations concerning common buckthorn and sweet clover removal see Unit 2.

Around 5% of this unit is covered in smooth brome. The majority of individuals will be targeted with glyphosate from backpack sprayers in the spring. In the late spring of the next year, a prescribed burn should be organized to target the remaining brome.

This unit also contains the exotic and very invasive Siberian elm that we recommend removing. The treatment could be comparable to that used for common buckthorn, except that hand-pulling this species is not recommended as they are very very difficult to pull. Stems larger than ½ inch in diameter can be cut and treated with glyphosate. During the second phase in the following early spring, the leaves of resprouting stems and new seedlings should be treated with herbicide as soon as they appear. We recommend

continuous cutting and herbicide treatment in later phases until Siberian elm is eliminated entirely.

3. To improve light conditions and control the spread of smooth sumac by reducing the existing sumac individuals

Smooth sumac is considered an important part of oak savannas in the Midwest (Peterson *et al.* 2001), contributing to their mosaic-like character, and therefore doesn't need to be removed from the site entirely. It is, though, a very invasive shrub that can become dominant in the absence of disturbances and is out-shading large parts of this unit. To increase the light condition for the groundcover, it will be thinned by 10% in the fall of the first year and the stumps will be treated with Garlon 4. In later phases, after the introduction of fire, the spread of smooth sumac will automatically be controlled.

Property-Wide Recommendations

1. Create a mosaic of all types of communities natural to oak savannas

Oak savannas in the Midwest are commonly regarded as ecosystems along a continuum between prairie and oak woodlands (Wolf 2004, Curtis 1957, Maloney 1997). The canopy density can vary between one tree per acre and a cover of up to 80% (Henderson 1995, Wolf 2004, Bray 1960), and the distribution of canopy trees is often very patchy (Curtis 1957). This patchiness can be related to soil texture, light availability, and fire frequency (Leach *et al.* 1999, Peterson *et al.* 2001). The variability in canopy distribution creates several microsites in oak savannas, with mottled sunlight in some and full sunlight in other areas during the day. As a consequence, oak savannas in the Midwest feature rich and heterogeneous herbaceous understories, with a high diversity in grasses and forbs (Maloney 1997, NPS, Curtis 1957). This diversity also creates different types of habitat for various animal species.

To mimic the naturally occurring variety in community structure, we therefore recommend supporting the currently patchy oak distribution of Old Mill Park with a denser canopy in Unit 5 and more open areas in the savanna of Unit 3 and 4.

2. Re-introduce regular natural disturbances within 2 years

In oak savannas, fire has to occur frequently enough to prevent the dominance of trees and shrubs, but breaks between fires have to be long enough to allow some of the trees to survive to maturity. Frequencies that are either too high or too low can easily shift resource availability and alter species dominance. Mortality rates due to fire differ among oak species: for example, they are much higher for northern pin oak than for bur oak (Peterson *et al.* 2001). The oak savanna in Old Mill Park is dominated by bur oak and therefore we recommend using a burn frequency of every 4-6 years for the savannas (Wolf 2006, Peterson *et al.* 2001). For the oak woodland the frequency should be less, so we suggest omitting every other burn in Unit 2.

According to DNR management practices, fires should not be conducted on the entire site in the same year, in order to provide a refuge for plants and animals. Therefore the park should be divided into two burn units, one of which located to the north and the other one to the south of the concrete path that leads down to the Old Mill ruins. Prescribed burns in those units would have to be at least one year apart.

3. Manage vegetation to encourage use by oak savanna specialists

Oak savanna specialists are animal species that benefit from the patchiness of oak savannas and the combination of denser, forest-like plant communities on the one hand

and more open, light-intensive plant communities on the other. For example, wild turkeys prefer tree-like conditions for nesting, but open sites close to their nests to observe predators. The DNR estimates that 93 Species in Greatest Conservation Need (SGCN) can be found in oak savannas, which emphasizes the importance of oak savanna preservation and restoration. Examples of SGCNs found at oak savannas are rose-breasted grosbeak, hooded warbler, and eastern fox snakes (Minnesota DNR 2006).

Savanna restoration and fire have a large impact on the animal communities present. Restored savannas with regular fires have fewer trees, more snags, and variable understories. For example, Davis *et al.* (2000) reported that the richness of bird species in a Midwestern oak savanna was significantly higher in restored savannas compared to unburned sites and that the community structure varied markedly with the intensity of management. As a consequence, it can be expected that restoring the oak savanna in Old Mill Park to a plant community resembling natural oak savannas will encourage the use by birds and other specialists.

Additionally, cavity-nesting birds have been declining due to habitat loss and many prefer to use oak savannas as their habitat as they combine the features of trees and prairies. For example, eastern bluebirds like to nest in tree cavities and forage in grassy areas. As cavity-nesting birds require snags to build their nests in, dead oak trees should not be removed as long as they don't pose a hazard to visitors.

4. Manage vegetation to provide a corridor for forest song birds migration
During the spring and fall, migratory bird species require continuous corridors of vegetation from their country of origin to their final destination. Many bird species use oak savannas as a stopover. For example, the red-headed woodpecker is a federally protected migratory bid and potentially the only true oak savanna bird specialist (Temple 1998). The DNR considers the management of oak savannas as particularly beneficial for this species (Minnesota DNR 2006). By restoring the savannas and woodlands on the site, removing the invasive species, supporting the development of a native ground cover, and by leaving snags, an essential part of the migratory corridor is preserved for birds that prefer to use oak savannas.

5. Management of steep slopes on-sites
On the steep slopes and cliffs down to the Vermillion River in the south of the property there is a large number of common buckthorn. Dealing with this area is beyond the scope of this project, but we highly recommend removing the buckthorn and restoring the slopes as soon as possible to eliminate the seed sources for the restored areas and to create a continuous high quality oak savanna all the way down to the Vermillion River.

6. Cooperate with ConAgra Foods Inc. and other neighbors to restore their property to reduce the seed source of invasive species and to increase the corridor
To avoid the spread of buckthorn seeds and seeds of other invasive species from properties close by Old Mill Park, we consider cooperation with neighbors very important. We recommend encouraging the owners of adjacent parcels of land and to invest in the restoration of their property. The small site that belongs to ConAgra in the west of Old Mill Park would be an ideal site to use the unit recommendations in this plan as the current conditions of both properties are comparable.

Restoration Schedule And Cost Estimates

Table 3: Old Mill Park Schedule and Cost Estimates

Phase 1: Exotic Species Control and Preparation

Pior-ity	Yr	Season	Units	Activity	Ac	Cost/Ac		Cost est
2	1	Fall	2-5	Acorn collection	7.1		$	
1	1	Fall	1-5	Woody invasive species removal	9.4		$	
2	1	Fall	5	Thinning of sumac	0.6		$	
1	1	Late fall	2	Ground ivy treatment after frost	1.7		$	
1	1	Winter	1, 3	Removal of selected non-savanna trees	5.8		$	
2	1	Winter	1	Create sign to describe site	1.3		$	
1	2	Early spring	2-5	Treat resprouts and seedlings of invasive woody species	7.1		$	
1	2	Early Spring	2,5	Pulling of sweet clover before it seeds out	1.7		$	
1	2	Spring	2-5	Spot-treatment of invasive grasses	7.1		$	
2	2	Spring	1	Light evaluation	1.3		$	
1	2	Spring	3	Stabilize eroded path	4.5		$	
1	2	Spr + Fall	1	Broadcast herbicide treatment	1.3		$	
1	2	Summer	1-5	Purchase seed mixes	9.4			
1	2	Fall	1	Tilling soil	1.3		$	
1	2	Late Fall	1	Seeding	1.3		$	
2	2	Fall	1	Create forbs and grasses demonstration garden	1.3		$	
1	1-2	All	1-5	Annual ecological evaluation and assessment of next steps needed	9.4		$	

Phase 2: Savanna and Woodland Understory Enhancement

Pior-ity	Yr	Season	Units	Activity	Ac	Cost/Ac		Cost est
1	1	Spring	2	Removal of sweet clover before it seeds out	1.7		$	
2	1	Spring	3	Removal of concrete patch + tilling	4.5		$	
1	1	Late Spring	2-5	Prescribed burn	7.1		$	
1	1	Late spring	2-5	Seeding/ interseeding right after burn (except steep slopes unit 3)	7.1		$	
1	1	Late spring	3	Plant cover crop on steep slopes	4.5		$	
1	1	Spr-Fall	1	Mow 3 times	1.3		$	
1	2	Spring	1	Mow once	1.3		$	
1	2	Spr-Fall	3	Mow three times	4.5		$	
1	3	Spring	3	Mow once	4.5		$	
1	3	Spring	1	Prescribed burn	1.3		$	
1	4	Spring	3,4	Prescribed burn	4.8		$	
1	4	Fall	1	Plant oaks	1.3		$	
1	4	Fall	2-5	Plant understory where necessary	7.1		$	
1	1-4	All	1-5	Ecological evaluation	9.1		$	

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Appendix A. Characteristics and Condition of Oak Savannas in the Midwest

The word 'savanna' was originally used by the Carib Indians to describe ecosystems, in which the tree density was so low that the understory grasses and herbaceous species were dominant (Curtis 1957). In the Midwest the most common savanna type is the oak savanna, ecosystems that are generally regarded as existing along a continuum between tallgrass prairie and woodlands (Wolf 2004, Curtis 1971, Maloney 1997), i.e. they are part of a larger complex (Henderson 1995). Oak savannas are distinct from prairies chiefly because they contain fewer grasses, but more forbs and woody species. And they differ from forests, as they have fewer trees, fewer forbs, more grasses, and a comparable number of shrubs (Bader 2001, Leach *et al.* 1996). In Minnesota, oak savannas were found in the southeastern Big Woods area on end moraines. These moraines reduced fire intensity and frequency to an extent that was too low to support prairie systems, but still too high for forests to develop (MN DNR 2005).

There is an ongoing debate of what the canopy cover in Midwestern oak savannas used to be like and in the literature interpretations range from 1 tree per acre to a cover of up to 80% (e.g. Henderson 1995, Wolf 2004, Bray 1960). In his book 'The Vegetation of Wisconsin', Curtis (1957) described the maximum coverage as 50%, but made sure that this was quite arbitrary, as the transition from savanna to woodland is usually gradual and it is impossible to draw a sharp line within this continuum. Because oak savannas used to have very open canopies, oak trees had sufficient space and light to develop very broad crowns and horizontal limbs with large low branches that would sometimes be sweeping close to the ground (Curtis 1957, Wolf 2006). But even though many oak savannas had freestanding trees, it was not uncommon to find oaks clumped together, either in isolated patches, groves, or tongues (Curtis 1957). This varying canopy distribution created several microsites, with mottled sunlight in some and full sunlight in other areas during the day (Maloney 1997). As a consequence, oak savannas in the Midwest featured rich and heterogeneous herbaceous understories, with a high diversity in grasses and forbs (Maloney 1997, NPS). Among these herbaceous species were true sun-loving prairie species, prairie-associated species that needed some shade, true savanna species that needed a mix of shade and sun (also called 'savanna indicator species'), forest-associated species that were able to withstand fire and needed some shade, and true forest species that preferred shade and were able to persist, but not thrive when fires were frequent (Henderson 1996). Warm-season grasses were generally dominant in the Midwest, but cool-season grasses were sometimes more frequent in savannas that had a relatively closed canopy (Savanna Oak Foundation). The shrub layer, on the other hand, was usually sparse (Abella 2004).

Savanna ecosystems were kept up by the low-impact grazing of large ungulates, such as bison, poor soils, drought, and by frequent low-intensity fires that occurred probably every 1-2 years (Hendersen 1995, Leach 1996). This high frequency of fires allowed for the survival of only the most disturbance-prone species, such as large oak trees and deep-rooted forbs and grasses, while small oaks, brushy species, and other tree species were not able to survive (Maloney 1997, Brudvig *et al.* 2011). Because oak savannas often have distinct cohorts of oak trees, it is assumed that oak recruitment was largely triggered by rare catastrophic fires that occurred every 25-100 years, followed by a cessation of low-intensity fires to allow young oaks to grow tall enough to withstand future fires (Apfelbaum *et al.* 1987).

In pre-settlement times, oak savannas used to cover around 10% of the landscape in Minnesota, but only a fraction of that is left today. The main reasons for that is logging, livestock over-grazing, fire suppression (starting in the 1930s), drainage for development, and climate change (Brudvig *et al.* 2007, Apfelbaum *et al.* 1991, Wolf 2004, Brudvig *et al.* 2005, NPS). In the absence of disturbances, the tallgrass savanna is readily invaded by invasive exotics, such as European buckthorn, and mesophytic woody species, such as *Ostrya virginiana* (ironwood) or *Fraxinus americana* (white ash) (Brudgvig 2007). After a while, the clumped or widely scattered canopy pattern of savannas changes to a more random distribution, and the understory becomes less heterogeneous with a prominent shrub later and a more continuous cover of exotic and invasive species. Smaller oak saplings don't survive in the closed canopy due to a lack of sun and other resources, and they thrive only at the edges of the vegetation (Wolf 2004). As the canopy becomes more and more dense, it eventually changes from open savanna into woodland and forest.

Haney *et al.* (1993) distinguishes 6 types of oak savannas in the Midwest, three associated with dry sites (southern oak savanna, eastern sand savanna, northern sand savanna) and three associated with mesic sites (clay-loam savanna, floodplain savanna, mesic loam savanna). In the Midwest, oak savannas occur on moderate to poorly drained, rich black organic soils. Out of six oak savanna types, the site in Hastings can be classified as southern oak savanna, where *Quercus macrocarpa* (bur oak) is the dominant oak species in the canopy and the herbaceous species layer is especially rich (Haney *et al.* 1993, Brudvig *et al.* 2005).

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Appendix B. Old Mill Park Plant Species List

The listed species were identified by the University of Minnesota, and by Friends of the Mississippi River in the summer of 2012.

The relative cover classes (Cov) for individual species and vegetation layers: R (1 individual), + (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%)

Unit 1: Managed Landscape

Non-Native	Family	Scientific Name	Common Name	Cov	Comments
GROUNDCOVER to 4ft			**Total cover:**	**5**	
	Forbs				
	Asteraceae	*Anthemis arvensis*	field chamomile	1	especially in shade of trees
	Asteraceae	*Conyza Canadensis*	Canadian horseweed	+	
	Chenopodiaceae	*Chenopodium album*	lambsquarters	+	
	Fabaceae	*Hypocgoeris radicata*	cat's ear	+	
	Fabaceae	*Medicago lupulina*	black medic	5	
	Plantaginaceae	*Plantago lanceolata*	narrowleaf plantain	+	
	Asteraceae	*Senecio* sp.	ragwort	+	
	Asteraceae	*Solidago canadensis*	Canada goldenrod	+	
	Asteraceae	*Taraxacum officinale*	common dandelion	+	
	Graminoids				
X	Poaceae	*Bromus inermis*	smooth brome	+	
X	Poaceae	*Poa pratensis*	Kentucky bluegrass	5	
	Vines and woody species				
	Fagaceae	*Quercus macrocarpa*	bur oak	+	seedling
	Rhamnaceae	*Rhamnus cathartica*	common buckthorn	+	seedling
CANOPY 40-80 ft			**Total cover:**	**2**	
	Sapindaceae	*Acer saccharum*	sugar maple	1	5 large trees
	Fagaceae	*Fraxinus pennsylvanica*	green ash	1	7 large trees
	Salicaceae	*Populus deltoids*	cottonwood	1	2 large trees

Unit 2: Southern Dry-Mesic Oak Woodland FDs37

Non-Native	Family	Scientific Name	Common Name	Cov *	Comments
GROUNDCOVER to 4 ft			**Total cover:**	**5**	
	Forbs				
	Malvaceae	*Albutilon theophrasti*	velvetleaf	+	
	Ranunculaceae	*Anemone virginiana*	tall timbleweed	1	
	Asteraceae	*Arctium minus*	lesser burdock	+	
	Asteraceae	*Aster oblongifolius*	aromatic aster	1	
	Asteraceae	*Aster oolentangiensis*	sky blue aster	+	
	Asteraceae	*Erigeron strigosus*	prairie fleabane	+	
	Rosaceae	*Fagaris* sp.	strawberry	1	
	Rubiaceae	*Galium boreale*	northern bedstraw	3	
	Rubiaceae	*Galium triflorum*	fragrant bedstraw	1	
X	Lamiaceae	*Glechoma hederacea*	ground ivy	1	
	Fabaceae	*Medicago lupulina*	black medic	1	
X	Fabacaea	*Meliolotus officinalis*	sweet clover	+	
	Lamiaceae	*Monarda fistulosa*	wild bergamot	+	
	Apiaceae	*Myrrhis odorata*	sweet cicely	+	
	Verbenaceae	*Phyrma leptostachya*	American lopseed	+	Continuous
	Liliaceae	*Polygonatum biflorum*	smooth Solomon's seal	+	
	Asteraceae	*Solidago Canadensis*	Canada goldenrod	2	
	Anacardiaceae	*Toxicodendron rydbergii*	western poison ivy	2	Patchy
	Grossulariaceae	*Ribes missouriense*	Missouri gooseberry	+	
	Asteraceae	*Taraxacum officinale*	common dandelion	+	
	Fabaceae	*Trifolium pretense*	red clover	+	
	Graminoids				
X	Poaceae	*Bromus inermis*	smooth brome	+	
	Poaceae	*Carex pennsylvanica*	Pennsylvanica sedge	4	
X	Poaceae	*Poa pratensis*	Kentucky bluegrass	1	
	Vines and woody species				
	Sapindaceae	*Acer platanoides*	Norway maple	1	seedling
	Juglandaceae	*Carya cordiformis*	bitternut hickory	+	seedling
	Juglandaceae	*Juglans nigra*	Black walnut	+	seedling
	Cupressaceae	*Juniperus virginiana*	eastern red cedar	1	only in opening
	Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	3	

	Vitaceae	*Vitis* sp.	wild grape	1	
	Rosaceae	*Prunus serotina*	black cherry	1	seedling
	Fagaceae	*Quercus alba*	white oak	+	seedling
	Fagaceae	*Quercus macrocarpa*	bur oak	+	seedling
	Fagaceae	*Quercus rubra*	northern red oak	+	seedling, mainly in opening
X	Rhamnaceae	*Rhamus cathartica*	common buckthorn	2	continuous
	Rutaceae	*Zanthoxylum americanum*	prickley ash	2	seedling

UNDERSTORY/SHRUB LAYER 4-15 ft **Total cover: 2**

	Sapindaceae	*Acer platanoides*	Norway maple	1	
	Rosaceae	*Amelanchier* sp.	serviceberry	2	
	Juglandaceae	*Carya cordiformis*	bitternut hickory	+	sapling
	Moraceae	*Morus alba*	white mulberry	+	sapling
	Rosaceae	*Prunus serotina*	black cherry	3	sapling
	Rosaceae	*Prunus virginiana*	chokecherry	+	sapling
	Rosaceae	*Rubus occidental*	black raspberry	2	continuous
X	Rhamnaceae	*Rhamus cathartica*	common buckthorn	3	
	Rutaceae	*Zanthoxylum americanum*	prickley-ash	2	sapling

CANOPY 40-80 ft **Total cover: 4**

	Juglandaceae	*Juglans nigra*	Black walnut	1	Especially at edge to lawn
	Cupressaceae	*Juniperus virginiana*	eastern red cedar	+	2 grown trees in opening
	Salicaceae	*Populus deltoides*	cottonwood	1	
	Rosaceae	*Prunus serotina*	black cherry	2	
	Rosaceae	*Prunus virginiana*	chokecherry	1	
	Fagaceae	*Quercus alba*	white oak	2	
	Fagaceae	*Quercus macrocarpa*	bur oak	1	
	Fagaceae	*Quercus palustris*	pin oak	3	
	Fagaceae	*Quercus rubra*	red oak	2	
	Tiliaceae	*Tilia americana*	American basswood	1	

Unit 3: High Brome Oak Savanna UPs14

Non-Native	Family	Scientific Name	Common Name	Cov	Comments
GROUNDCOVER to 4 ft			**Total cover:**	**5**	
	Forbs				
	Ranunculaceae	*Anemone cylindrica*	candle anemone	+	
	Malvaceae	*Albutilon theophrasti*	velvetleaf	+	
	Asteraceae	*Ambrosia artemisiifolia*	annual ragweed	+	Mainly on edge of path
	Asteraceae	*Ambrosia trifida*	great ragweed	+	Mainly on edge of path
	Apocynaceae	*Asclepias syriaca*	common milkweed	+	
	Asteraceae	*Aster oblongifolius*	aromatic aster	+	
	Asteraceae	*Aster oolentangiensis*	sky blue aster	+	
	Scrophulariaceae	*Besseya bullii*	kittentail	+	
	Asteraceae	*Erigeron strigosus*	prairie fleabane	+	Mainly on edge of path
	Rubiaceae	*Galium boreale*	northern bedstraw	+	
	Fabaceae	*Medicago lupulina*	black medic	1	Mainly on edge of path
X	Fabacaea	*Meliolotus officinalis*	Sweet clover	3	discontinuous
	Plantaginaceae	*Plantago lanceolata*	narrowleaf plantain	+	Mainly on edge of path
	Liliaceae	*Polygonatum biflorum*	smooth Solomon's seal	R	
	Asteraceae	*Solidago canadensis*	Canada goldenrod	2	patchy
	Asteraceae	*Taraxacum officinale*	common dandelion	1	
	Asteraceae	*Tragopogon dubies*	yellow salsify	+	
	Asteraceae	*Tragopogon pratensis*	yellow goat's beard	+	
	Fabaceae	*Trifolium pretense*	red clover	1	Mainly on edge of path
	Fabaceae	*Trifolium retens*	white clover	+	
	Anacardiaceae	*Toxicodendron rydbergii*	western poison ivy	2	Patchy
	Verbenaceae	*Verbena stricta*	hoary verbena	+	
	Asteraceae	*Xanthium strumarium*	rough cocklebur	+	
	Graminoids				
X	Poaceae	*Bromus inermis*	smooth brome	5	continuously
	Cyperaceae	*Carex rosea*	rosy sedge	+	
	Poaceae	*Panicum virgatum*	switchgrass	+	
X	Poaceae	*Poa pratensis*	Kentucky bluegrass	3	especially near lawn
	Poaceae	*Schizachyrium scoparium*	little bluestem	+	
	Poaceae	*Sorghastrum*	Indiangrass	1	Patchy

		nutans			

Vines and woody species

	Oleaceae	*Fraxinus pennsylvanica*	green ash	+	seedling
	Rubiaceae	*Galium trifidum*	threepetal bedstraw	+	
	Rubiaceae	*Juglans cinera*	stickywilly		
	Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	2	patchy
	Vitaceae	*Vitis* sp.	wild grape	2	patchy
	Rosaceae	*Prunus serotina*	black cherry	1	seedling
	Fagaceae	*Quercus rubra*	red oak	+	seedling
	Asteraceae	*Vicia grandiflora*	yellow vetch	1	Mainly on edge of path
	Vitaceae	*Vitis riparia*	riverbank grape	2	patchy

UNDERSTORY/SHRUB LAYER 4-15 ft **Total cover: 2**

	Aceraceae	*Acer negundo*	boxelder	+	sapling
	Juglandaceae	*Carya cordiformis*	bitternut hickory	+	sapling
	Liliaceae	*Asparagus officinalis*	garden asparagus	+	
	Celastraceae	*Celastrus candens*	American bittersweet		
	Cornaceae	*Cornus racemosa*	grey dogwood	1	sapling
X	Caprifoliaceae	*Lonicera tartarica*	Tartarian honeysuckle	1	
	Rosaceae	*Prunus serotina*	black cherry	1	sapling
	Rosaceae	*Prunus virginiana*	chokecherry	+	sapling
	Fagaceae	*Quercus rubra*	red oak	1	sapling
	Fagaceae	*Quercus macrocarpa*	bur oak	3	sapling
	Fagaceae	*Quercus rubra*	red oak	1	sapling
X	Rhamnaceae	*Rhamnus cathartica*	common buckthorn	1	
	Anacardiaceae	*Rhus typhina*	poison sumac	+	
	Saxifragaceae	*Ribes* spp.	currant	+	
	Rosaceae	*Rosa* spp.	wild rose	+	
	Rosaceae	*Rubus occidental*	black raspberry	+	
	Ulmaceae	*Ulmus americana*	American elm	R	sapling
X	Ulmaceae	*Ulmus pumila*	Siberian elm	+	sapling
	Rutaceae	*Zanthoxylum americanum*	prickley-ash	1	

CANOPY 40-80 ft **Total cover: 3**

	Cupressaceae	*Juniperus virginianum*	eastern redcedar	+	
	Moraceae	*Morus alba*	white mulberry	R	
	Rosaceae	*Prunus serotina*	black cherry	2	patchy
	Fagaceae	*Quercus macrocarpa*	bur oak	2	patchy
	Fagaceae	*Quercus rubra*	red oak	2	patchy
	Tiliaceae	*Tilia Americana*	American basswood	+	

Unit 4: Low Brome Oak Savanna UPs14

Non-Native	Family	Scientific Name	Common Name	Cov	Comments
GROUNDCOVER to 4 ft			**Total cover:**	**5**	
	Forbs				
	Asteraceae	*Achillia millefolium*	common yarrow	+	
	Fabaceae	*Amorpha canescens*	leadplant	+	
	Ranunculaceae	*Anemone cylindrical*	candle anemone	+	
	Ranunculaceae	*Anemone virginiana*	tall thimpleweed	+	
	Asteraceae	*Antennaria* sp.	pussytoes	+	patchy
	Asteraceae	*Aster* sp.	Aster	2	
	Asteraceae	*Erigeron annuus*	eastern daisy fleabane	+	
	Fabaceae	*Lespedeza leptostachya*	prairie lespedeza	+	
	Anacardiaceae	*Rhus typhina*	staghorn sumac	1	
	Asteraceae	*Senecio* sp.	ragwort	+	
	Asteraceae	*Solidago canadensis*	Canada goldenrod	+	
	Anacardiaceae	*Toxicodendron rydbergii*	western poison ivy	2	
	Graminoids				
X	Poaceae	*Bromus inermis*	smooth brome	1	
	Cyperaceae	*Carex pennsylvanica*	Pennsylvanian sedge	4	
X	Poaceae	*Poa pratensis*	Kentucky bluegrass	2	
	Poaceae	*Sorghastrum nutans*	Indiangrass	3	patchy
	Vines and woody species				
	Celastraceae	*Celastrus scandens*	American bittersweet	1	
	Cornaceae	*Cornus racemosa*	grey dogwood	2	seedling
	Fagaceae	*Quercus macrocarpa*	bur oak	+	seedling
	Anacardiaceae	*Rhus glabra*	smooth sumac	+	
	Rosaceae	*Rosa arkansana*	prairie rose	1	patchy
	Vitaceae	*Vitis riparia*	riverbank grape	1	
UNDERSTORY/SHRUB LAYER 4-15 f			**Total cover:**	**2**	
	Fabaceae	*Amorpha canescens*	leadplant	+	
	Liliaceae	*Asparagus officinalis*	garden asparagus	R	
	Celastraceae	*Celastrus scanadens*	American bittersweet	1	
	Cornaceae	*Cornus racemosa*	grey dogwood	1	sapling
	Rosaceae	*Prunus serotina*	black cherry	+	sapling
	Rosaceae	*Prunus virginiana*	chokecherry	+	sapling
	Fagaceae	*Quercus alba*	white oak	1	sapling
	Fagaceae	*Quercus*	bur oak	+	sapling

		macrocarpa			
	Fagaceae	*Quercus rubra*	red oak	1	sapling
	Anacardiaceae	*Rhus typhina*	poison sumac	2	
	Rosaceae	*Prunus serotina*	black cherry	+	sapling
	Tiliaceae	*Tilia Americana*	American basswood	2	sapling

CANOPY 40-80 ft **Total cover: 3**

	Fagaceae	*Quercus alba*	white oak	2	One big tree
	Fagaceae	*Quercus macrocarpa*	bur oak	3	

Unit 5: Buckthorn infested oak savanna UPs14

Non-Native	Family	Scientific Name	Common Name	Cov	Comments
GROUNDCOVER to 4 ft Forbs			**Total cover:**	**4**	
	Asteraceae	*Ambrosia artemisiifolia*	annual ragweed	1	Mainly in open patch
	Ranunculaceae	*Anemone virginiana*	tall timbleweed	1	
	Asteraceae	*Arctium minus*	lesser burdock	+	
	Apocynaceae	*Asclepias syriaca*	common milkweed	+	
	Asteraceae	*Aster lateriflorus*	calico aster	+	
	Asteraceae	*Aster oblongifolius*	aromatic aster	1	
	Asteraceae	*Aster oolentangiensis*	sky blue aster	+	
	Celastraceae	*Celastrus candens*	American bittersweet	+	
	Asteraceae	*Erigeron strigosus*	prairie fleabane	+	
	Asteraceae	*Helianthus microcephalus*	small wood sunflower	1	
	Rubiaceae	*Galium boreale*	northern bedstraw	1	
	Rubiaceae	*Galium triflorum*	fragrant bedstraw	1	
	Geraniaceae	*Geranium maculatum*	wild geranium	+	
	Scrophulariaceae	*Linaria vulgaris*	butter and eggs	+	
	Lythraceae	*Lythrum salicaria*	purple loosestrife	+	
	Fabaceae	*Medicago lupulina*	black medic	+	
X	Fabacaea	*Meliolotus officinalis*	sweet clover	+	
	Lamiaceae	*Monarda fistulosa*	wild bergamot	1	
	Liliaceae	*Polygonatum biflorum*	smooth Solomon's seal	+	
	Asteraceae	*Tragopogon dubies*	yellow salsify	+	
	Plantaginaceae	*Plantago lanceolata*	narrowleaf plantain	+	Mainly on edge of path
	Asteraceae	*Solidago Canadensis*	Canada goldenrod	2	
	Asteraceae	*Taraxacum*	common dandelion	+	

		officinale			
	Anacardiaceae	*Toxicodendron rydbergii*	western poison ivy	2	Patchy
	Asteraceae	*Tragopogon dubies*	yellow salsify	1	
	Fabaceae	*Trifolium pretense*	red clover	+	
	Asteraceae	*Eupatorium* spp.	Aster species	+	
	Verbenaceae	*Verbena urticifolia*	white vervain	+	
	Violaceae	*Viola* sp.	violet	+	

Graminoids

X	Poaceae	*Bromus inermis*	smooth brome	1	
	Poaceae	*Panicum virgatum*	switchgrass	2	
	Poaceae	*Poa pratensis*	Kentucky bluegrass	1	

Vines and woody species

	Aceraceae	*Acer negundo*	box elder	1	seedling
	Oleaceae	*Fraxinus pennsylvanica*	green ash	+	seedling
	Cupressaceae	*Juniperus virginiana*	eastern red cedar	1	seedling
	Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	2	
	Fagaceae	*Quercus macrocarpa*	bur oak	+	seedling
	Fagaceae	*Quercus palustris*	northern pin oak	+	seedling
X	Rhamnaceae	*Rhamus cathartica*	common buckthorn	3	seedling
	Vitaceae	*Vitis* sp.	wild grape	2	

UNDERSTORY/SHRUB LAYER 4-15 ft **Total cover: 4**

	Aceraceae	*Acer negundo*	box elder	1	sapling
X	Caprifoliaceae	*Lonicera tartarica*	Tartarian honeysuckle	+	sapling
	Moraceae	*Morus alba*	white mulberry	+	sapling
	Rosaceae	*Prunus virginiana*	chokecherry	+	sapling
	Fagaceae	*Quercus palustris*	northern pin oak	+	sapling
X	Rhamnaceae	*Rhamus cathartica*	common buckthorn	3	
	Anacardiaceae	*Rhus glabra*	smooth sumac	4	
	Rosaceae	*Rubus occidental*	black raspberry	1	
	Tiliaceae	*Tilia americana*	American basswood	+	sapling
	Ulmaceae	*Ulmus Americana*	American elm	1	sapling
X	Ulmaceae	*Ulmus pumila*	Siberian elm	+	sapling
	Rutaceae	*Zanthoxylum americanum*	prickley-ash	1	

CANOPY 40-80 ft **Total cover: 5**

	Aceraceae	*Acer negundo*	box elder	2	
	Oleaceae	*Fraxinus pennsylvanica*	green ash	1	
	Fagaceae	*Quercus macrocarpa*	bur oak	4	wide crowns
	Fagaceae	*Quercus palustris*	northern pin oak	1	

The following is a tree inventory done by Andrew Gibbs, 2007. It lists all hardwood species >8'' and all softwood species >12'' diameter at breast height (dhb).

Botannical Name	Common Name	Code	Actual # of Trees.	Percentage of
Quercus macrocarpa	Bur Oak	QM	74	45.1%
Quercus rubra	Red Oak	QR	44	26.8%
Quercus palustris	Pin Oak	QP	12	7.3%
Populus deltoides	Cottonwood	PD	10	6.1%
Fraxinus	Green Ash	FP	7	4.3%
Acer saccharum	Sugar Maple	AM	5	3.0%
Ulmus americana	American Elm	UA	4	2.4%
Fraxinus nigra	Black Ash	FN	2	1.2%
Prunus serotina	Black Cherry	BC	2	1.2%
Tilia americana	American Linden or	TA	2	1.2%
Betula papyrifera	Paper Birch	BP	1	0.6%
Juniperus virginiana	Eastern Red Cedar	JV	1	0.6%

Appendix C. General Restoration Strategies and Considerations for Oak Savannas in the Midwest

There are several ways in which oak savannas in the Midwest can be restored. The longer the savanna has faced fire-suppression, grazing and other stresses the more intensive the restoration efforts that are needed. If an alternate stable state has been reached, several methods have to be combined for an extended amount of time. For example, it might be impossible to get rid of encroached woody species as long as there is not the right understory fuel availability to create large enough fires. Or removing the woody invasive species might not lead to the expected results as after removal of mesophytic species, other mesophytic instead of the required savanna species encroach the site again (Brudvig *et al.* 2007).

The main goals of restoration are the reduction of the overstory tree density and the promotion of oak dominance (Brudvig *et al.* 2011). Specifically this includes the creation of a natural savanna age structure and canopy composition, the reduction of exotics species, and the creation of refugia for oaks and oak-dependent species (Wolf 2006).

A number of restoration approaches have been used in the past: In some cases it might be enough to re-introduce the main natural disturbance, which in case of oak savannas is fire. This approach assumes that the system is already within its natural range of variability and that the re-introduction of a natural disturbance is enough to restore the original system (Nielsen et al. 2003). In other cases the initial removal of selected trees followed by the re-introduction of fire, sometimes referred to as the 'structural manipulation approach', might be necessary. This approach is based on the idea that the reintroduction of a more natural structure before the use of fire will assist the recovery of dynamics much faster and more efficiently than the mere use of the disturbance (Nielsen et al. 2003). It is especially useful if there have been major structural changes, such as canopy closure and the development of a midstory canopy layer (Brudvig *et al.* 2007).

Generally, the use of just one method can be short-sided. For example, Abella *et al.* (2004) and Nielsen *et al.* (2003) were unable to find a change in understory diversity and richness after using fire only. When using the structural manipulation approach, on the other hand, Nielsen *et al.* (2003) achieved increases in species richness. Brudvig *et al.* (2007) did a study in which they didn't use fire and purely removed encroaching species in a savanna. They never got past a threshold and mesophytic species were the dominant invaders after 3 years, while oak was largely unaffected by the treatment. Also shrub-densities returned to pre-treatment levels. They concluded that repeated treatments in combination with fire might be more efficient.

Structural manipulation approach

The first step of regenerating an oak savanna when using the structural manipulation approach is the removal of invasive shrubby species and encroaching trees to create a structure that more resembles a natural system. For example Brudvig (2007) recommends the reduction of the basal area to 30 m^2/ha, the creation of a canopy cover up to 50% of the site, and the removal of all non-oak woody stems that are larger than 150 cm in size. Treatments should be organized during the winter months when the soil is frozen to reduce negative impacts. There are several ways of removing trees and shrubs, including manual, chain saws, brush cutters. In many cases, especially for exotic invasive species, the use of herbicides will be necessary (Maloney 1997).

After the removal of encroaching exotic species and tree species, fires should be re-introduced. Because of their thick bark and ability to resprout after topkill, most oak species are naturally adapted to fire and fires have been an essential disturbance that keeps savannas from developing into woodland (Wolf 2006). The specific effect of fire in degraded savannas is the reduction of invasive grasses and woody species and to sustain higher levels of habitat and species diversity (Wolf 2004). But fires don't always yield the expected result as all plant species that are part of a savanna respond to fire in an individualistic manner. For example, in study in Minnesota, Tester (1996) found that true prairie grasses and forbs generally were positively related to burn frequency, but that also some introduced grasses, e.g. *Poa pratensis* (C3) and *Setaria lutescens* (C4), reacted to the disturbance with increased growth. On the other hand, *Agropyron repens* (C3) and *Bromus inermis* (C3) and six of seven native non-savanna species that are associated with forests showed decreased growth after fire. This study shows how important it is to understand the response of species to fire.

Knowledge about fire frequency and intensity is also essential. Taking natural fire regimes in a savanna as a reference, the frequency of low-intensity fires was every 4 or 8 years for bur oak or white oak dominated savannas respectively. So even oak trees, whose germination is supported by fires, need fire-free periods for seedlings and saplings to successfully develop (Wolf 2006). Extreme fires, on the other hand, occurred much less frequently, only around every 35-100 years (Apfelbaum *et al.* 1991). There is a range of recommendations concerning the use of prescribed fires in the literature. Generally, fire frequencies that are either too high or too low can shift resource availability and alter species dominance. Some sources say that low-intensity precribed fires should be used annually or at least every other year (Maloney 1997, Apfelbaum *et al.* 1991). Others say that rather than that high-intensity fires should be used, because low-intensity fires are not likely to result in the mortality of large overstory stems. Additionally, frequent low-intensity fires have the potential to destroy seed-banks and endangered savanna species (Nielsen *et al.* 2003, Packard 1997), increase the likelihood of invasive species infestation, change resource availability, and prevent the growth of oak seedlings large enough to survive future fires (Wolf 2006).

In many savannas it is necessary to seed and/or plant the site, especially if no viable seed bank is available and no remnants are close enough for seeds to reach the area. It is possible to either collect seeds from functional remnant savanna sites or order them. After the soil type has been determined, a seed mix should be used that is suitable for the microhabitat. The seeds can be applied by broadcasting or with a native seed drill (Maloney 1997). A good time for seeding is spring or fall, after the seeds have ripened (Packard 1997). Several native plant lists for the Midwest are available: Wolf (2004), Maloney (1997), Tester (1996), Brudvig (2008), Packard (1997). After initial treatment it is necessary to monitor the site for some years, continue removing invasive species and potentially interseed. After that, it might be sufficient to regularly burn the site (Maloney 1997)

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Appendix D. Minnesota State Seed Mixes

36-211 **Woodland Edge South & West**

Common Name	Scientific Name	Rate (kg/ha)	Rate (lb/ac)	% of Mix (% by wt)	Seeds/ sq ft
big bluestem	*Andropogon gerardii*	1.12	1.00	2.90%	3.68
side-oats grama	*Bouteloua curtipendula*	1.12	1.00	2.89%	2.20
kalm's brome	*Bromus kalmii*	1.68	1.50	4.34%	4.40
nodding wild rye	*Elymus canadensis*	1.40	1.25	3.61%	2.38
bottlebrush grass	*Elymus hystrix*	0.36	0.32	0.91%	0.88
slender wheatgrass	*Elymus trachycaulus*	1.40	1.25	3.64%	3.18
switchgrass	*Panicum virgatum*	0.07	0.06	0.17%	0.30
little bluestem	*Schizachyrium scoparium*	0.69	0.62	1.79%	3.40
Indian grass	*Sorghastrum nutans*	1.12	1.00	2.89%	4.40
	Total Grasses	**8.97**	**8.00**	**23.14%**	**24.82**
common yarrow	*Achillea millefolium*	0.03	0.03	0.09%	2.00
blue giant hyssop	*Agastache foeniculum*	0.11	0.10	0.28%	3.20
white snakeroot	*Ageratina altissima*	0.03	0.03	0.09%	1.70
white prairie clover	*Dalea candida*	0.19	0.17	0.50%	1.20
Canada tick trefoil	*Desmodium canadense*	0.16	0.14	0.42%	0.29
ox-eye	*Heliopsis helianthoides*	0.15	0.13	0.38%	0.30
wild bergamot	*Monarda fistulosa*	0.07	0.06	0.18%	1.60
stiff goldenrod	*Oligoneuron rigidum*	0.07	0.06	0.17%	0.90
Clayton's sweet cicely	*Osmorhiza claytonii*	0.07	0.06	0.17%	0.06
smooth wild rose	*Rosa blanda*	0.07	0.06	0.17%	0.06
black-eyed susan	*Rudbeckia hirta*	0.20	0.18	0.52%	6.10
Lance-leaved Figwort	*Scrophularia lanceolata*	0.06	0.05	0.14%	3.20
zigzag goldenrod	*Solidago flexicaulis*	0.02	0.02	0.05%	0.50
showy goldenrod	*Solidago speciosa*	0.07	0.06	0.18%	1.80
smooth aster	*Symphyotrichum laeve*	0.07	0.06	0.19%	1.30
American vetch	*Vicia americana*	0.20	0.18	0.52%	0.14
golden alexanders	*Zizia aurea*	0.12	0.11	0.33%	0.46
	Total Forbs	**1.68**	**1.50**	**4.38%**	**24.80**
Oats or winter wheat (see note at beginning of list for recommended dates)		28.02	25.00	72.48%	11.14
	Total Cover Crop	**28.02**	**25.00**	**72.48%**	**11.14**
	Totals:	**38.67**	**34.50**	**100.00%**	**60.75**
Purpose:	Partly shaded grassland planting for native roadsides, reclamation, etc.				
Planting Area:	Tallgrass Aspen Parklands, Prairie Parkland, and Eastern Broadleaf Forest Provinces. Mn/DOT Districts 2(west), 3B, 4, Metro, 6, 7 & 8.				

35-641 **Mesic Prairie Southeast**

Common Name	Scientific Name	Rate (kg/ha)	Rate (lb/ac)	% of Mix (% by wt)	Seeds/ sq ft
big bluestem	*Andropogon gerardii*	1.01	0.90	7.49%	3.30
side-oats grama	*Bouteloua curtipendula*	1.54	1.37	11.38%	3.01
nodding wild rye	*Elymus canadensis*	1.18	1.05	8.77%	2.01
slender wheatgrass	*Elymus trachycaulus*	1.01	0.90	7.50%	2.28
switchgrass	*Panicum virgatum*	0.24	0.21	1.78%	1.10
little bluestem	*Schizachyrium scoparium*	1.42	1.27	10.59%	7.00
Indian grass	*Sorghastrum nutans*	2.24	2.00	16.68%	8.82
	Total Grasses	**8.63**	**7.70**	**64.19%**	**27.52**
butterfly milkweed	*Asclepias tuberosa*	0.07	0.06	0.53%	0.10
whorled milkweed	*Asclepias verticillata*	0.01	0.01	0.10%	0.05
Canada milk vetch	*Astragalus canadensis*	0.18	0.16	1.33%	1.00
partridge pea	*Chamaecrista fasciculata*	0.67	0.60	5.00%	0.60
white prairie clover	*Dalea candida*	0.01	0.01	0.07%	0.06
purple prairie clover	*Dalea purpurea*	0.10	0.09	0.76%	0.50
Canada tick trefoil	*Desmodium canadense*	0.17	0.15	1.24%	0.30
ox-eye	*Heliopsis helianthoides*	0.06	0.05	0.43%	0.12
rough blazing star	*Liatris aspera*	0.03	0.03	0.21%	0.15
great blazing star	*Liatris pycnostachya*	0.03	0.03	0.29%	0.14
wild bergamot	*Monarda fistulosa*	0.01	0.01	0.06%	0.18
stiff goldenrod	*Oligoneuron rigidum*	0.02	0.02	0.17%	0.31
gray-headed coneflower	*Ratibida pinnata*	0.02	0.02	0.15%	0.20
black-eyed susan	*Rudbeckia hirta*	0.06	0.05	0.38%	1.54
heath aster	*Symphyotrichum ericoides*	0.01	0.01	0.05%	0.40
smooth aster	*Symphyotrichum laeve*	0.06	0.05	0.41%	1.00
bracted spiderwort	*Tradescantia bracteata*	0.04	0.04	0.34%	0.15
blue vervain	*Verbena hastata*	0.04	0.04	0.37%	1.50
hoary vervain	*Verbena stricta*	0.11	0.10	0.85%	1.05
golden alexanders	*Zizia aurea*	0.08	0.07	0.60%	0.29
	Total Forbs	**1.79**	**1.60**	**13.34%**	**9.64**
Oats or winter wheat (see note at beginning of list for recommended dates)		3.03	2.70	22.47%	1.20
	Total Cover Crop	**3.03**	**2.70**	**22.47%**	**1.20**
	Totals:	**13.45**	**12.00**	**100.00%**	**38.36**
Purpose:	Regional mesic prairie reconstruction for wetland mitigation, ecological restoration, or conservation program plantings.				
Planting Area:	Eastern Broadleaf Forest Province excluding Hardwood Hills subsection. Mn/DOT Districts Metro & 6.				

Appendix E. Methods for Invasive Species Removal

Out of the hundreds of species that have been introduced to the U.S. from other countries, only a small fraction managed to become invasive. These very persistent exotics are able to out-compete native vegetation, often develop very dense mono-dominant stands, and can cause a shift in species composition, soil nutrient content and shade conditions. Invasive s species use various strategies that lead to their competitive advantage over native species, including a faster growth rate, the ability to grow in impoverished and disturbed soils, the lack of natural enemies, and the use of allelopathic chemicals that inhibit the growth of other plants. This appendix deals with the control of the exotic invasives that are found at Old Mill Park.

TREES AND SHRUBS

Common buckthorn, Tartarian honeysuckle, and Siberian elm are some of the most common woody species likely to invade native woodlands or savannas in Minnesota. Common buckthorn is a Eurasian species that was introduced to the U.S. in the Mid-1800 s. It is very widespread at Old Mill Park and can be found in nearly all units. It is highly invasive and has several competitive advantages over the native vegetation. It leaves out earlier and keeps leaves longer than other species, therewith extending its growing season. It can survive in shade and sun, and has very high seedling densities. (Source).

Tartarian honeysuckle and Siberian elm are thus far rare at the site, but Siberian elm, native to eastern Asia, readily grows, especially in disturbed and low-nutrient soils with low moisture. Seed germination is high and seedlings establish quickly in sparse vegetation. It can invade and dominate disturbed areas in just a few years.

Chemical Control

The most efficient way to remove woody plants that are 1/2 inch or more in diameter is to cut the stems close to the ground and treat the cut stumps with herbicide immediately after they are cut, when the stumps are fresh and the chemicals are most readily absorbed. Failure to treat the stumps will result in resprouting, creating much greater removal difficulty. In non-freezing temperatures, a glyphosate herbicide such as Roundup can be used for most woody species. It is important to obtain the concentrated formula and dilute it with water to achieve 10% glyphosate concentration. Adding a marker dye can help to make treated stumps more visible. In winter months, an herbicide with the active ingredient triclopyr must be used. Garlon 4 is a common brand name and it must be mixed with a penetrating oil, such as diluent
blue. Do not use diesel fuel, as it is much more toxic in the environment and for humans.

Brush removal work can be done at any time of year except during spring sap flow, but late fall is often ideal because buckthorn retains its leaves longer than other species and is more readily identified. Cutting can be accomplished with loppers or handsaws in many cases. Larger shrubs may require brush cutters and chainsaws, used only by properly trained professionals.

In the year following initial cutting and stump treatment, there will be a flush of new seedlings as well as resprouting from some of the cut plants. Herbicide can be applied to the foliage of these plants. Fall is the best time to do this, when desirable native plants are dormant and when the plant is pulling resources from the leaves down into the roots.

Glyphosate and Krenite (active ingredient – fosamine ammonium) are the most commonly used herbicides for foliar application. Krenite prevents bud formation so the plants do not grow in the spring. This herbicide can be effective, but results are highly variable. Glyphosate or a triclopyr herbicide such as Garlon can also be used. Glyphoste is non specific and will kill anything green, while triclopyr targets broadleaf plants and does not harm graminoids. All herbicides should be applied by licensed applicators and should not be applied on windy days. Care should be taken to avoid application to other plants. “Weed Wands” or other devices that allow dabbing of the product can be used rather than spraying, especially for stump treatment.

Undesirable trees and shrubs can also be destroyed without cutting them down. Girdling is a method suitable for small numbers of large trees. Bark is removed in a band around the tree, just to the outside of the wood. If girdled too deeply, the tree will respond by resprouting from the roots. Girdled trees die slowly over the course of one to two years. Girdling should be done in late spring to mid-summer when sap is flowing and the bark easily peels away from the sapwood. Herbicide can also be used in combination with girdling for a more effective treatment.

Basal bark herbicide treatment is another effective control method. A triclopyr herbicide such as 10% Garlon 4, mixed with a penetrating oil, is applied all around the base of the tree or shrub, taking care so that it does not run off. If the herbicide runs off it can kill other plants nearby. More herbicide is needed for effective treatment of plants that are four inches or more in diameter.

Mechanical Control

Three mechanical methods for woody plant removal are hand pulling (only useful on seedlings and only if few in number), weed wrenching (using a weed wrench tool to pull stems of one to two inches diameter), and repeated cutting. Pulling and weed wrenching can be done any time when the soil is moist and not frozen. The disadvantage to both methods is that they are somewhat time-consuming, as the dirt from each stem should be shaken off. Weed wrenching also creates a great deal of soil disturbance and should not be used on steep slopes or anywhere that desirable native forbs are growing. The soil disturbance also creates opportunities for weed germination. This method is probably best used in areas that have very little desirable native plant cover.

Repeated cutting consists of cutting the plants (by hand or with a brush cutter) at critical stages in its growth cycle. Cutting in mid spring (late May) intercepts the flow of nutrients from the roots to the leaves. Cutting in fall (about mid-October) intercepts the flow of nutrients from the leaves to the roots. Depending on the size of the stem, the plants typically die within three years, with two cuttings per year.

Stems, Seedlings and Resprouts

Prescribed burning is the most efficient, cost effective, and least harmful way to control very small stems, seedlings, and resprouts of all woody plants. It also restores an important natural process to fire-dependant natural communities (oak forests, for example). Burning can only be accomplished if adequate fuel (leaf litter) is present and can be done in late fall or early spring, depending site conditions. If burning is not feasible, critical cutting in the spring is also effective, though it can impact desirable herbaceous plants as well. Foliar (leaf) application of a bud-inhibitor herbicide (Krenite) during fall is also effective. This method can also affect non-target species, though most natives will be dormant by that time.

Prickly ash
A native shrub, prickly ash can become excessively abundant, especially in areas that have been disturbed or grazed. Complete eradication may not be necessary, but management may target reducing the extent of a population. Removal is most easily accomplished in the same manner as for buckthorn – cutting shrubs and treating cut stumps with glyphosate herbicide. Cutting can be completed at any time of the year.

Disposal
The easiest and most cost-effective method to handle large amounts of brush is usually to stack it and burn it in winter. In areas where brush is not dense, it can be cut up into smaller pieces and left on the ground where it will decompose in one to three years. This method is especially useful on slopes to reduce erosion potential. Small brush piles can also be left in the woods as wildlife cover. Where there is an abundance of larger trees, cut trees may be hauled and chipped and used for mulch or as a biofuel. Alternatively, the wood can be cut and used for firewood, if a recipient can be found.

FORBS

There are only two invasive non-native forb species at the site. Sweet clover can be found in the oak woodlands in the east and west of the property, but it is relatively rare. As it increases with fire, it is best to hand-pull it before burns are organized. The best timing is in the early spring before it starts to seed out. It is easiest to pull forbs when the soil is damp and the roots come out easily. This procedure needs to be repeated every spring.

Ground ivy is very hard to control in woodlands because of the far-spread roots and the persistent seed banks. When the soil is damp, individuals should be hand-pulled as much as possible with their roots attached. The species can also be treated with Super Trimec (glyphosate 2, 4-D in combination with dicamba and dichlorprop) in the fall after the first hard frost. Spot treatments are recommended to avoid damage to adjacent plants.

GRASSES

The two most common invasive grass species at Old Mill Park are smooth brome and Kentucky bluegrass. Both of them were introduced from Europe, have long growing seasons, and tend to form dense, dominating sods. In unit 3 of the park property, smooth brome grass is very dominant, but it can be found in smaller numbers in most other units as well. Kentucky bluegrass is the main species in unit 1, and is also found throughout the entire park.

Eliminating both grass species is not an easy task. The two most common methods are fire and the use of herbicides. Most smooth brome and Kentucky bluegrass cultivars are rhizomatous and survive fire by sprouting from rhizomes if prescribed burns are timed incorrectly. Early spring (late March-April) or late-season (late summer-fall) fire can increase the productivity in both grasses. Later spring fires (late May), on the other hand, have shown to damage them. It is often necessary to combine herbicide and fire treatments to achieve the best results. In the spring, smooth brome and Kentucky bluegrass individuals can be targeted with glyphosate from backpack sprayers. Broadcast treatments only make sense when the cover of brome is extremely high and no valuable native species can be found. In the late spring of the following year, a prescribed burn should be organized to kill off the remaining individuals. Spot treatments with herbicides have to be repeated in the following years.