

Ecological Management Recommendations

Bruce Vento Nature Sanctuary



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Submitted to:
Lower Phalen Creek Project
804 Margaret Street
Saint Paul, MN 55106

Prepared by
Friends of the Mississippi River
101 East Fifth St, Suite 2000
St Paul MN, 55101

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Executive Summary

Background

This document was assembled by Friends of the Mississippi River (FMR) to guide the restoration and management of the Bruce Vento Nature Sanctuary. The 27-acre property, owned and managed by Saint Paul Parks and Recreation, is located along the Mississippi River just east of downtown Saint Paul. It sits adjacent to Indian Mounds Regional Park and just west of the nearby Pig's Eye and Battle Creek Regional Parks.

According to the 1850's public land survey, at the time of European colonization the site was a mix of vegetation types, including oak openings and barrens, river bottom forest, and Big Woods forest. The property has a long history of human activity, including as a sacred site for the Dakota people. The Wakan Tipi cave, located on the east end of the site, was the focal point of this importance. Meaning "dwelling place of the sacred" the cave was a place to honor the spirits that live within. The proximity to the burial mounds atop the bluff at Indian Mounds park also emphasizes the importance of this region to the Dakota people. Once Dakota people were forced from the area, European settlers developed the site and turned the site into an industrial hub, including sawmills and the North Star Brewery. Later, the site became one of the main railyards serving St. Paul.

The site was reclaimed and a comprehensive Natural Resource Management Plan was developed by Emmons & Olivier Resources in 2001. Intensive restoration began in the early 2000's, with removal of industrial debris, regrading, creating a series of ponds, and planting native trees, shrubs and prairie vegetation. Current vegetation is made up of three cover types: altered deciduous forest, floodplain forest, and degraded grassland. Due to past restoration efforts, the site retains ecological value, and its diversity provides an array of wildlife habitat. The property also provides an important natural areas connection within the Mississippi River corridor. Upland areas provide food and shelter for many wildlife species, including a variety of resident and migratory birds. The site's proximity to other natural areas allows wildlife to use it for critical habitat needs that may otherwise not be available in the surrounding fragmented, urban and industrial landscape.

While the primary restoration work to date has restored the property from its industrial state to one with more natural vegetation, the site still has an overwhelming abundance of non-native invasive plant species. In coordination with Saint Paul Parks and Recreation, Friends of the Mississippi River (FMR) has developed this "supplemental" natural resource management plan to assess existing ecological conditions at the sanctuary and determine steps to improve native plant diversity. The over-arching goal for the property is to restore ecological functions so that the property approximates conditions and functions that native plant communities provide. The plant communities present at the time of European colonization are used as a general guide, but not strictly adhered to as site conditions have been so drastically altered.

Specific ecological and cultural goals for the sanctuary are to:

- Restore a complement of native plant communities,
- Improve wildlife habitat,

- Provide connectivity with other natural areas in the landscape,
- Maintain and manage the property for water quality by:
 - avoiding or controlling any erosion that may develop, and
 - retaining continuous ground cover throughout the site
- Increase overall biological diversity,
- Create a model for responsible stewardship,
- Honor the site as a sacred space to the Dakota people by adding culturally important plant species in both the prairie and forest units.
- Utilize this property to enhance and expand the ecological functions of the property and of the larger Metro Conservation Corridor and Mississippi River Greenway.

Natural Resource Inventory and Assessment

The site is included in a number of important corridors, including the Metro Conservation Corridors - a regional land protection plan, and the City of Saint Paul's Great River Passage Strategic Plan. While no rare plant or animal species have been recorded on the property, there are a number of records from the surrounding area, and the site is within the high potential zone for rusty patched bumblebee habitat. Thus, the site has the potential to provide important wildlife habitat to these and other species, and to provide habitat connectivity to the Mississippi River - a globally significant migratory flyway. Improving the habitat quality at this property may provide habitat for dozens of species that use the flyway.

The site was divided into Land Cover Management Units (Units) based on existing land cover, realistic restoration goals, and proposed restoration tasks. Current conditions were compared to historical conditions to develop target plant communities and prioritize activities to progress toward those targets. The existing land cover is primarily degraded grasslands and altered non-native dominated woodlands. The site also contains pockets of pond and emergent wetland vegetation.

The primary ecological concerns at the property are non-native invasive woody and herbaceous species, depauperate native species diversity in some areas, and erosion. Larger issues such as earthworms and climate change are factors that affect the plant communities and for which there may be no solution other than to mitigate effects as much as possible. Without on-going management, this property will inevitably be overtaken by buckthorn, crown vetch and other invasive plants, and gradually lose structural and species diversity. These species displace native prairie species and decrease habitat for pollinators and wildlife. In the woodlands, the dense shade and competitiveness of buckthorn is likely to eventually displace most native species in the ground layer, shrub layer and canopy, as it has already done in much of Units R and P. As ground cover species decline, erosion will increase, negatively affecting water quality. Migratory birds and other wildlife primarily depend on the cover and food provided by native trees and shrubs and would be less likely to find the resources they need in a buckthorn dominated woods. Similarly, other native wildlife, especially pollinators, will not find adequate nutrition and habitat in a grassland dominated by non-native species.

Final Natural Resource Management Plan Recommendations

This document outlines a proposal to continue ecological management tasks on all units of the property, working toward the goal of well-established, self-sustaining native plant communities.

Ecological restoration of the site is already underway through long-term efforts by Saint Paul Parks and Recreation Staff, Lower Phalen Creek Project, Urban Roots, and other organizations. The target plant communities for the site include Southern Dry and Mesic Prairie, dry oak-hickory woodland, and terrace forest.

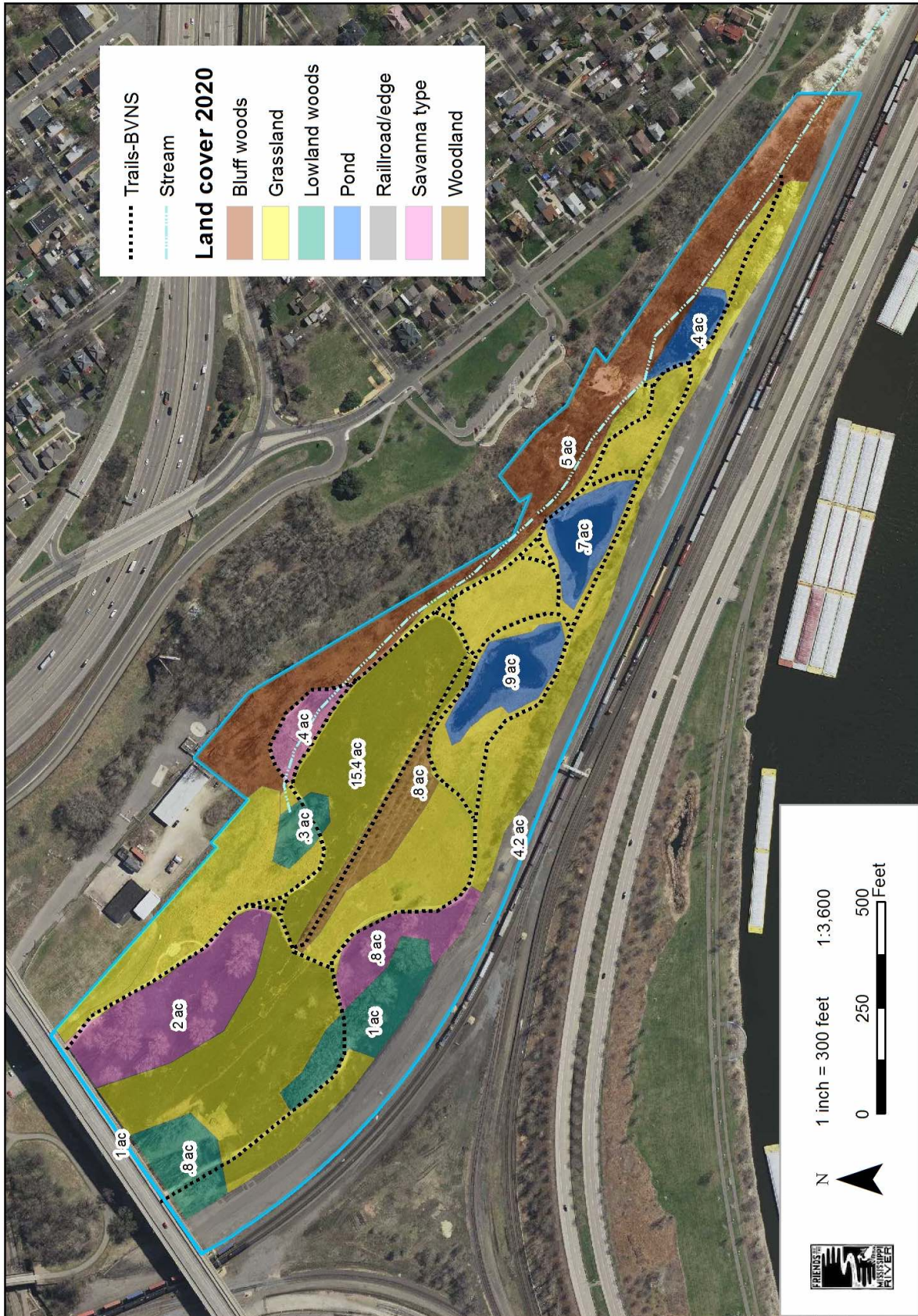
The first restoration priority is to eradicate the non-native woody species throughout the site, especially common buckthorn and Tatarian honeysuckle, which are most prevalent in the wooded areas. After initial removal, it will be important to continue to monitor and control them in the future. Controlling non-native herbaceous plants such as garlic mustard and burdock is a secondary priority in the woodlands. Methods for additional control or suppression of non-native species through native plantings need to be further explored. Conducting annual monitoring and assessment is also a high priority to address emerging issues and to evaluate the success of management efforts.

The second main priority that warrants timely intervention is the rapidly-degrading grassland areas. A number of herbaceous invaders are beginning to crowd out native prairie species, and while native prairie species persist in most units, non-native and invasive grass and forb species are abundant, including smooth brome, crown vetch, birdsfoot trefoil, mugwort, spotted knapweed, and others. Removal of both woody and herbaceous invaders should be a first step, with overall restoration of the degraded grassland to prairie to be taken on as funding allows.

In the above priorities, attention should be paid to incorporating native plant species that honor the cultural significance of the site. Many native prairie and forest plants that will be important for their ecological benefits also have cultural importance for the Dakota and larger native community. Intentionally including these species will honor the site's native history and help the restoration better interface with the Wakan Tipi Center, a place that will provide authentic interpretation of the site and its history through an indigenous lens.

Given the robust organizational support at the site, these activities can be completed by a combination of the landowner, private contractors that specialize in ecological restoration, and other conservation-minded organizations and volunteers. The estimated cost for implementing all recommendations, including project management and ecological surveys over a 5-year period is roughly \$91,000. This does not include costs for tasks the City of St Paul may provide as in-kind, totaling approximately about \$17,000. Actual project bids may also be significantly more or less than these estimates, depending on site conditions and other factors. If initial grant funding does not cover the entire anticipated project costs, then secondary priority tasks can be delayed, and/or tasks in years 4 and 5 could be put on hold and additional grant fund applied for later.

FIGURE 1. Existing Land Cover



Background

This document will not address most of the background information for this site as much of the historical uses, soils, geology and other details were provided in the 2001 plan. However, it is interesting to see how the site has changed over time. The earliest aerial photograph available from 1940 (below) shows the site in heavy industrial use as a railyard. These uses likely date back to the mid-1800's and continued through the 1980's. The railroad uses ceased in the late 80's or early 90's, and by 2003 the site was being reclaimed by trees and shrubs (photo below). That is what the site looked like at the time reclamation and restoration began.



Ecological Assessment

Methods

Ecologists from Friends of the Mississippi River conducted site assessments in summer 2020 to evaluate the existing conditions of the sanctuary and to develop recommendations for improving and managing the plant communities. We began by defining the existing land cover types at the site (**Figure 1**). These cover types are similar to the Minnesota Land Cover Classifications (MLCCS), but are simplified, for the purposes of this document.

Each of the land cover types was evaluated to assess the conditions of the plant communities and the management needs. This process resulted in defining different management strategies for different areas. Using that information and incorporating the trail systems and other natural dividing lines, we defined 27 ecological management units at the site (**Figure 2**). For each unit we compiled a plant species list, including relative coverages of each species (**Appendix A**). The species lists are not comprehensive, but intended to identify the most common species at a unit. The three Pond units, including their associated wetland, were not evaluated other than to note if there were any invasive species present.

Each of the units was then assigned a Quality rank from 1 to 4, high to low (**Table 2**), based primarily on the species composition. Specific criteria were the abundance of invasive, non-native plants and the abundance and diversity of native plant species. The rankings were subjective and entirely relative for this site; they do not relate to state Quality rankings or to other sites. The highest ranking units, therefore, do not necessarily denote what would be considered a high Quality unit by MN DNR standards, but were units that had the least abundance of non-native invasive species, and greatest cover and diversity of native species.

Four units totaling 3.1 acres were ranked Quality-1: grassland unit N and all of the pond units and their associated bank and wetland vegetation. These units were well vegetated with a very good abundance of native plants. Some invasive non-native plants were still present, and there would be opportunities to improved plant species diversity, but management needs were very low.

Five grassland units (5.9 ac) and four woodland units (2.9 ac), 8.8 acres total, were ranked Quality-2, indicating somewhat higher amounts of non-native, invasive plant species than Quality-1 and greater management needs than Quality-1.

Three grassland units (5.0 ac), one savanna unit (1 ac) and three woodland units (4.9 ac), totaling 10.9 acres, were ranked Quality-3. All of these units had high amounts of invasive species and will require fairly intensive management. However, there were still enough native species present to try to build on what was there.

At the bottom of the ranking, Quality-4 units were those with such a high coverage of non-native, invasive plants and so few desirable native plant species that we considered these areas to be candidates for a complete re-restoration. Seven units fell into this category, totaling 5.5 acres

and consisting of 3.3 acres of grassland and 2.2 acres of savanna. Together they represent about 20 percent of the vegetated areas of the sanctuary.

FIGURE 2. Relative Habitat Quality Ranking

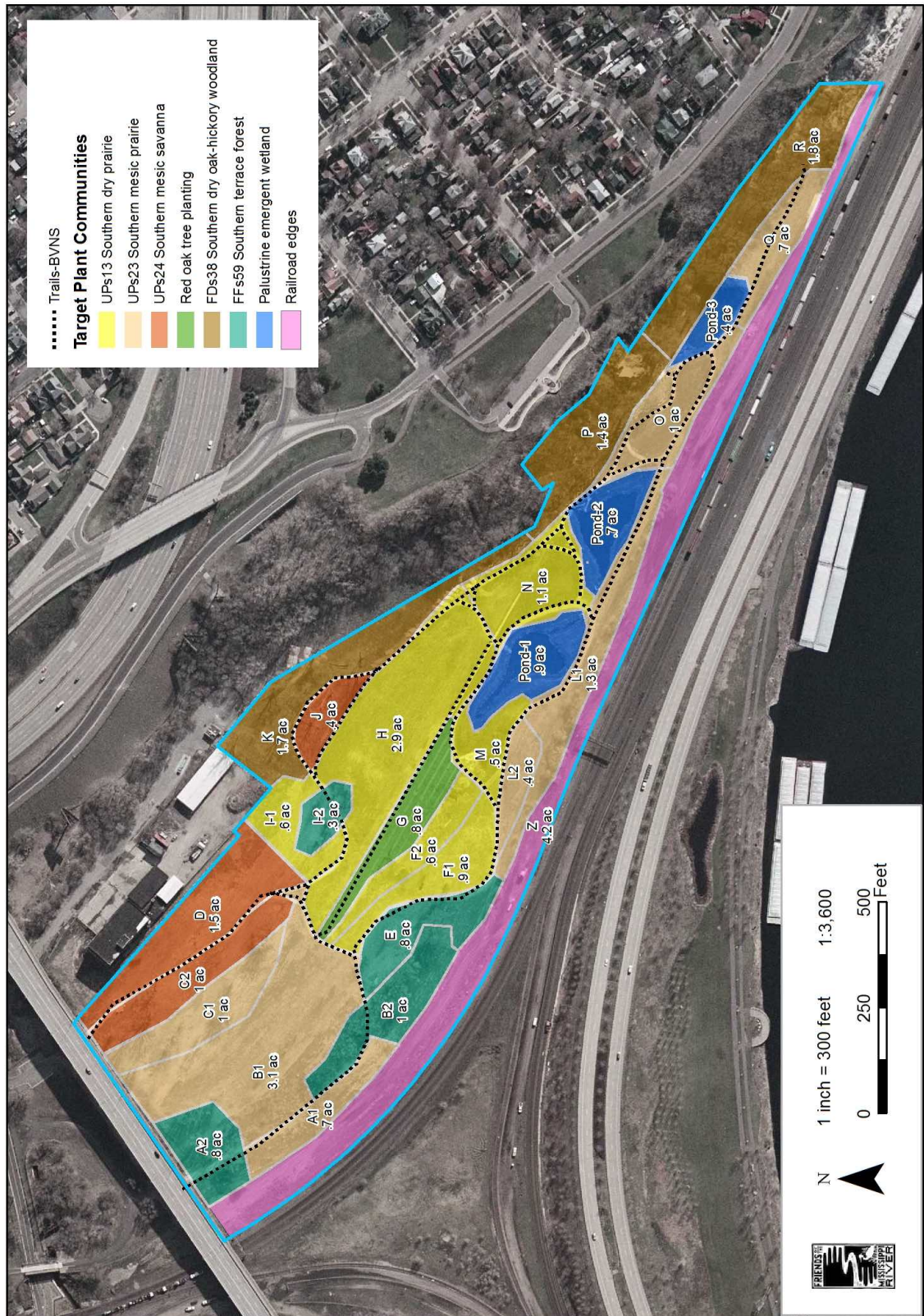


Table 1. Existing Land Cover, Quality and Target Plant Communities

Unit	Acres	Existing vegetation	Condition	
			Rank *	Target Plant Community
GRASSLAND				
A1	0.7	Mesic prairie grasses and forbs	2	UPs23 Southern mesic prairie
B1	3.1	Mesic prairie grasses and forbs	3	UPs23 Southern mesic prairie
C1	1	Non-native dom grasses & forbs, scattered trees	3	UPs24 Southern mesic savanna
C2	1	Non-native dom grasses & forbs, scattered trees	4	UPs24 Southern mesic savanna
D	1.5	Non-native dominated grasses and forbs	4	UPs24 Southern mesic savanna
E	0.8	Non-native dominated grasses and forbs	4	UPs23 Southern mesic prairie
F1	0.9	Non-native dominated grasses and forbs	4	UPs13 Southern dry prairie
F2	0.6	Non-native dominated grasses and forbs	3	UPs13 Southern dry prairie
H	2.9	Dry prairie grasses and forbs	2	UPs13 Southern dry prairie
I1	0.6	Dry prairie grasses and forbs	2	UPs13 Southern dry prairie
J	0.4	Non-native dominated grasses, forbs, scattered trees	4	UPs24 Southern mesic savanna
L1	1.3	Mesic prairie grasses and forbs	3	UPs23 Southern mesic prairie
L2	0.4	Mesic prairie grasses and forbs	4	UPs23 Southern mesic prairie
M	0.5	Non-native dominated grasses and forbs	4	UPs13 Southern dry prairie
N	1.1	Dry prairie grasses and forbs	1	UPs13 Southern dry prairie
O	1	Mesic prairie grasses and forbs	2	UPs23 Southern mesic prairie
Q	0.7	Mesic prairie grasses and forbs	2	UPs23 Southern mesic prairie
18.5				
WOODLAND				
A2	0.8	Lowland/floodplain forest	2	FFs59 Southern terrace forest
B2	1	Lowland/floodplain forest	2	FFs59 Southern terrace forest
G	0.8	Red oak tree planting	2	Red oak tree planting
I2	0.3	Lowland/floodplain forest	2	FFs59 Southern terrace forest
K	1.7	Altered/non-native deciduous woodland	3	FDs38 Southern dry oak-hickory woodland
P	1.4	Altered/non-native deciduous woodland	3	FDs38 Southern dry oak-hickory woodland
R	1.8	Altered/non-native deciduous woodland	3	FDs38 Southern dry oak-hickory woodland
7.8				
POND/WETLAND				
Pond-1	0.9	Palustrine emergent wetland	1	Palustrine emergent wetland
Pond-2	0.7	Palustrine emergent wetland	1	Palustrine emergent wetland
Pond-3	0.4	Palustrine emergent wetland	1	Palustrine emergent wetland
	2			
OTHER				
Z	4.2	Railroad edges		
Total	32.5			

* 1 is highest quality, 4 is lowest

FIGURE 3. Target Plant Communities



Unit A1- Mesic prairie grasses and forbs

Unit A is a 0.7-acre grassland in the far western part of the site. It was dominated by native prairie species, especially big bluestem. Species diversity was low, but included yellow coneflower, sunflower and heath aster. The unit also had a few silver maple trees, about 8 inches diameter. Invasive species were very sparse but included mugwort, a short re-sprouted white mulberry tree, and a few very small buckthorn. The native and non-native woody plants could be removed to keep the well-established prairie species intact.



This unit was ranked quality 2 and the target plant community would be southern mesic prairie.

Big bluestem dominated at Unit A, with good native cover overall.

Unit A2, B2, I2 - Lowland/floodplain forest

These units are not so much distinct management units, but rather small pockets of woodland vegetation surrounded by a larger prairie matrix. While management of the site might be simpler if each of these units were converted to the prevailing vegetation type, these pockets provide important habitat value and create habitat heterogeneity across the site. These units are all dominated by large cottonwoods in the canopy, with a mix of cottonwood, American elm, and silver maple in the subcanopy. The units all have an open character. A2 (0.8 acres) and B2 (1 acre) also contain a smaller shrub layer individuals consisting of American elm, box elder, green ash, and black walnut. Siberian elm and white mulberry are also regenerating in A2 and B2 and should be removed before they reach seed-producing age. Standalone silver maple and hackberry also occupy the interstitial space between A2 and B2. Due to the trail through the middle of the unit, I2 (roughly 0.3 acres) has fewer shrubs and regenerating woody species, but shrubs in A2 and B2 include the occasional elderberry, dogwood, and chokecherry, some of which have been planted and remain in tree tubes, and red raspberry. The understory of these units is a mix of more prairie-like vegetation, including Canada goldenrod and some grasses like big bluestem, and more woodland edge vegetation, with white snakeroot, Canada wild rye, and some seedlings of box elder, cottonwood, and raspberries. Mugwort, giant ragweed, garlic mustard, motherwort and burdock and all species that deserve some management attention.

Because of their size and abundant edge habitat, management will consist of tasks from both the prairie and forest units, and should focus on the remaining removal of both woody and herbaceous invasives through a combination of cut and stump-treat, and spot sprays. All three

subunits were ranked Quality-2, mostly due to the lack of invasive plants present in each, and are targeted for restoration to a terrace forest community type. Supplementing the diversity of the shrub and understory layers through planting and seeding would also provide additional pollinator and wildlife benefits. Lastly, the main trail runs through I2, but is quite wet for most of the year due to the spring that terminates at the unit. Small paths have diverged to the west of the unit to avoid the wet areas, and it is recommended that the official path be shifted to follow these side paths. Then, wetland and wet forest vegetation could be established in I2, providing additional habitat heterogeneity at the site.



Unit A2 is dominated by cottonwoods, with a mix of woodland edge and savanna plants in the understory. Unit I2 is bisected by the main trail. Neither unit has an in-tact shrub layer or high diversity in any vegetative strata.

Unit B1 - Mesic prairie grasses and forbs

Unit B1 was about 3.1 acres of grassland at the northwest part of the park. It had more native forb species than most of the units, with 15 recorded. Most species had very low abundances, however, with the exception of black-eyed Susan's which was quite abundant. Other native forbs included bergamot, purple prairie clover, yellow coneflower, goldenrod and hoary vervain. Indiangrass, big bluestem and side oats were the most common native grasses, but their coverages were patchy. Non-native, invasive species dominated parts of the unit, especially crown vetch, mugwort, smooth brome and Kentucky bluegrass. A few small black locust trees were found.

Also at this unit are some honey bee hives in the northwest area among some trees. It would be good to plant some native trees and shrubs on the north and west sides of these hives for wind break. Several excellent species that would provide pollen for the bees are: prairie crab apple, smooth rose, elderberry, snowberry or wolfberry, hazelnut and Juneberry. Bedrock is close to the surface so bareroot plants should be used and plants should have follow up watering.

This unit was ranked Quality-3 due to the abundance of non-native species. There is still enough native vegetation that a complete redo would not be warranted, but it will need fairly intensive management to shift to a native dominated community.

The target community for this unit would be southern mesic prairie.



Non-native grasses and crown vetch were abundant at Unit B (left). Soapwort was found in occasional patches (right foreground).

Units C1 and C2 – Non-native dominated grasses and forbs with scattered trees

Units C1 and C2 were each about 1 acre, located on the south side of the park entrance trail. The canopy of scattered large cottonwoods and ground layer of grassland plants gave this unit a structure similar to savanna, with the exception of cottonwood trees instead of bur oak, and a lack of savanna shrubs such as hazelnut. Unit C2 was largely dominated by non-native invasive species, especially smooth brome, crown vetch, mugwort, hoary alyssum and common burdock.

Unit C1 had a greater abundance of native forbs, especially Canada goldenrod and bergamot. The goldenrod, though native, can be very invasive and form monotypic stands, excluding other species. It is not overly abundant at the sanctuary overall, but should be monitored to keep it in check.

Native grasses, which were generally patchy and mostly in C1, included Canada wild rye, big bluestem, switchgrass and Indiangrass.

Due to the very degraded condition of Unit C2, and the strong dominance of non-native species, it was ranked Quality-4. We recommend this unit could undergo a re-restored. Details are in the Management Recommendations section. Unit C1 had a greater coverage of native plants and was ranked Quality-3. The target community for both of these units would be southern mesic savanna.

However, the new Wakan-Tipi center is planned for part of the C1 and C2 units, with construction beginning in 2022. Significant restoration of these units should therefore wait until after the center is built. However, some management to prevent weed seed production should still occur, especially mowing.



Unit C1 (left) had patches of goldenrod and bergamot. Medium-sized cottonwood trees form a scattered canopy. Crown vetch and mugwort were especially abundant at Unit C2 (right).

Units D – Non-native dominated grasses and forbs

Unit D was 1.5 acres located along the north side of the park entrance trail. This unit was very similar to C, except it lacked the cottonwood trees and had a greater abundance of non-native species, perhaps 90 percent of the vegetation. There were, however, a few desirable native prairie forbs and grasses in the area around the stone benches. These can be protected if possible during the restoration process.

This unit was ranked Quality-4 and would be recommended for a complete redo. The target community would be southern mesic savanna.



Mugwort was especially abundant at Unit D.

Units E - Non-native dominated grasses and forbs with scattered trees

Located near the south border of the sanctuary, Unit E was a small 0.8-acre unit with a somewhat savanna-type structure. Large scattered cottonwood trees formed the canopy and ground cover was heavily dominated by non-native grasses - smooth brome, quack grass and yellow foxtail.

Crown vetch and Canada goldenrod were the dominant forbs. The southeast end of the unit had a dense cover of small Siberian elm trees, about 4 to 5 ft tall. Unfortunately Siberian elm will continue to be a problem at the sanctuary due to the abundance of mature trees in the adjacent landscape, especially along the railroad.

Unit E had more native forb species than many units, with at least 14 species recorded. The total forb cover, however, was less than 25 percent and most of that was Canada goldenrod. Other species detected in very low abundances were black-eyed Susan, heath aster, hoary vervain, white snakeroot, fleabane, and four o'clock.

Due to the non-native grasses and forb species, and the lack of native plant cover and diversity, this unit is recommended for a complete re-restoration. The target community for this unit would be southern mesic prairie.



Mature cottonwood trees created a savanna type structure at Unit E (left). The ground cover was dominated by smooth brome and goldenrod with patches of crown vetch (right).

Units F1, F2 and M - Non-native dominated grasses and forbs

These units, located west of the first pond, were very degraded. F1 (0.9 acres) and M (0.8 acres) were heavily dominated by non-native invasive species while F2 (0.6 acres) was dominated by weedy native species, especially daisy fleabane. Mugwort and hoary alyssum dominated at F1 as well as smooth brome and Kentucky bluegrass and one apple tree. Though the apple tree provides some habitat diversity, it shades the prairie and could be removed to support the prairie habitat. Native crab apple trees could be planted at the site, especially at B1 by the bee hives, to replace that feature.



Although low diversity, Unit F1 had more native plants and fewer invasives than F2.

At unit M, mugwort and crown vetch dominated, with some soapwort. Non-native grasses had minor abundances there.

Daisy fleabane, a weedy native annual species, was the dominant forb at all the Units. Small amounts of black-eyed Susan, bergamot and purple prairie clover were found, especially in F2, but native forbs were very sparse.

Due to the abundance of very invasive forb species, and the overall lack of native plant cover and diversity, units F1 and G were ranked Quality-4 and recommended for a complete re-restoration. Unit F2, somewhat less degraded, was ranked Quality-3 and could have a less intensive management.

The target community for all three units would be southern dry prairie.

Units F1 and G, as well as the west part of Unit L, have previously undergone a complete redo. In 2018, glyphosate herbicide was several times during the growing season, followed by burning, Milestone herbicide and finally drill-seeding in late fall. Unfortunately, for undetermined reasons, the redo has not been successful. These units may need a longer site preparation or a somewhat different strategy. This will be explored in the Management section.



Units F1 (left) and M (right) were both heavily dominated by crown vetch and mugwort.

Unit G - Oak Planting

Unit G (right) was a 0.8-acre red oak plantation installed among the rows of concrete paths that were part of the former industrial uses at the site. The oaks are now about 30 feet tall, with an understory dominated by white snakeroot. Although not diverse, this unit does not have a lot of undesirable species and does not need a lot of management. It was therefore given a Quality-2 ranking. There were some small invasive woody trees that need to be removed – a few Siberian elm and boxelder. This unit does not have a native plant community target, but the target would simply be to maintain it as is.



Rows of young red oak trees among the concrete paths at Unit G.

Units H - Dry prairie grasses and forbs

Unit H is 2.9 acres to the north of the red oak plantation (unit G). Unit H has drier soils than much of the site and supports dry prairie species. Native prairie species dominated, with an abundance of grasses and a good variety of forbs. More forb species were recorded here than at any other grassland unit, though the most abundant were weedy species, such as Canada goldenrod, late goldenrod, and common ragweed.

Non-native invasive species were still abundant, especially burdock and crown vetch. However, they were primarily in patches, mostly on the southern side of the unit. There were also scattered small trees and shrubs that should be removed to maintain the prairie, including cottonwood,

green ash, and Tatarian honeysuckle. There was also stand of sandbar willow on the west side. While it is a good native shrub, it spreads readily and may need to be cut back periodically.

This unit was one of the three units that ranked Quality-2. The target plant community is southern dry prairie.



Most of Unit H had a very good cover of native grasses (left) with a good variety, though not abundant, native forbs. The southwest side of the unit had large patches of crown vetch (right).

Units I-1 - Dry prairie grasses and forbs

Unit I-1 is a 0.6 acre grassland unit mostly dominated by little bluestem. Native forbs were sparse but included anise hyssop, common milkweed, stiff goldenrod and biennial gaura. Mugwort was abundant at the unit and there were patches of Kentucky bluegrass. There were also a few buckthorn stems and small Siberian elm.

The unit was ranked Quality-2. The target plant community is southern dry prairie.

Units J and K - Altered/non-native deciduous woodland

Unit K is the main upland forest unit running east-west along the north side of the site. The 1.7-acre unit is separated from Unit H, the central prairie unit, by a trail, of which a spur through the woods also separates J from K. The unit abuts Mounds park on its north side. This unit was likely historically forested (a mix of big woods and oak openings and barrens species), but also experienced development and degradation due to human uses. In fact, the units housed portions of historical sawmills and the brewers' homes from the North Star brewery. Today, the unit contains multiple large cottonwoods – relics from the pre-settlement forest – as well as younger trees that have filled in since the site was converted to a natural area.

Currently, unit J (Quality-4) is a 0.4-acre disturbed hillside with a south-facing slope. It's largely shaded by the maturing woody vegetation of Unit K, and as a result has a vegetative character that is more of a mix of woodland and prairie species, though largely non-native. While it lacks any canopy or subcanopy species, there are many woody seedlings and shrub layer species, including small cottonwoods, box elders, and raspberries. Siberian elms and buckthorn are also common. Herbaceous vegetation consist of some Canada goldenrod, wild mint, and mostly disturbance tolerant non-natives like mugwort, burdock, and garlic mustard. Overall this section of the site is trending toward forest cover, and should be managed as shrubland or savanna rather than grassland.

Unit K has a non-uniform vegetative character, with a few large trees - particularly the few towering cottonwoods - separated by larger gaps with varying subcanopy and shrub coverage. American elm is the only other true canopy species in the unit, while hackberry and box elder have many large subcanopy individuals. Box elder is the most abundant tree species, followed by cottonwoods, hackberry, and American elm. The subcanopy is made up of a few box elder, hackberry, cottonwood, green ash, black walnut, and black locust. Both bur oak and red oak were at one point planted in the unit, and are starting to reach the subcanopy level. Siberian elm, white mulberry and black locust are occasional shrub and subcanopy layer species. Shrubs have also been planted in this unit, and are infrequent but large, and include elderberry, chokecherry, nannyberry, high bush cranberry, gray dogwood, and ninebark.



Unit K's non-uniform vegetative structure includes areas of closed canopy forest with both native and invasive species regeneration (left) and open areas devoid of any woody plants (right).

The ground layer vegetation in the unit is patchy – dense where large canopy openings exist, and virtually non-existent where the canopy and subcanopy cast dense shade on the forest floor. Canopy gaps are dominated by a mix of Canada goldenrod and invasive species like garlic mustard and burdock, while gap edges and mid-light areas are dominated by white snakeroot and vines like wild grape and Virginia creeper. Virginia stickseed, wild mint, and stinging nettle are common but patchy, and areas of Canada thistle persist even as the canopy begins to close. Overall, the vegetative quality of this unit is low, with little in the way of native plant diversity. However, the canopy gaps currently provide pollinator resources in the form of goldenrod and

white snakeroot and provide opportunities to supplement diversity as the woody vegetation in the unit continues to mature.

Given the previous effort to establish native vegetation in this unit, the unit is still ranked as a Quality-3 and is a high priority for restoration, both in terms of protecting previous investment, and given the easier access and topography of the unit. Restoration should focus on invasive plant removal and on supplementing both woody and herbaceous native vegetation.



In closed canopy areas, Unit K had a poor assemblage of native forbs and grasses (left). In other areas, buckthorn is common and producing abundant seed (right).

Unit L1 and L2 - Non-native dominated grasses and forbs

The L units occupy a long, narrow strip, 1.7 acres, along the south side of the sanctuary. Unit L1 (1.3 ac) was dominated by grasses, with at least six native species and three non-native. Smooth brome was the dominant non-native grass and big bluestem was the dominant native grass.

Native forbs were sparse, with common ragweed and heath aster the most abundant. Non-native forbs were also not abundant, but mugwort and crown vetch were the most common.

Unit L2 was part of the 2018 redo, along with Units F1 and M. The area had been mowed so species composition was unclear, but smooth brome was prominent.

The unit also had quite a bit of small Siberian elm saplings.

Unit L1 was ranked Quality-3, due to the overall lack of native species diversity while Unit L2 was ranked Quality-4. The target plant community for both units is southern mesic prairie. Invasive woody plants will continue to be an issue at this unit with nearby mature Siberian elm trees.

Unit N - Dry prairie grasses and forbs

Unit N is one of the smallest units, at 1.1 acres, but was determined to be the highest Quality of the grassland units. There were 13 native forb species, including an abundance of purple prairie clover, as well as purple coneflower, rattlesnake master, and hoary vervain. There were at least six species of native graminoids, with little bluestem the dominant species at the unit. This was the only unit where hairy grama was found.

Crown vetch, bird's foot trefoil, smooth brome and Kentucky bluegrass were the primary non-native species, but all had low abundances.

The lack of non-native species at this unit, as well as Unit H, is likely due primarily to the dry, sandy soils found there. While native shortgrass prairie species are well-adapted to the low-nutrient, dry soil types, most of the non-native species are not.

This unit ranked as Quality-1, and the target plant community is southern dry prairie.



Unit N had a good assemblage and abundance of native forbs and grasses, with few patches of invasive non-native plants. Yellow coneflower, purple coneflower, hoary vervain, bergamot, black-eyed Susan, and purple coneflower can all be seen in the left photo.

Units O and Q - Mesic prairie grasses and forbs

Unit O is a 1-acre unit located between the middle pond and easternmost pond and Unit Q was past the last pond. Both units were dominated by native species, especially switchgrass, early sunflower and Canada goldenrod. Other native forbs included black-eyed Susan, blue lobelia, heath aster and blue vervain. Sandbar willow was abundant and needs to be controlled.

Non-native species were not abundant but there was some mugwort, crown vetch, Canada thistle and absinthe wormwood, as well as smooth brome. There was also a small amount of purple loosestrife at Unit Q and quite a few small Siberian elm trees at both units.

These units were ranked Quality-2 and the target plant community is southern mesic prairie.

Unit P - Altered/non-native deciduous woodland

Unit P is a 1.4-acre disturbed forest unit that encompasses both the lower and upper portions of the middle bluff. Here, the vegetative community is heavily disturbed, though the canopy is still dominated by similar species – with box elder, hackberry, and cottonwoods the dominant species and American elm, green ash and black walnut subdominant. Black locust becomes more abundant on the north edge of this unit as well. The trees are, on average, similar in size to those in Unit K, but include more varied smaller size classes and a much denser shrub layer. Numerous smaller elms, hackberries, ash, and white mulberries make up the youngest regenerative classes.

The shrub layer contains abundant common buckthorn and fewer native species, though the areas along the stream have planted with shrubs including chokecherry, elderberry, pagoda dogwood, and high bush cranberry. Vines are common and include wild grape and Virginia creeper. The understory has low diversity, but is made up of a mix of native edge species such as white snakeroot and stickseed, as well as more sun-loving species like Canada goldenrod and invaders like burdock and garlic mustard. Due to the dense shrub layer, fewer tree and shrub seedlings are present.

This unit is more steeply sloped than Unit K, as the bluff begins to rise just on the other side of the creek. The unit is ranked Quality-3 due to lack of native diversity and abundance invasive species, and the target community is dry oak-hickory woodland. The main trail along the unit provides easy access for the management of the lower portions of the unit, while the upper portion can be accessed by a small trail that ascends a stone staircase. Buckthorn is abundant along the path as well as in the upslope section of the unit; however, maintaining the viewshed to the creek makes managing this unit a priority area when beginning restoration.



Portions of Unit P along the stream had a good assemblage of native woody species, with fewer patches of non-native, invasive plants (left). Other sections of the unit, especially at the top of the bluff, were dominated by buckthorn (right).

Unit R - Altered/non-native deciduous woodland

Unit R is a 1.8 acre unit on the far east end of the site. This unit is composed primarily of disturbed forest sandwiched between the bluff and the BNSF railyard. While this unit has less documented evidence of historical disturbance, its current state ranks among the most disturbed units on the site. This is the most altered forest of the three units along the north border of the site, with abundant invasive species including Siberian elm, black locust, buckthorn, honeysuckle and garlic mustard. The native species composition and distribution is slightly different than the other two units, with an overall younger character evident of more recent succession from more open habitat. There are also fewer canopy gaps, meaning the understory is virtually non-existent. The canopy is dominated by large cottonwoods and a few large box elder. The subcanopy and shrub layers are mostly made up of box elder, American elm, hackberry, black walnut and Siberian elm. Buckthorn is abundant in the shrub layer. Vines like wild grape and woodbine also indicate the forest's young, disturbed nature.

The unit also houses a number of rubble piles and homeless encampments, leading to quite a large amount of trash and rubble cleanup necessary to recover the natural character of the unit. The two larger encampments on the far east end also prevented a thorough survey of the entirety of the unit. Due to the disturbed ground and the steep slopes of the bluff, native vegetation is largely absent from the ground layer. White snakeroot and Canada goldenrod are present along edges, and invasive plants like burdock and garlic mustard are present as well.

This unit will require quite an overhaul to remove abundant invasive vegetation and re-establish native cover in all vegetative strata, and is currently ranked Quality-3, but borders on a 4. The target community (dry oak-hickory woodland) will be harder to attain due to a lack of previously planted oaks and other native vegetation. Because the unit is quite difficult to access and abuts disturbed properties outside of the site, this unit is the lowest priority for woodland restoration.



Unit P had areas dominated by buckthorn, and had very little ground-layer vegetation throughout (left). There were also numerous encampments and refuse piles in the flat sections of the unit (right).

Stream

Also of note at the sanctuary is the seepage stream that flows east and west at the base of the bluff. A few wetland species noted along the rivulet included purple leaf willow herb, broadleaf arrowhead, dark green bulrush, softstem bulrush, hybrid cattail and peach leaf willow sapling.

Some of the species identified in the community survey as culturally important could be planted along the streambank or the pond banks, especially sweetgrass, boneset, blue flag iris, and ironweed.

Restoration Process

Restoration is a process. It takes time to restore ecosystems to their former functionality and diversity. Sometimes this can only be approximated. It took many decades to degrade the ecosystem and biological communities on site, so it will not be restored overnight. Many steps are typically involved in a successful restoration; even deciding when a restoration is complete/successful can be very difficult. Restoration should be viewed as a process not a state of being. The ultimate goal is to achieve and maintain a diverse natural community at the site, though this will not always proceed in a linear fashion. Using the concept of *adaptive management* will be key to continual progress at the site. Adaptive management is a strategy commonly used by land managers, and integrates thought and action into the restoration process. It can be described as a strategy that uses evaluation, reflection, communication, and also incorporates learning into planning and management. It is set up like a feedback loop and looks like this: Assess Problem → Design → Implement → Monitor → Evaluate → Adjust → Assess Problem → and so forth. Thus, moving forward with restoration, each round of adaptive management refines and hones the process to better fit the conditions of the site. This strategy should be emphasized at the sanctuary.

Given the many small units and the overall layout of the property, restoration of the site will be difficult. Access to some of the units is challenging, and the varied topography will necessitate skill and patience. Restoring and maintaining any site takes dedicated time and effort. However, the location of these units away from direct sources of propagules means that restoration may be less hampered by the cycle of continual reinvasion that plagues many sites. Engaging neighbors (both the Railroad to the south and other city properties to the north, east, and west) in the importance of restoration on their lands will not only help the restoration on the property be more successful - as it will reduce the potential seed source of non-native invasive plants - but will also increase the size of natural communities being protected and managed in the area.

The restoration of the biological communities at the Bruce Vento Nature Sanctuary will be broken into phases. Each phase will address the restoration of a given target plant community. Restoration tasks will also be prioritized, with the most important resources or vital areas taking precedence. However, restoration will ultimately be conducted based on available funds and resources and may not occur sequentially or as prioritized.

On this site removal of woody invasive plants throughout the property is the highest priority, with a focus on restoration of the forest units. Without this crucial step, the forests will continue to lose diversity and the future prairie restorations will be consistently plagued by re-invasion. Prioritizing invasive removal will lead to better results in subsequent restoration tasks. The second priority is restoring and improving prairie habitat in the current grassland areas of the property. Prairie is a rare and vulnerable plant community, and increasing its presence on the landscape is an important goal which will provide sorely needed pollinator habitat. All priorities will help to accomplish the main goal of increasing wildlife and pollinator habitat throughout the property.

Restoration Goals

This site has both areas that are used for recreation and those that serve as primarily natural areas. Thus, the main goal of this restoration will be to create diverse, healthy habitats that support wildlife and overall ecosystem health. The second goal will be to improve the units for human visitors, including by providing aesthetic beauty and the ability to passively recreate in the units, as well as incorporating species and practices that recognize and honor the site's history and sacred nature for the Dakota people. Healthy ecosystems will support a variety of wildlife, and will provide a number of ecosystem services, including water retention and filtration. Toward achieving this goal, restoration will aim to improve the diversity, composition and structure of the plant communities throughout the property, which will also better reflect what would have been present pre-European settlement and seek to enhance and highlight species with cultural significance. This includes the improvement of habitat (prairie and forest) that has been historically decimated throughout the state, but does not mean that the restoration will go out of its way to convert current natural communities to what may have been present in the past. However, adding new habitat and restoring degraded areas will improve the ecological functions that both historic native plant communities and current healthy communities provide, including:

- habitat for a diversity of wildlife species,
- nutrient and water cycling,
- carbon storage,
- moderation of water-table levels,
- erosion control,
- filtration of nutrients, sediments and pollutants,
- development and enrichment of soils,
- local temperature moderation,
- food and healing resources for both people and wildlife

Though degraded by past uses, the existing plant cover retains a good variety of native species and could be readily improved. A healthy and diverse plant community can provide much greater wildlife value than a degraded one, and tends to be much more stable and less susceptible to disease, invasive species, and other disturbances. Moreover, a diverse, healthy plant community will contain more species that are culturally important and provide resources that support and nurture human life.

Management recommendations were developed for each land cover area, with the overall objectives for the property focused on protecting and restoring high Quality habitat by removing invasive plant species, restoring prairie, and providing pollinator and wildlife habitat. Specific goals include the following, and should be attained by the fifth year of the restoration process:

1) Reduce invasive woody stems over ½ inch diameter to <10% in treated units by the end of the second year.

- 2) Restore grassland units to prairie and obtain 90% coverage of native, non-woody species by the fifth year.
- 3) Improve pollinator habitat in the prairie restorations by including an abundance of milkweed species, with pollinator plants having at least 30% coverage in the prairie.
- 4) Honor the site as a sacred space to the Dakota people by adding or augmenting at least 20 culturally important plant species in both the prairie and forest units.
- 5) Increase native plant diversity in the forest areas: successfully establish native grass and sedge species and increase overall floral abundance while simultaneously including tree species adapted for a changing climate.

Overall management practices to achieve those goals are:

- remove non-native, invasive, woody species;
- control non-native, invasive herbaceous species;
- remove or thin out native woody species encroaching on restoration areas;
- restore ground layer and shrub layer diversity in prairie and woodland areas;
- conduct periodic prescribed burning to maintain prairie and woodland vegetation and reduce invasive shrubs and overabundant tree seedlings;
- monitor annually for potential erosion, as well as for non-native invasive woody and herbaceous species;
- add culturally important species from the Lower Phalen Creek Project's 2020 NRMP Native Plantings Survey
- add climate adapted tree species to improve the overall resiliency of the forested unit;
- institute a monitoring plan to track effectiveness of management and restoration activities;
- explore other opportunities to create wildlife habitat, including but not limited to snake hibernaculums, osprey towers, turtle nesting habitat etc.

Management Recommendations

Grassland Units

All of the grassland units within the same Quality ranking will have essentially the same management tasks, as described below. For all units, the initial task would be removal of non-native and undesired woody plant species. Control methods for targeted herbaceous plants (crown vetch, mugwort, bird's-foot trefoil, Canada thistle) are described in greater detail in **Appendix C**. In all cases, a top priority will be to prevent seed production of the targeted plants. Spot-mowing, therefore, is an inherent step to be included as needed when other control methods are not effective or not feasible.

If contractors are hired to conduct herbicide application, recommended specifications are provided in **Appendix D**, along with state guidelines for minimizing impacts to pollinators.

Quality-1 Rank Grasslands

Unit N, 1.1 ac, is currently the only unit with Quality-1 ranking. Management of this unit would consist of spot-treating invasive weeds with the suitable herbicides at the appropriate time (**Appendix C**). At Unit N, this will consist of spot-spraying trefoil and crown vetch in late spring, before seed formation, and again in late summer. Smooth brome and Kentucky bluegrass are at low enough abundances that treating them will not likely be needed. However, if these grasses increase in the future they can be sprayed with glyphosate in late fall, when native plants are dormant (**Appendix C**).

In addition to weed control, Unit N could be enhanced with additional forb species (**Appendix B**). Plugs can be inter-planted in

Quality-2 Rank Grasslands

The five units in this category are A1, H, I1, O, Q, totaling 5.9 acres. The management for these units would be the same as for Quality-1 units: spot spray (mugwort, crown vetch, trefoil, burdock) in spring and fall, spot-mowing as needed to prevent seed formation or to reduce thatch. These steps will likely need to be repeated each year until the weed seedbank is depleted. Note that fall herbicide application is typically the most effective long-term for most weed species. However, herbicide treatment in spring, or repeated mowing, is needed to prevent seed production.

An alternative to chemical application for burdock is mechanical control. Because it is a biennial, the flowering stalks can be cut, bagged and removed from the site before they begin to form seed (e.g. late July or August). This can also be a good activity for volunteers.

A potential additional step for Quality-2 units is that native seed may be needed after the invasive plants are controlled, where weed patches were fairly large. Seed can be broadcast in fall, at least a month after the final herbicide treatment, or on the snow in winter. A seed mix of primarily native grasses can be used for these patches (**Appendix B**). Follow-up management will then be needed the next few years.

In the first growing season after seeding, seeded areas will need to be mowed 2 or 3 times during the summer to prevent weed species from maturing. Mowing will also help the slow-growing native grasses to establish. The patches may need to be mowed again the second year after seeding. By that fall, any weed species that have persisted can be sprayed in the same manner as the initial treatment. Herbicides should not be used in the first growing season as the native plants are too tender.

In addition to seeding, some of the larger patches in these units could be planted with native plugs and especially forbs, to increase the forb diversity and pollinator habitat. Plantings would be an excellent volunteer opportunity. Plants should be installed either in early summer (no later than mid-June) or after mid-August, when temperatures are lower and less stressful for transplants. Since plants may not be watered after planting, they should be watered very well at the time of planting, then mulched. A grass mulch would be ideal. If woodchip is used, it should not be too thick, no more than two inches, as prairie plants seem to be suppressed by heavy mulch.

Quality-3 Rank Grasslands

The three Quality-3 units are B1, C1, F2, and L1, totaling 5 acres. Here the invasive weeds form large patches and may necessitate a broadcast application, rather than spot-treating. At the same time, there are many desirable native plants to protect as much as possible.

Taking advantage of the cool-season time periods will be key to controlling invasives and retaining natives, and combining mechanical and chemical control methods. Starting in spring, burn the unit in very late spring (late May). If burning is not feasible the unit can be mowed. The second step is to mow the unit before invasive weeds begin to form seed. This may be about a month after the burn (or mow). Patches of native plants can be left unmowed where possible. Monitoring should continue and if needed mow again to a height of about 6 inches to prevent weed seed formation.

By mid to late fall, most of the native species will be dormant and the primary species that will be growing will be the non-native invasive species. The exact timing for fall treatment is a balancing act between hitting target plants at an optimal time and avoiding late season desirable plants. It is best to treat the invasive species as early in the fall as possible, as cold weather may cause them to become less receptive to herbicides. Late September or early October may be feasible.

Milestone can be applied to target the legumes and some of the other forbs (e.g. crown vetch, trefoil, butter and eggs, thistles, knapweed) and a broad spectrum herbicide such as glyphosate can be used to target the grasses and some of the other forbs such as mugwort.

The units should then be heavily overseeded with a native seed mix, especially focused on Canada wild rye and other grasses (**Appendix B**). The wild rye is a cool season grass that establishes fairly quickly to provide dense cover and help deter weed species. It persists in abundance only a few years.

In the second year, careful monitoring will be needed to assess results. The seeded areas should not be sprayed in year two, because the native seedlings will be sensitive to the chemical, but mowing should be done two or three times to suppress the weeds and support the natives. In the third year, it may be necessary to repeat the mowing and spraying on all or part of the unit, or the unit may have “advanced” to a Quality-2 and need mostly spot management.

Quality-4 Rank Grasslands

The four units of Quality-4 are D, F1, L2 and M, totaling 3.3 acres. F1 and L2 were redone in 2018, but the restoration did not appear to be successful. All the units would essentially be starting over, with a burn in spring (or mow if burn is not feasible) followed by a full season of herbicide treatment. This would likely entail three to four treatments, with progressively less vegetation to treat each time. Given the failed result of the 2018 work, it may be optimal to allow a second season of treatment before seeding, or at least a second spring, followed by seeding. A similar seed mix as for Quality-3 can be used (**Appendix B**). These species are somewhat tolerant of Milestone and will be able to withstand future applications to control the vetch.

After seeding, standard restoration practices can proceed, with mowing two or three times the first growing season to keep vegetation at about a 6-inch height and never allow weed species to produce seed or get taller than about 12-15 inches. There would be a second mow in spring of the second season. Then spot-spray any invasive species as they occur in that season.

A burn would be done in spring of the third season, followed by spot-spraying targeted weeds as needed. However, burning can stimulate certain species like crown vetch and bird’s foot trefoil, so it may be better to mow the units instead of burning.

Screening and Pollution Filtering

The Met Council septic management facility lies directly north of the main entrance to the Bruce Vento Nature Sanctuary. The odor and industrial appearance of the facility are not complementary to the function of the sanctuary so it would be beneficial to install some natural screening. Conifers are among the best trees for capturing air pollution and their year-round foliage provides excellent screening. Red cedar would be the most suitable conifer for this site, as it naturally occurs in savanna habitats. To provide a more natural appearance, other savanna trees and shrubs could be interspersed with the cedars, especially red oak, American plum and hazelnut. Planting grapevine or Virginia creeper along the fence would also provide some screening in the short term, until the trees fill in, though the vines would only cover the fence height.

Long-term Maintenance

For all grassland units, long-term management will be needed to maintain the plant communities. Regular monitoring and spot-treating or spot-mowing will be needed. A rotating burn schedule should be set up to burn no more than one third of the entire grassland in any year, and avoid burning adjacent units in consecutive years. Each unit can be burned approximately every three years, though frequency may vary depending on site conditions and objectives.

The timing of burns should be alternated for each unit between spring and fall as much as possible, to avoid always benefitting or harming the same species. Fall burns tend to favor forbs, spring burns tend to favor grasses.

Additionally, summer burns could be done occasionally, if possible. Summer burns are especially effective at reducing woody plants, much more so than at any other season.

Mowing can be used as an alternative to burning and is especially useful for reducing Canada goldenrod. For that purpose, the mowing should be done early to mid-August, when the goldenrod is about to flower. This should be repeated two consecutive years where the goldenrod is a problem.

Another alternative to burns and mowing would be grazing. Grazing animals were very important components of native prairies and are now virtually absent. To the extent possible, periodically bringing sheep or other grazing animals to site could be very beneficial. Sheep are grass grazers whereas goats, for example, eat more forbs so the animal selected would depend on the objective for the unit.

Monitoring and Community Engagement

Lastly, the entire site needs regular monitoring, at least monthly during the growing season, to stay on top of the weed issue and to adjust strategies based on observed results, i.e. the adaptive management process. The frequency of monitoring may decrease over time as the control is gained and as more knowledge is gained on the timing needs. It may be beneficial to set up vegetation survey plots (e.g. releve) or to use other quantitative vegetation survey methods to better track the progress of the site and the plant diversity.

In addition to monitoring plant communities, it would be very beneficial to monitor some of the animals. In particular, birds and pollinators are two groups of animals that are relatively easily seen and for which there are good monitoring protocols established. Both types of surveys could also be done by volunteers, with some training.

Engaging the community in many aspects of the sanctuary stewardship has been and will continue to be a top priority. There are many opportunities, including installing and monitoring plantings, removal of invasive woody and herbaceous plants, photography, and surveying plants and animals. Some examples of community science opportunities that FMR has used with volunteers are: the Xerces Society protocols for monitoring pollinators (*Upper Midwest Citizen Science Monitoring Guide-Native Bees*) and the monarch larva monitoring project with Monarch Joint Venture (<https://monarchjointventure.org/mlmp>).

Keeping detailed records of management activities and results will also be extremely important to inform future steps. A very generalized history of the site management is provided in **Appendix F**. There are many different organizations that engage community members to get involved at the sanctuary. Keep track of who is doing what, where and when can be challenging. It may be useful to develop a simple shared calendar and/or other document that all organizations can use to better communicate among each other. Something as simple as a Google spreadsheet could be used as a Project Log to record on-going activities, including details, for example, of

what plant species were installed, how many, and where; what weed species were treated with what herbicide, when and where.

Woodland Units

All of the woodland units within the same Quality ranking will have essentially the same management tasks, as described below. For all units, the initial task would be removal of non-native and undesired woody plant species. Control methods for targeted herbaceous plants (garlic mustard, burdock, etc) are described in greater detail in **Appendix C**. In all cases, a top priority will be to prevent seed production of the targeted plants. Spot-mowing or spot whipping, therefore, is an inherent step to be included as needed when other control methods are not effective or not feasible.

If contractors are hired to conduct herbicide application, recommended specifications are provided in **Appendix D**, along with state guidelines for minimizing impacts to pollinators.

Quality-2 Rank Woodlands

Units A2/B2/I2 are all ranked Quality-2 due in large part to the overall lack of invasive plants in the units. Management of these unit would consist of spot-treating invasive weeds with the suitable herbicides at the appropriate time (**Appendix C**) and ensuring that invasive woody stems are cut and treated before their reach reproductive age. Additional native shrubs and trees should be planted to add diversity and structure once invasive plants are well controlled. Finally, native wildflowers, grasses, and sedges can be added by both seeding and planting.

Quality-3 Rank Woodlands

Units J/K, P, and R will be far more difficult to restore than the Quality 2-units. Work will occur on all three work units and include a variety of management options. The simplest and most effective is to cut stems ½” or more in diameter and treat the stumps. Do not allow any shrubs to reach fruiting size. If resources are limited, focus first on reproductive buckthorn (and other invasive woody species) throughout the units. Due to topography, forestry mowing could only be used in Unit K and long the edges of Units P and R. Cut brush can be chipped brought to District Energy, as per standard City process. The use of goats is also a possibility to deal with re-sprouts and seed bank issues, and SPPR has experience with goats on other properties. Goats could be used to defoliate seedlings and sapling buckthorn in all three Quality-3 units, though they would need to be deployed multiple times per year over at least two years. Evaluate the site every 1-2 years and repeat eradication efforts as needed (approximately every 3-5 years).

Follow-up management will include treating re-sprouting shrubs and seedlings in the fall for at least two years. Once species are controlled, long-term maintenance will consist of small amounts of cutting or treating every 1 to 3 years, and the use of prescribed burning to control seedlings and stimulate woodland vegetation. Finally, restoring native vegetation should be approached with a combination of native seeding and planting. Seeding should focus on gaps and other high-light areas, while planting could be done throughout the units (where accessible).

Management Priorities

PRIORITY 1: Invasive woody removal

Woody Plant Removal

Given the size of the property, clearing all of the non-native, invasive brush is somewhat daunting but doable. However, the layout, orientation, and topography of the units will present challenges. If funding is an issue, removal should be prioritized based on the ecological quality and topography of the units. Removal should first focus on the areas with highest native diversity and those that are easily treated. In W2 understory diversity remains high and removal will be important to prevent further species loss. W3 is less diverse, but removal will be relatively simple, and post-removal seeding and planting can help ensure that the area stays free of woody invasives. Removal in the W1 and grassland units should follow the forest units. If removal will take place over a number of years, crews could initially remove especially prolific seed-producing individuals from these units.

During the removal process, the site can be assessed for further woody removal, including native shrub and tree species. Primary non-native species to remove are common buckthorn, Tartarian honeysuckle, black locust, Siberian elm, and white mulberry. Some flatter areas of the site may lend themselves to brush mowing, though hand work will be the primary mode of removal. Hand cutting can be done at various times of the year, though the fall is recommended, as native plants will have senesced and buckthorn and other invaders that hold their leaves longer will be easier to identify. Cut stumps should be treated with a triclopyr- or glyphosate-based herbicide, though aquatic formulas should be used within 100 feet of the stream and ponds. Glyphosate can be applied to stumps on a calm day during the growing season when temperatures are above freezing but not above 85 degrees. Triclopyr can be applied even when temperatures are below freezing, and is the best choice for fall and winter application, though application earlier than late fall is not recommended due to potential non-target effects on native vegetation. Less toxic formulations, including Vastlan and Trycera, should be considered. Use of chemicals should be done with extreme care on this site given the proximity to water and potential for groundwater contamination. Glyphosate binds to soil particles and is generally not mobile, so may be a better choice than other herbicides that are more mobile, especially near the water. However, triclopyr-based herbicides like Garlon are generally more effective at preventing resprouting. Due to the sensitivity of the site, Garlon 3A is preferred over Garlon 4. See **Appendix C** for more information on controlling both native and non-native species.

Brush disposal includes several different options that will be determined as the project progresses, and will depend on the volume as well as site access. Cut brush may be stacked and burned, chipped and blown back on the site, or removed for biofuels, whichever is more cost effective. The paths around the grassland and woodland provide easy access for large equipment and vehicles to reach the units. In some areas, chipping the material on site could provide mulch that would suppress buckthorn regeneration from the seedbank and protect against erosion. Access along trails and unit edges provides many possible areas to utilize a chipper.

Once the first phase of removal is complete, yearly follow-up treatments will be necessary. If done correctly, stump-sprouting should only occur in small numbers (if at all), though these sprouts will need to be treated by cut and stump-treat herbicide application or foliar spray. The seedbank will be more problematic, as buckthorn seeds can remain viable for at least five years. Treating germinating seedlings will be a difficult and repetitive process, but can be accomplished through foliar herbicide application. Prescribed fire is a seedling management option in drier areas, but will be difficult in many of the forest areas. Prescribed burns should occur in the spring if possible, when buckthorn is actively growing and its carbohydrate stores are low. Light surface fires should burn these woodlands on a rotation of about once every 10-20 years once initial management is complete. In the more open areas of the forests, seeding will be necessary after buckthorn removal. Cover of native plants will help to fill unoccupied niches and compete with and suppress germinating buckthorn seedlings. Forb, shrub and tree planting events could also help restore shrub and sapling-layer diversity. Tree planting should focus on important habitat trees like cottonwoods as well as climate adapted species like sycamore, hickory, Kentucky coffee tree, and others. See **Appendix B** for a list of native plant species for restoration of the forest units.

PRIORITY 2: Prairie restoration

Prairie restoration could result in some of the biggest habitat and water quality benefits for the site. Because of the rarity of this habitat in the state, and its provision of important pollinator and wildlife habitat, restoration of the grassland units is an important priority.

First, while most of the non-native woody brush has been removed from the grasslands, all remaining plants should be targeted before additional management activities. The primary species present - Siberian elm, buckthorn, black locust and Tatarian honeysuckle - should be removed from the grassland units. In addition, scattered small native trees such as cottonwood, green ash, boxelder and black walnut should also be removed. In most cases, the woody plants are small and can be cut and stump-treated. Detailed woody species removal information is provided in **Appendix C**, though it bears repeating that any use of chemicals should be done with extreme care on this site.

Management Task Schedule and Costs

GRASSLAND AND SAVANNA UNITS

Yr	Season	Ecological Task	Prio rity	Ac	Detail	Cost/ac	Cost est	FMR Contractor	City In-Kind	Vol Option
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Grassland & Savanna- all units. A1, B1, C1, C2, D, E, F1, F2, H, I1, J, L1, L2, M, N, O, Q.

1	Jan-Mar or Fall	Woody removal - all grassland/ savanna units	1	17.5	Cut, treat, chip and haul away or stack and burn. Includes All non- native species, small boxelder (8" dbh or less), green ash. Also apple tree at F1 if desired, thin willow in O, and remove silver maple in A1.	\$ 300.00	\$ 5,250.00		\$ 5,250.00	x
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Unit N. (Quality 1 unit). 1.1 acres

1	May-July	Invasive weed control	1	1.1	Spot-mow invasive weeds (e.g. mugwort, crown vetch, trefoil, burdock) before seeds form. 2x	\$ 300.00	\$ 330.00		\$ 330.00	
1	Aug-Oct	Invasive weed control	1	1.1	Spot-spray invasive weeds (esp crown vetch, BF trefoil, mugwort) before seeds form. 2 visits. Milestone	\$ 300.00	\$ 330.00	\$ 330.00		
1	Oct	Rx burn	1	1.1	Fall burn to promote forbs	\$ 600.00	\$ 660.00		\$ 660.00	
1	Oct	Seeding	1	1.1	Broadcast seed of milestone-tolerant species in sprayed patches. Don't seed if planning to install plants.	\$ 175.00	\$ 192.50	\$ 192.50		
2	May-June	Planting	2	1.1	Optional: If weeds are 90% controlled, plant plugs of milestone- tolerant species in sprayed patches. Use little bluestem mulch, not wood chip. Schedule watering.		\$ 1,350.00	\$ 1,350.00		x
2	Late May- early June & late Aug- Sep	Invasive weed control	1	1.1	Spot-spray invasive weeds (esp crown vetch, BF trefoil, mugwort) before seeds form. 2 visits. Milestone	\$ 200.00	\$ 220.00	\$ 220.00		
3	Late May- early June & late Aug- Sep	Invasive weed control	1	1.1	Spot-spray invasive weeds (esp crown vetch, BF trefoil, mugwort) before seeds form. 2 visits. Milestone	\$ 200.00	\$ 220.00	\$ 220.00		

Units A1, H, I1, O, Q. (Quality 2 units). 5.9 acres

1	May-July	Invasive weed control	1	5.9	Spot-mow invasive weeds (e.g. mugwort, crown vetch, trefoil, burdock) before seeds form. 2x	\$ 375.00	\$ 2,212.50		\$ 2,212.50	
1	July	Optional burdock control	1	5.9	Lop flowering stalks before seed production. Bag and remove.		\$ 500.00	\$ 500.00		x
1	August	Goldenrod control	2	1.0	Mow dense stands of goldenrod in Units H and N, when flowering starts. About 1 ac.	\$ 300.00	\$ 300.00	\$ 300.00		
1	Aug-Oct	Invasive weed control	1	5.9	Spot-spray invasive weeds before seeds form. 2 visits. Milestone	\$ 400.00	\$ 2,360.00	\$ 2,360.00		
1	August	Purchase Seed for Q-1 & Q-2 units	1	2.0	Seed mix of milestone-tolerant grasses and forbs (see seed mix). Patch area approx 2 ac (max).	\$ 700.00	\$ 1,400.00	\$ 1,400.00		

GRASSLAND AND SAVANNA UNITS - continued

Yr	Season	Ecological Task	Prio rity	Ac	Detail	Cost/ac	Cost est	FMR Contractor	City In-Kind	Vol Option
1	Oct	Seeding	1	5.9	Broadcast seed of milestone-tolerant species, mostly grasses (see seed mix), where sprayed weeds were in sizable patches.	\$ 200.00	\$ 1,180.00	\$ 1,180.00		
2	Late May-early June & late Aug-Sep	Invasive weed control	1	5.9	Spot-spray any additional invasive weeds before seeds form. 2 visits. Milestone. Do not spray seeded patches.	\$ 300.00	\$ 1,770.00	\$ 1,770.00		
2	June, Aug	Invasive weed control	1	5.9	Seeded patches: mow 2x when 12"-15" tall. Do not allow weeds to produce seeds.	\$ 400.00	\$ 2,360.00	\$ 2,360.00		
2	August	Goldenrod control	2	1.0	Repeat mow of dense stands of goldenrod in Units H and N, when flowering starts.	\$ 300.00	\$ 300.00	\$ 300.00		
3	Late May-early June & late Aug-Sep	Invasive weed control	1	5.9	Spot-spray any additional invasive weeds, including seeded patches , before seeds form. 2 visits. Milestone.	\$ 300.00	\$ 1,770.00	\$ 1,770.00		
3	May	Invasive weed control	1	5.9	Seeded patches: mow ONCE when 12"-15" tall. Do not allow weeds to produce seeds.	\$ 200.00	\$ 1,180.00	\$ 1,180.00		
4	Late May-early June & late Aug-Sep	Invasive weed control	1	5.9	Spot-spray any additional invasive weeds, including seeded patches , before seeds form. 2 visits. Milestone.	\$ 300.00	\$ 1,770.00	\$ 1,770.00		
4	Oct	Rx burn	1	4.5	Fall burn to promote forbs. Units A1, I1, O, Q, and half of H.	\$ 500.00	\$ 2,225.00		\$ 2,225.00	

Units F2, L1. (Quality 3 Units). 1.9acres

1	Late May	Rx burn	1	1.9	Late spring to target cool season grasses.	\$ 500.00	\$ 950.00		\$ 950.00	
1	May-July	Invasive weed control	1	1.9	About a month after green up, mow to prevent weed seeds. Mow HIGH. May need second mow to prevent seeds.	\$ 400.00	\$ 760.00	\$ 380.00	\$ 380.00	
1	Aug-Oct	Invasive weed control	1	1.9	Spray invasive weeds when natives are dormant. Milestone. Clethodim for grasses.	\$ 400.00	\$ 760.00	\$ 760.00		
2	April-May	Invasive weed control	1	1.9	Spot-spray any additional invasive weeds Milestone. Clethodim for grasses.	\$ 300.00	\$ 570.00	\$ 570.00		
2	Feb	Purchase Seed		1.9	Seed mix of milestone-tolerant grasses and forbs (see seed mix)	\$ 700.00	\$ 1,330.00	\$ 1,330.00		
2	June	Seeding	1	1.9	Drill seed	\$ 175.00	\$ 332.50	\$ 332.50		
2	June, Aug	Invasive weed control	1	5.9	Mow seeded areas 2x when 12"-15" tall. Do not allow weeds to produce seeds.	\$ 400.00	\$ 2,360.00	\$ 2,360.00		
3	June, Aug	Invasive weed control	1	5.9	Mow seeded areas 1x when 12"-15" tall. Do not allow weeds to produce seeds.	\$ 150.00	\$ 885.00	\$ 885.00		
3	Late May-early June & late Aug-Sep	Invasive weed control	1	1.9	Spot-spray invasive weeds (e.g. mugwort, crown vetch, trefoil, burdock) before seeds form. 2 visits. Milestone	\$ 300.00	\$ 570.00	\$ 570.00		
4	April	Rx burn	1	1.9	3rd Yr establishment burn. Also burn E, F1, L1	\$ 500.00	\$ 950.00		\$ 950.00	

GRASSLAND AND SAVANNA UNITS - continued

Yr	Season	Ecological Task	Prio rity	Ac	Detail	Cost/ac	Cost est	FMR Contractor	City In-Kind	Vol Option
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Units B1

2	April	Purchase shrubs	2	0.1	20 bareroot native shrubs (see spp list), plus fencing		\$ 200.00	\$ 200.00		
2	April	Shrub planting	2	0.1	Install about 20 bare root native shrubs for windbreak by bee hives. Schedule follow-up watering		\$ 2,800.00	\$ 2,800.00		x

Units E, F1, L2, M (Quality 4 Units) 2.2 acres

1	Late May-early June & late Aug-Sep	Site prep	1	2.6	Broadcast spray after spring greenup. Repeat 3-4 times as needed until Oct. Glyphosate/Milestone/Garlon 3a.	\$ 800.00	\$ 2,080.00	\$ 2,080.00		
2	May	Site prep	1	2.6	Broadcast spray unit after spring greenup. Glyphosate/Milestone/Garlon 3a.	\$ 220.00	\$ 572.00	\$ 572.00		
2	Feb	Purchase Seed		2.6	Seed mix of milestone-tolerant grasses and forbs (see seed mix)	\$ 700.00	\$ 1,820.00	\$ 1,820.00		
2	June	Seeding	1	2.6	Drill seed milestone-tolerant species, mostly grasses (see seed mix), in sprayed patches.	\$ 200.00	\$ 520.00	\$ 520.00		
2	June, Aug	Establishment mow	1	2.6	Mow 2x when 12"-15" tall. Do not allow weeds to produce seeds.	\$ 450.00	\$ 1,170.00	\$ 1,170.00		
3	May	Establishment mow	1	2.6	Mow 1x when 12"-15" tall. Do not allow weeds to produce seeds.	\$ 200.00	\$ 520.00	\$ 520.00		
3	Late May-early June & late Aug-Sep	Invasive weed control	1	2.6	Spot-spray invasive weeds (e.g. mugwort, crown vetch, trefoil, burdock) before seeds form. 2 visits. Milestone	\$ 400.00	\$ 1,040.00	\$ 1,040.00		
4	April	Rx burn	1	2.6	3rd Yr establishment burn. Also burn F2, L1	\$ 500.00	\$ 1,300.00		\$ 1,300.00	

Units B1, C1, C2, D *

1	May-Jul	Invasive weed control	1	6.6	Mow 2x to keep weeds reduced and prevent seeds.	\$ 200.00	\$ 1,320.00		\$ 1,320.00	
2	May-Sept	Invasive weed control	1	6.6	Mow 2x to keep weeds reduced and prevent seeds.	\$ 200.00	\$ 1,320.00	\$ 1,320.00		

\$ 52,009.50 \$ 36,432.00 \$ 15,577.50

* Restoration of these units will need to wait until completion of the Wakan Tipi Center. When ready for restoration, can follow Q-3 steps for B1 & C' Until then periodic mowing will help to keep weeds reduced and prevent their seeding.

Annual Ecological monitoring

June	Breeding bird surveys	2 visits. Timed survey, point count or transect	\$ 700.00	
May-Oct	Vegetation monitoring	At least monthly visits to evaluate conditions.	\$ 2,250.00	
Apr-Nov	Project management		\$ 1,600.00	
			\$ 4,550.00	\$ 13,650.00

Optional Volunteer events

June	Prairie Planting		\$ 1,587.00	
June-Sept	Pollinator surveys	One visit per month, follow Xerces protocols.	\$ 900.00	
Jul	Invasive weed pull - burdock		\$ 548.00	
			\$ 3,035.00	

FOREST UNITS

Year	Season	Ecological Task	Priority	Acres	Detail	Cost/ac	Cost est	FMR Contractor	City in-kind	Vol. option
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Unit A2/B2/I2. (Quality 2)

1	Fall	Woody invasive removal	2	2.1	Cut and treat non-native woody brush. Haul brush to piles and either chip or burn in winter. Brush mowing may be used (in winter) where feasible.	\$500.00	\$1,050.00	\$1,050.00	Disposal	
1	Fall	Invasive weed control	2	2.1	Spot-spray or pull invasive weeds (e.g. Burdock, Canada thistle, etc)	\$350.00	\$735.00	\$735.00		x
1	Fall	Seeding	2	1	Purchase simple, native graminoid mix for post-removal seeding.	\$500.00	\$500.00	\$500.00		
1	Fall	Seeding	2	1	Seed open areas after removal – seed with native graminoid mix. In forestry mowed areas, wait until following year to allow breakdown of woody material.	\$300.00	\$300.00	\$300.00		x
2	Fall	Woody invasive follow-up	2	2.1	Treat woody resprouts/seedlings	\$400.00	\$840.00	\$840.00		
3	Spring	Planting	2	1	Plant plugs of woodland forbs and bareroot or potted shrubs. Mulch and protect plantings.	\$1,000.00	\$1,000.00	\$1,000.00		x
3	Summer	Watering	2	1	Water installed plants 2x	\$400.00	\$400.00		\$400.00	x
3	Fall	Woody invasive follow-up	2	2.1	Treat woody resprouts/seedlings	\$400.00	\$840.00	\$840.00		

Unit J/K (Quality 3)

1	Spring	Invasive weed control	1	2.1	Spot-spray or pull garlic mustard	\$350.00	\$735.00	\$735.00		x
1	Early fall	Invasive weed control	1	2.1	Spot-spray or pull invasive weeds (e.g. Burdock, Canada thistle, etc)	\$350.00	\$735.00	\$735.00		x
1	Fall	Woody invasive removal	1	2.1	Cut and treat non-native woody brush and trees. Haul brush off site, or haul to piles and either chip or burn in winter. Brush mowing may be used (in winter) where feasible.	\$1,750.00	\$3,675.00	\$3,675.00	Disposal	
1	Fall	Seeding	1	1	Purchase simple, native graminoid mix for post-removal seeding.	\$500.00	\$500.00	\$500.00		
1	Fall	Seeding	1	1	Seed open areas after removal – seed with native graminoid mix. In forestry mowed areas, wait until following year to allow breakdown of woody material.	\$300.00	\$300.00	\$300.00		x
2	Spring	Invasive weed control	1	2.1	Spot-spray or pull garlic mustard	\$350.00	\$735.00	\$735.00		x
2	Early fall	Invasive weed control	1	2.1	Spot-spray or pull invasive weeds (e.g. Burdock, Canada thistle, etc)	\$350.00	\$735.00	\$735.00		x
2	Fall	Woody invasive follow-up	1	2.1	Treat woody resprouts/seedlings	\$400.00	\$840.00	\$840.00		
3	Spring	Planting	1	1	Plant plugs of woodland forbs, bareroot and potted shrubs, and bareroot trees. Mulch and protect plantings.	\$1,000.00	\$1,000.00	\$1,000.00		x
3	Summer	Watering	1	1	Water installed plants 2x	\$400.00	\$400.00		\$400.00	x
3	Fall	Woody invasive follow-up	1	2.1	Treat woody resprouts/seedlings	\$400.00	\$840.00	\$840.00		

FOREST UNITS - continued

Year	Season	Ecological Task	Priority	Acres	Detail	Cost/ac	Cost est	FMR Contractor	City in-kind	Vol. option
Unit P (Quality 3)										
1	Spring	Invasive weed control	2	1.4	Spot-spray or pull garlic mustard	\$350.00	\$490.00	\$490.00		x
1	Early fall	Invasive weed control	2	1.4	Spot-spray or pull invasive weeds (e.g. Burdock, Canada thistle, etc)	\$350.00	\$490.00	\$490.00		x
1	Fall	Woody invasive removal	2	1.4	Cut and treat non-native woody brush and trees. Haul brush off site, or haul to piles and either chip or burn in winter. Brush mowing may be used (in winter) where feasible.	\$2,000.00	\$2,800.00	\$2,800.00	Disposal	
1	Fall	Seeding	2	1	Purchase simple, native graminoid mix for post-removal seeding.	\$500.00	\$500.00	\$500.00		
1	Fall	Seeding	2	1	Seed open areas after removal – seed with native graminoid mix. In forestry mowed areas, wait until following year to allow breakdown of woody material.	\$300.00	\$300.00	\$300.00		x
2	Spring	Invasive weed control	2	1.4	Spot-spray or pull garlic mustard	\$350.00	\$490.00	\$490.00		x
2	Early fall	Invasive weed control	2	1.4	Spot-spray or pull invasive weeds (e.g. Burdock, Canada thistle, etc)	\$350.00	\$490.00	\$490.00		x
2	Fall	Woody invasive follow-up	2	1.4	Treat woody resprouts/seedlings	\$400.00	\$560.00	\$560.00		
3	Spring	Planting	2	1	Plant plugs of woodland forbs, bareroot and potted shrubs, and bareroot trees. Mulch and protect plantings.	\$1,000.00	\$1,000.00	\$1,000.00		x
3	Summer	Watering	2	1	Water installed plants 2x	\$400.00	\$400.00		\$400.00	x
3	Fall	Woody invasive follow-up	2	1.4	Treat woody resprouts/seedlings	\$400.00	\$560.00	\$560.00		
Unit R (Quality 3)										
1	Spring	Invasive weed control	3	1.8	Spot-spray or pull garlic mustard	\$400.00	\$720.00	\$720.00		x
1	Early fall	Invasive weed control	3	1.8	Spot-spray or pull invasive weeds (e.g. Burdock, Canada thistle, etc)	\$400.00	\$720.00	\$720.00		x
1	Fall	Woody invasive removal	3	1.8	Cut and treat non-native woody brush and trees. Haul brush off site, or haul to piles and either chip or burn in winter. Brush mowing may be used (in winter) where feasible.	\$2,250.00	\$4,050.00	\$4,050.00	x	
1	Fall	Seeding	3	1	Purchase simple, native graminoid mix for post-removal seeding.	\$500.00	\$500.00	\$500.00		
1	Fall	Seeding	3	1	Seed open areas after removal – seed with native graminoid mix. In forestry mowed areas, wait until following year to allow breakdown of woody material.	\$350.00	\$350.00	\$350.00		x
2	Spring	Invasive weed control	3	1.8	Spot-spray or pull garlic mustard	\$400.00	\$720.00	\$720.00		x
2	Early fall	Invasive weed control	3	1.8	Spot-spray or pull invasive weeds (e.g. Burdock, Canada thistle, etc)	\$400.00	\$720.00	\$720.00		x
2	Fall	Woody invasive follow-up	3	1.8	Treat woody resprouts/seedlings	\$450.00	\$810.00	\$810.00		
3	Spring	Planting	3	1	Plant plugs of woodland forbs, bareroot and potted shrubs, and bareroot trees. Mulch and protect plantings.	\$1,000.00	\$1,000.00	\$1,000.00		x
3	Summer	Watering	3	1	Water installed plants 2x	\$400.00	\$400.00		\$400.00	x
3	Fall	Woody invasive follow-up	3	1.8	Treat woody resprouts/seedlings	\$450.00	\$810.00	\$810.00		
							\$35,040.00	\$33,440.00	\$1,600.00	

Annual Ecological monitoring

May-Oct	Vegetation monitoring	At least monthly visits to evaluate conditions.	\$ 2,250.00
Apr-Nov	Project management		\$ 1,600.00
			\$ 3,850.00

Optional Volunteer events

May	Invasive removal - garlic mustard		\$ 600.00
June	Forest Planting		\$ 2,302.00
Jul	Invasive removal - burdock		\$ 600.00

Appendices

Appendix A. Plant species recorded

Appendix B. Recommended plants species for restoration

Appendix C: Methods for Controlling Non-native Invasive Plant Species

Appendix D. Recommended work specifications for restoration activities

Appendix E. Future Considerations and Ecological Impacts

Appendix F: General historical land management at Bruce Vento Nature Sanctuary

Appendix A. Plant species recorded

Vegetation Survey – GRASSLAND Native Species Bruce Vento Nature Sanctuary 2020

Scientific name	Common name	A1	B1	C&D	E	F	H	I1	L	M	N	O
Forbs												
<i>Agastache foeniculum</i>	wild anise hyssop							1				
<i>Ageratina rugosum</i>	white snakeroot	1	1		1							
<i>Ambrosia artemisiifolia</i>	common ragweed		1				2	1	1		0.5	
<i>Asclepias syriaca</i>	common milkweed		0.5		0.5		1	1			0.5	
<i>Bidens frondosa</i>	devil's beggartick						0.5					
<i>Cirsium discolor</i>	field thistle						0.5					
<i>Coreopsis palmata</i>	prairie coreopsis										0.5	
<i>Dalea purpurea</i>	purple prairie clover		1				1		0.5	1	2	
<i>Echinacea purpurea</i>	purple coneflower						0.5				1	
<i>Erigeron annuus</i>	daisy fleabane		1		1	2				2		
<i>Eryngium yuccifolium</i>	rattlesnake master										0.5	
<i>Eupatorium maculatum</i>	Joe pye weed											0.5
<i>Grindelia squarrosa</i>	gumweed		1		0.5		1					1
<i>Heliopsis annuus</i>	common sunflower	1		0.5	0.5						0.5	
<i>Heliopsis helianthoides</i>	early sunflower		0.5								0.5	2
<i>Lactuca canadensis</i>	wild lettuce			0.5								
<i>Liatris ligulostylis</i>	meadow blazing star						0.5					
<i>Lobelia syphilitica</i>	blue lobelia					0.5						1
<i>Mentha sp</i>	mint				0.5							
<i>Mirabilis nyctaginea</i>	4 o'clock				1							
<i>Monarda fistulosa</i>	bergamot		1	1	0.5	1	1		0.5	1		0.5
<i>Oenothera biennis</i>	evening primrose								0.5			
<i>Oenothera gaura</i>	biennial gaura						0.5	0.5				
<i>Physalis virginiana</i>	ground cherry		1									
<i>Ratibida columnifera</i>	columnar cone flower						0.5					
<i>Ratibida pinnata</i>	yellow coneflower	1	1				0.5				0.5	
<i>Rudbeckia hirta</i>	black eyed Susan		2		1	1	1			1		1
<i>Solidago canadensis</i>	Canada goldenrod	1		2	3		2	1			2	2
<i>Solidago gigantea</i>	late goldenrod		1				1					
<i>Solidago rigida</i>	stiff goldenrod	1	1				0.5	1			1	
<i>Symphyotrichum ericoides</i>	heath aster	1			1		0.5		1		0.5	1
<i>Symphyotrichum novae-angliae</i>	New England aster			0.5					0.5			0.5
<i>Symphyotrichum sp</i>	aster sp				1							
<i>Tradescantia cf ohiensis</i>	spiderwort		1									
<i>Verbena hastata</i>	blue vervain									1		1
<i>Verbena stricta</i>	hoary vervain		1		1		0.5		0.5		1	
<i>Viola sp</i>	violet				0.5							
		6	15	5	14	4	18	6	7	5	13	10

Vegetation Survey – **GRASSLAND Native Species (continued)**
Bruce Vento Nature Sanctuary 2020

Graminoids												
<i>Andropogon gerardii</i>	big bluestem	3	2	0.5			0.5		2		1	
<i>Bouteloua curtipendula</i>	sideoats grama		1						1		1	
<i>Bouteloua gracilis</i>	blue grama			0.5						0.5		1
<i>Bouteloua hirsuta</i>	hairy grama										0.5	
<i>Carex sp</i>	sedge						1-west					
<i>Elymus canadensis</i>	Canada wild rye	1		1	1		0.5		0.5		0.5	
<i>Juncus torreyi</i>	Torrey's rush					0.5						
<i>Panicum virgatum</i>	switchgrass			0.5		1	1		1		1	2
<i>Schizachrium scoparium</i>	little bluestem					1	2	2	1		3	
<i>Sorghastrum nutans</i>	Indiangrass		1	0.5					1			
<i>Spartina pectinata</i>	prairie cordgrass						1-west					
		2	3	5	1	3	4	1	6	1	6	2
Woody - seedlings, saplings, vines												
<i>Acer negundo</i>	boxelder	1			0.5							
<i>Fraxinus pensylvanica</i>	green ash			1			0.5					
<i>Juglans nigra</i>	black walnut											0.5
<i>Parthenocissus quinquefolia</i>	Virginia creeper		1									
<i>Populus deltoides</i>	cottonwood			0.5			0.5					
<i>Rubus ideaus</i>	red raspberry				1							
<i>Salix exigua</i>	sandbar willow											1
<i>Viburnum trilobum</i>	highbush cranberry							0.5				
<i>Vitis riparia</i>	wild grape vine	1	1		1							
Canopy Trees												
<i>Acer saccharinum</i>	silver maple	3										
<i>Populus deltoides</i>	cottonwood			3	3							
<i>Quercus macrocarpa</i>	bur oak			1								
<i>Quercus rubra</i>	red oak			1								

Vegetation Survey – GRASSLAND Non-Native Species
Bruce Vento Nature Sanctuary 2020

Scientific name	Common name	A1	B1	C&D	E	F	H	I1	L	M	N	O	Q	Pond 1
Forbs														
<i>Arctium minus</i>	common burdock		1	2			3							
<i>Artemisia absinthium</i>	Absinthe wormwood											+		
<i>Artemisia vulgaris</i>	mugwort	1	2		1	2	1	2	1	2		1		
<i>Berteroa incana</i>	hoary alyssum		1	3		2								
<i>Centaurea stoebe</i>	spotted knapweed		+											
<i>Cirsium arvense</i>	Canada thistle		1									+		
<i>Cirsium vulgare</i>	bull thistle					+								
<i>Daucus carota</i>	Queen Anne's Lace						+							
<i>Hypericum punctatum</i>	dotted St John's wort		+						+					
<i>Linaria vulgaris</i>	butter and eggs		1		1									
<i>Lotus corniculatus</i>	birdsfoot trefoil		1	2							1			
<i>Lythrum salicaria</i>	purple loosestrife					+							+	
<i>Melilotus officinalis</i>	yellow sweet clover		1	1	1									
<i>Pastinaca sativa</i>	wild parsnip		+											
<i>Plantago major</i>	common plantain		1											
<i>Potentilla recta</i>	sulfur cinquefoil				+									
<i>Rumex crispus</i>	curly dock	+	+											
<i>Saponaria officinalis</i>	soapwort		+	+	1					1				
<i>Securigera varia</i>	crown vetch		2		2	1	2		2	3	1	1	+	
<i>Silene latifolia</i>	white campion							+						
<i>Tragopogon dubius</i>	yellow goat's beard								+					
<i>Verbascum thapsus</i>	common mullein		1		+		+							
Graminoids														
<i>Bromus inermis</i>	smooth brome		2	2	3		1		2		1			
<i>Echinochloa crus-galli</i>	barnyard grass						+							
<i>Elymus repens</i>	quackgrass				2									
<i>Hordeum jubatum</i>	foxtail barley			+										
<i>Phalaris arundinaceae</i>	reed canary grass											1		
<i>Phleum pratense</i>	Timothy grass						1							
<i>Poa pretensis</i>	Kentucky bluegrass		2					2			1			
<i>Setaria faberi</i>	giant foxtail			+					1					
<i>Setaria pumila</i>	yellow foxtail	1	1		1		2	1	1					
Woody														
<i>Lonicera tatarica</i>	Tatarian honeysuckle						1			1				
<i>Morus alba</i>	white mulberry	+												
<i>Rhamnus cathartica</i>	common buckthorn	+		+				+						
<i>Robinia pseudoacacia</i>	black locust		+											
<i>Ulmus pumila</i>	Siberian elm			1	(4-5')		in wds	+	2 small	1	1	1	+	3 S side

Vegetation Survey – **WOODLAND Native Species**
Bruce Vento Nature Sanctuary 2020

	Quality Rank	Units			
		A2/B2/I2	J&K	P	R
Forbs		2	3	3	3

Scientific name	Common name				
<i>Ageratina rugosum</i>	white snakeroot	3	3	2	2
<i>Ambrosia artemisiifolia</i>	common ragweed	1	1		
<i>Asclepias syriaca</i>	common milkweed	+	+		
<i>Bidens frondosa</i>	devil's beggartick		+		
<i>Circaea lutetiana</i>	enchanter's nightshade	+	1	1	+
<i>Erigeron annuus</i>	daisy fleabane		1		
<i>Eupatorium maculatum</i>	Joe pye weed			+	
<i>Geum canadense</i>	white avens			+	
<i>Hackelia virginiana</i>	Virginia stickseed	1	2	1	1
<i>Hydrophyllum virginianum</i>	Virginia waterleaf			1	
<i>Lactuca canadensis</i>	wild lettuce		1		
<i>Mentha sp</i>	mint	+	1	+	+
<i>Mirabilis nyctaginea</i>	4 o'clock		1		
<i>Rudbeckia hirta</i>	black eyed Susans			+	
<i>Rudbeckia laciniata</i>	cut leaf coneflower			1	
<i>Solanum ptychanthum</i>	black nightshade		+	+	
<i>Solidago canadensis</i>	Canada goldenrod	2	1	1	1
<i>Urtica dioica</i>	stinging nettle	+	2	+	+
<i>Viola sororia</i>	common blue violet		+		

Graminoids

<i>Carex pensylvanica</i>	Pennsylvania sedge		1	+	+
<i>Leersia virginica</i>	white grass		+	+	+
<i>Panicum virgatum</i>	switchgrass		1		

Woody (0-0.5m)					
<i>Acer negundo</i>	boxelder	1	1	1	1
<i>Celtis occidentalis</i>	hackberry	1	2	1	1
<i>Cornus alternifolia</i>	Pagoda dogwood				
<i>Cornus racemosa</i>	gray dogwood				
<i>Cornus sericea</i>	red osier dogwood				
<i>Fraxinus pensylvanica</i>	green ash	+	1		
<i>Juglans nigra</i>	black walnut	+	1	+	+

<i>Juniperus virginiana</i>	red cedar		+		
<i>Parthenocissus quinquefolia</i>	Virginia creeper	1	1	1	1
<i>Physocarpus opulifolius</i>	ninebark				
<i>Populus deltoides</i>	cottonwood	+	+		1
<i>Prunus virginiana</i>	chokecherry				
<i>Quercus macrocarpa</i>	bur oak				+
<i>Quercus rubra</i>	red oak		+		
<i>Rubus ideaus</i>	red raspberry	+	+		+
<i>Salix exigua</i>	sandbar willow				
<i>Sambucus racemosa</i>	elderberry				
<i>Tilia americana</i>	basswood				
<i>Ulmus americana</i>	American elm	1	1	1	1
<i>Viburnum lentago</i>	nannyberry				
<i>Viburnum trilobum</i>	highbush cranberry				
<i>Vitis riparia</i>	wild grape vine	1	1	1	1

Woody (0.5-2m)					
<i>Acer negundo</i>	boxelder	2	2	2	2
<i>Celtis occidentalis</i>	hackberry	2	1	+	2
<i>Cornus alternifolia</i>	Pagoda dogwood	+	+		+
<i>Cornus racemosa</i>	gray dogwood	+	+		
<i>Cornus sericea</i>	red osier dogwood			+	
<i>Fraxinus pensylvanica</i>	green ash	1	1		1
<i>Juglans nigra</i>	black walnut	1	1	1	1
<i>Juniperus virginiana</i>	red cedar		+		
<i>Larix laricina</i>	tamarack			1	
<i>Malus spp</i>	crabapple			1	
<i>Parthenocissus quinquefolia</i>	Virginia creeper	1	2	1	1
<i>Physocarpus opulifolius</i>	ninebark		+	+	
<i>Populus deltoides</i>	cottonwood	+	+		1
<i>Prunus virginiana</i>	chokecherry	+	1		
<i>Quercus macrocarpa</i>	bur oak	+	1	1	
<i>Quercus rubra</i>	red oak		1		
<i>Rhus hirta</i>	sumac	+	+	+	+
<i>Ribes missouriense</i>	Gooseberry				+
<i>Rubus ideaus</i>	red raspberry	1	1		
<i>Salix exigua</i>	sandbar willow		1	1	
<i>Sambucus racemosa</i>	elderberry	1	1	+	
<i>Tilia americana</i>	basswood				

<i>Ulmus americana</i>	American elm	2	+	1	
<i>Viburnum lentago</i>	nannyberry		1	+	
<i>Viburnum trilobum</i>	highbush cranberry	+	1	1	
<i>Vitis riparia</i>	wild grape vine	1	2	1	1

Woody (2m+)					
<i>Acer negundo</i>	boxelder		2	2	2
<i>Acer saccharinum</i>	silver maple	2			
<i>Celtis occidentalis</i>	hackberry	1	2	1	2
<i>Cornus alternifolia</i>	Pagoda dogwood				
<i>Cornus racemosa</i>	gray dogwood				
<i>Cornus sericea</i>	red osier dogwood				
<i>Fraxinus pensylvanica</i>	green ash		2		+
<i>Juglans nigra</i>	black walnut		2	1	1
<i>Juniperus virginiana</i>	red cedar				
<i>Larix laricina</i>	tamarack			1	
<i>Parthenocissus quinquefolia</i>	Virginia creeper				
<i>Physocarpus opulifolius</i>	ninebark				
<i>Populus deltoides</i>	cottonwood	3	2	2	3
<i>Prunus virginiana</i>	chokecherry				
<i>Quercus macrocarpa</i>	bur oak		2	1	1
<i>Quercus rubra</i>	red oak		1		
<i>Rubus ideaus</i>	red raspberry				
<i>Salix exigua</i>	sandbar willow			1	
<i>Sambucus racemosa</i>	elderberry				
<i>Tilia americana</i>	basswood			+	
<i>Ulmus americana</i>	American elm	2	2	1	2
<i>Viburnum lentago</i>	nannyberry				
<i>Viburnum trilobum</i>	highbush cranberry				
<i>Vitis riparia</i>	wild grape vine	+	+	+	+

Vegetation Survey – **WOODLAND Non-Native Species**
Bruce Vento Nature Sanctuary 2020

	Quality Rank	Units			
		A2/B2/I2	J&K	P	R
Forbs		2	3	3	3

Scientific name	Common name				
<i>Alliaria petiolata</i>	garlic mustard	2	3	1	1
<i>Arctium minus</i>	common burdock	2	3	2	2
<i>Artemisia absinthium</i>	Absinthe wormwood	+	1	+	+
<i>Artemisia vulgaris</i>	mugwort	1	1	1	+
<i>Berteroa incana</i>	hoary alyssum	1	+	+	+
<i>Centaurea stoebe</i>	spotted knapweed		+		
<i>Cirsium arvense</i>	Canada thistle	+	1	+	
<i>Cirsium vulgare</i>	bull thistle		+		
<i>Daucus carota</i>	Queen Anne's Lace		+		
<i>Hypericum punctatum</i>	dotted St John's wort				
<i>Linaria vulgaris</i>	butter and eggs		1		
<i>Lotus corniculatus</i>	birdsfoot trefoil	1	2	1	
<i>Lythrum salicaria</i>	purple loosestrife			+	+
<i>Melilotus officinalis</i>	yellow sweet clover	+	+		
<i>Pastinaca sativa</i>	wild parsnip				
<i>Plantago major</i>	common plantain	1	2	1	1
<i>Potentilla recta</i>	sulfur cinquefoil				
<i>Rumex crispus</i>	curly dock	+	+		
<i>Saponaria officinalis</i>	soapwort				
<i>Securigera varia</i>	crown vetch	1	2		
<i>Silene latifolia</i>	white campion	+	+		
<i>Tragopogon dubius</i>	yellow goat's beard				
<i>Verbascum thapsus</i>	common mullein	+	1		1

Graminoids					
<i>Bromus inermis</i>	smooth brome	1	1		
<i>Echinochloa crus-galli</i>	barnyard grass				
<i>Elymus repens</i>	quackgrass				
<i>Hordeum jubatum</i>	foxtail barley				
<i>Phalaris arundinaceae</i>	reed canary grass	+			
<i>Phleum pratense</i>	Timothy grass		1		
<i>Poa pretensis</i>	Kentucky bluegrass		1		

<i>Setaria faberi</i>	giant foxtail	+	1		
<i>Setaria pumila</i>	yellow foxtail	+	1		

Woody (0-0.5m)

<i>Lonicera tatarica</i>	Tatarian honeysuckle	+	+		+
<i>Morus alba</i>	White mulberry	+	+	1	+
<i>Rhamnus cathartica</i>	common buckthorn	+	1	1	1
<i>Robinia pseudoacacia</i>	black locust		+	+	+
<i>Ulmus pumila</i>	Siberian elm	1	1	1	1

Woody (0.5-2m)

<i>Lonicera tatarica</i>	Tatarian honeysuckle	+	1	1	1
<i>Morus alba</i>	White mulberry	1	1	1	1
<i>Rhamnus cathartica</i>	common buckthorn	1	2	3	3
<i>Robinia pseudoacacia</i>	black locust	+	1	+	+
<i>Ulmus pumila</i>	Siberian elm	1	1	1	2

Woody (2m+)

<i>Lonicera tatarica</i>	Tatarian honeysuckle				
<i>Morus alba</i>	White mulberry	1	1	1	1
<i>Rhamnus cathartica</i>	common buckthorn	+	2	1	2
<i>Robinia pseudoacacia</i>	black locust		2	2	2
<i>Ulmus pumila</i>	Siberian elm		2	2	2

Appendix B. Recommended plants species for restoration

CULTURALLY IMPORTANT SPECIES

In 2020, the Lower Phalen Creek Project conducted a community survey to identify culturally significant native plant species. Listed here are most of the species mentioned. These can be incorporated in the planting plans wherever possible.

Dry Prairie

Aster species
Beardstongue
Buffaloberry
Four O'Clock
Leadplant
Prairie rose
Prairie sage
Prairie Smoke
Prairie turnip
Red cedar
Sand cherry
Wild Lupine
Wild strawberry

Wetland

Boneset
Ironweed
Sweetgrass

Woodland

Forbs
Blue cohosh
Jack-in-the-pulpit
Trillium (nodding)
Wild ginger
Wild leeks
Trees and shrubs
Basswood
Bitternut hickory
Black cherry
Chokecherry
Elderberry
Gooseberry
Hackberry
Juneberry
Nannyberry
Wild grape

Mesic Prairie

Aster sp.
Compass Plant
Dogbane
Mountain mint
Rattlesnake master
Sumac (*R. glabra*)
Yarrow

Savanna

Forbs
Sunchoke
Trees and shrubs
Bur oak
Hazelnut
Pincherry
Raspberry
Red osier dogwood
Wild plum

Important species identified that are already present

Arrowhead	Little bluestem
Bergamot	Milkweed
Big bluestem	Sideoats grama
Blue flag iris	Stinging nettle
Cottonwood	Sunflower
Echinacea	Willows
Goldenrod	Wood nettle

Not suitable for site

Black ash	Needs bog/seepage swamp
Bog Labrador Tea	Needs bog
Cut-leaved toothwort	Needs mesic hardwood forest
Indian ricegrass	MN endangered sp, found only in far NW MN.
Paper birch	Needs mesic hardwood forest
Sugar maple	Needs mesic hardwood forest
white cedar	Needs mesic hardwood forest

SPECIES LISTS FOR QUALITY-1 AND QUALITY-2 UNITS.

The following species can be used – either as seed or plants - where large patches of weeds have been treated at the Quality-1 or Quality-2 Units. This is not an exhaustive list - there may be other suitable species for the units.

Dry Prairie species

	Scientific name	Common name	Plants*
	Forbs and small shrubs		
1	<i>Agastache foeniculum</i>	Anise hyssop	
2	<i>Allium stellatum</i>	Prairie wild onion	
3	<i>Amorpha canescens</i>	leadplant	
4	<i>Antennaria sp</i>	Pussytoes	x
5	<i>Asclepias syriaca</i>	Common milkweed	
6	<i>Asclepias tuberosa</i>	Butterflyweed	
7	<i>Asclepias verticillata</i>	whorled milkweed	
8	<i>Aster sericeus</i>	silky aster	
9	<i>Astragalus crassicaarpus</i>	Buffalobean	x
10	<i>Campanula rotundifolia</i>	Harebell	
11	<i>Ceanothus americanus</i>	New Jersey tea	x
12	<i>Chamaecrista fasciculata</i>	partridge pea	
13	<i>Coreopsis palmata</i>	Coreopsis	
14	<i>Dalea candida</i>	White prairie clover	
15	<i>Dalea purpurea</i>	Purple prairie clover	
16	<i>Dalea villosa</i>	silky prairie clover	
17	<i>Delphinium virescens</i>	Prairie larkspur	x
18	<i>Fragaria virginiana</i>	wild strawberry	
19	<i>Geum triflorum</i>	prairie smoke	x
20	<i>Heliopsis helianthoides</i>	early sunflower	
21	<i>Lespedeza capitata</i>	Round-headed bush clover	
22	<i>Liatris aspera</i>	Rough blazing star	
23	<i>Liatris punctata</i>	dotted blazing star	
24	<i>Lupinus sericeus</i>	wild lupine	x
25	<i>Monarda fistulosa</i>	Wild bergamot	
26	<i>Pedimelum esculentum</i>	Prairie turnip	x
27	<i>Penstemon grandiflorus</i>	Large-flowered penstemon	x
28	<i>Phlox pilosa</i>	Prairie phlox	x
29	<i>Rosa arkansana</i>	Prairie rose	x
30	<i>Symphyotrichum ericoides</i>	Heath aster	
31	<i>Symphyotrichum laeve</i>	Smooth blue aster	
32	<i>Symphyotrichum oolentangiense</i>	Sky-blue aster	
33	<i>Tradescantia bracteata</i>	bracted spiderwort	
34	<i>Verbena stricta</i>	hoary vervain	
35	<i>Zizia aptera (or aurea)</i>	Heart-leaved Alexanders	

	Scientific name	Common name	Plants*
	Graminoids		
1	<i>Andropogon gerardii</i>	big bluestem - small amt	
2	<i>Bouteloua curtipendula</i>	Sideoats grama	
3	<i>Bouteloua gracilis</i>	blue grama	
4	<i>Elymus canadensis</i>	Canada wild rye	
5	<i>Eragrostis spectabilis</i>	Purple lovegrass	
6	<i>Koeleria macrantha</i>	Junegrass	X
7	<i>Schizachyrium scoparium</i>	Little bluestem	
8	<i>Sorghastrum nutans</i>	Indian grass	
9	<i>Sporobolus heterolepis</i>	Prairie dropseed	X
10	<i>Stipa spartea</i>	Porcupine grass	

*These species may do best when installed as plants rather than seed.

Mesic Prairie species

Scientific name	Common name
Forbs	
1 <i>Agastache foeniculum</i>	Anise hyssop
2 <i>Amorpha canescens</i>	leadplant
3 <i>Artemisia ludoviciana</i>	prairie sage
4 <i>Asclepias incarnata</i>	Swamp milkweed
5 <i>Asclepias syriaca</i>	Common milkweed
6 <i>Asclepias tuberosa</i>	Butterflyweed
7 <i>Astragalus canadensis</i>	Canada milk vetch
8 <i>Chamaecrista fasciculata</i>	partridge pea
9 <i>Coreopsis palmata</i>	Coreopsis
10 <i>Dalea candida</i>	White prairie clover
11 <i>Dalea purpurea</i>	Purple prairie clover
12 <i>Desmodium canadense</i>	Showy tick-trefoil
13 <i>Euphorbia corollata</i>	Flowering spurge
14 <i>Galium boreale</i>	Northern bedstraw
15 <i>Gentiana flavida</i>	Cream gentian
16 <i>Heliopsis helianthoides</i>	early sunflower
17 <i>Liatris ligulostylis</i>	Meadow blazing star
18 <i>Liatris pycnostachya</i>	Great blazing star
19 <i>Monarda fistulosa</i>	Wild bergamot
20 <i>Pycnanthemum virginianum</i>	Mountain mint
21 <i>Ratibida pinnata</i>	gray-headed coneflower
22 <i>Rudbeckia hirta</i>	black-eyed susan
23 <i>Solidago speciosa</i>	showy goldenrod
24 <i>Symphyotrichum oolentangiense</i>	Sky blue aster
25 <i>Symphyotrichum laeve</i>	Smooth blue aster
26 <i>Symphyotrichum novae-angliae</i>	New England aster
27 <i>Thalictrum dasycarpum</i>	Tall meadowrue
28 <i>Verbena hastata</i>	blue vervain
29 <i>Veronicastrum virginicum</i>	Culver's root
30 <i>Zizia aptera (or aurea)</i>	Heart-leaved Alexanders
Graminoids	
1 <i>Andropogon gerardii</i>	big bluestem - small amt
2 <i>Bouteloua curtipendula</i>	Sideoats grama
3 <i>Bromus kalmii</i>	Kalm's brome
4 <i>Carex bicknellii</i>	Bicknell's sedge
5 <i>Elymus canadensis</i>	Canada wild rye
6 <i>Schizachyrium scoparium</i>	Little bluestem
7 <i>Sorghastrum nutans</i>	Indian grass
8 <i>Sporobolus heterolepis</i>	Prairie dropseed

SPECIES LISTS FOR QUALITY-3 AND QUALITY-4 UNITS.

The following species can be used where large patches of weeds have been treated or for the redo units. All the species listed are fairly tolerant of the herbicide Milestone, which will be needed for subsequent weed treatment.

	Scientific name	Common name	Milestone tolerant
Forbs			
1	<i>Agastache foeniculum</i>	Anise hyssop	x
2	<i>Allium stellatum</i>	Prairie wild onion	x
3	<i>Amorpha canescens</i>	leadplant	x
4	<i>Asclepias syriaca</i>	Common milkweed	x
5	<i>Asclepias tuberosa</i>	Butterflyweed	x
6	<i>Coreopsis palmata</i>	Coreopsis	x
7	<i>Dalea candida</i>	White prairie clover	x
8	<i>Dalea purpurea</i>	Purple prairie clover	x
9	<i>Desmodium canadense</i>	Showy tick-trefoil	x
10	<i>Heliopsis helianthoides</i>	early sunflower	x
11	<i>Lespedeza capitata</i>	Round-headed bush clover	x
12	<i>Liatris aspera</i>	Rough blazing star	x
13	<i>Liatris ligulostylis</i>	Meadow blazing star	x
14	<i>Lupinus sericeus</i>	wild lupine	x
15	<i>Monarda fistulosa</i>	Wild bergamot	x
16	<i>Penstemon grandiflorus</i>	Large-flowered penstemon	x
17	<i>Symphyotrichum ericoides</i>	Heath aster	x
18	<i>Symphyotrichum laeve</i>	Smooth blue aster	x
19	<i>Symphyotrichum oolentangiense</i>	Sky-blue aster	x
20	<i>Verbena stricta</i>	hoary vervain	x
21	<i>Zizia aptera (or aurea)</i>	Heart-leaved Alexanders	x
Graminoids			
1	<i>Andropogon gerardii</i>	big bluestem - small amt	x
2	<i>Bouteloua curtipendula</i>	Sideoats grama	x
3	<i>Schizachyrium scoparium</i>	Little bluestem	x
4	<i>Sporobolus heterolepis</i>	Prairie dropseed	x
5	<i>Sorghastrum nutans</i>	Indian grass	x

SPECIES LISTS FOR FOREST AND SAVANNA UNITS.

Southern Dry-Mesic Oak Woodland (FDs38)

Scientific name	Common name		
Forbs			
<i>Amphicarpaea bracteata</i>	hog-peanut	<i>Oryzopsis asperifolia</i>	Mountain rice grass
<i>Antennaria</i> spp.	pussytoes	<i>Festuca subverticillata</i>	Nodding fescue
<i>Anemone americana</i>	round-lobed hepatica	<i>Elymus hystrix</i>	Bottlebrush grass
<i>Anemone quinquefolia</i>	Wood anemone	Shrubs	
<i>Apocynum androsaemifolium</i>	Spreading dogbane	<i>Amelanchier</i> spp.	Juneberries
<i>Aquilegia Canadensis</i>	columbine	<i>Cornus alternifolia</i>	Pagoda dogwood
<i>Aralia nudicaulis</i>	wild sarsaparilla	<i>Cornus racemosa</i>	Gray dogwood
<i>Aster cordifolius</i>	heart-leaved aster	<i>Cornus rugosa</i>	Round-leaved dogwood
<i>Aster macrophyllus</i>	Large-leaved aster	<i>Corylus americana</i>	American hazelnut
<i>Aster sagittifolius</i>	Tail-leaved aster	<i>Corylus cornuta</i>	Beaked hazelnut
<i>Athyrium filix-femina</i>	lady fern	<i>Diervilla lonicer</i>	Bush honeysuckle
<i>Campanula rotundifolia</i>	harebell	<i>Prunus virginiana</i>	Chokecherry
<i>Carex pensylvanica</i>	Pennsylvania sedge	<i>Prunus pennsylvanica</i>	pin cherry
<i>Circaea lutetiana</i>	enchanter's nightshade	<i>Ribes cynosbati</i>	Prickly gooseberry
<i>Desmodium glutinosum</i>	pointed-leaved tick-trefoil	<i>Sambucus racemosa</i>	Red berried elder
<i>Eupatorium rugosum</i>	white snakeroot	<i>Symphoricarpos albus or occidentalis</i>	Snowberry/wolfberry
<i>Euphorbia corollata</i>	flowering spurge	<i>Viburnum lentago</i>	Nannyberry
<i>Fragaria virginiana</i>	wild strawberry	<i>Viburnum rafenesquianum</i>	Downy arrowwood
<i>Galium boreale</i>	northern bedstraw	<i>Xanthoxylum americanum</i>	Prickly ash
<i>Galium triflorum</i>	three-flowered bedstraw	Trees	
<i>Geranium maculatum</i>	wild geranium	<i>Betula papyrifera</i>	Paper birch
<i>Geum canadense</i>	white avens	<i>Carya cordiformes</i>	Bitternut hickory
<i>Helianthus strumosus</i>	woodland sunflower	<i>Celtis occidentalis</i>	Hackberry
<i>Maianthemum canadense</i>	Canada mayflower	<i>Ostrya virginiana</i>	Ironwood
<i>Osmorhiza claytonii</i>	sweet cicely	<i>Prunus serotina</i>	Black cherry
<i>Osmunda claytoniana</i>	Interrupted fern	<i>Quercus alba</i>	White oak
<i>Pteridium aquilinum</i>	Bracken fern	<i>Quercus ellipsoidalis</i>	Northern pin oak
<i>Phryma leptostachya</i>	lopseed	<i>Quercus macrocarpa</i>	Bur oak
<i>Polygonatum biflorum</i>	Giant Solomon's seal	<i>Quercus rubra</i>	Northern red oak
<i>Pyrola elliptica</i>	Elliptic shinleaf		
<i>Sanicula gregari</i>	gregarious black snakeroot		
<i>Sanicula marilandica</i>	Maryland black snakeroot		
<i>Smilacina racemosa</i>	false Solomon's seal		
<i>Solidago ulmifolia</i>	elm-leaved goldenrod		
<i>Thalictrum dioicum</i>	Early meadow rue		
<i>Trientalis borealis</i>	Starflower		
<i>Uvularia grandiflora</i>	Large flowered bellwort		
<i>Uvularia sessilifolia</i>	Pale bellwort		
Grasses and Sedges			
<i>Carex pensylvanica</i>	Pennsylvania sedge		

Southern Mesic Savanna (UPs24)

Genus	Species	Common Name
Trees		
<i>Quercus</i>	<i>macrocarpa</i>	Bur oak
Shrubs		
<i>Amorpha</i>	<i>canescens</i>	Lead-plant
<i>Prunus</i>	<i>virginiana</i>	Chokecherry
<i>Rosa</i>	<i>arkansana</i>	Prairie rose
<i>Salix</i>	<i>humilis</i>	Prairie willow
<i>Symphoricarpos</i>	<i>abla</i>	Snowberry
Grasses, Rushes and Sedges		
<i>Andropogon</i>	<i>gerardii</i>	Big bluestem
<i>Bromus</i>	<i>kalmii</i>	Kalm's brome
<i>Carex</i>	<i>bicknellii</i>	Bicknell's sedge
<i>Carex</i>	<i>meadii</i>	Mead's sedge
<i>Carex</i>	<i>muhlenbergii</i>	Muhlenberg's sedge
<i>Elymus</i>	<i>canadensis</i>	Canada wild rye
<i>Dicanthelium</i>	<i>perlongum</i>	Long-leaved panic grass
<i>Panicum</i>	<i>virgatum</i>	Switchgrass
<i>Schizachyrium</i>	<i>scoparium</i>	Little bluestem
<i>Sorghastrum</i>	<i>nutans</i>	Indian grass
<i>Sporobolus</i>	<i>heterolepis</i>	Prairie dropseed
<i>Stipa</i>	<i>spartea</i>	Porcupine-grass
Forbs		
<i>Allium</i>	<i>canadense</i>	Wild garlic
<i>Allium</i>	<i>stellatum</i>	Prairie wild onion
<i>Anemone</i>	<i>canadensis</i>	Canada anemone
<i>Anemone</i>	<i>cylindrica</i>	Long-headed thimbleweed
<i>Anemone</i>	<i>virginiana</i>	Virginia thimbleweed
<i>Antennaria</i>	<i>species</i>	Pussytoes
<i>Apocynum</i>	<i>Androsae-mifolium</i>	Spreading dogbane
<i>Artemisia</i>	<i>campestris</i>	Tall wormwood
<i>Artemisia</i>	<i>frigida</i>	Prairie sagewort
<i>Asclepias</i>	<i>syriaca</i>	Common milkweed
<i>Asclepias</i>	<i>tuberosa</i>	Butterfly-weed
<i>Aster</i>	<i>ericoides</i>	Heath aster
<i>Aster</i>	<i>laevis</i>	Smooth aster
<i>Aster</i>	<i>lanceolatus</i>	Panicled aster
<i>Aster</i>	<i>novae-angliae</i>	New England aster
<i>Aster</i>	<i>oolentangiensis</i>	Sky-blue aster
<i>Astragalus</i>	<i>canadensis</i>	Canada milk-vetch
<i>Campanula</i>	<i>rotundifolia</i>	Harebell
<i>Comandra</i>	<i>umbellata</i>	Bastard toad-flax
<i>Coreopsis</i>	<i>palmata</i>	Stiff tickseed
<i>Dalea</i>	<i>candida</i>	White prairie-clover
<i>Dalea</i>	<i>purpurea</i>	Purple prairie-clover
<i>Desmodium</i>	<i>canadense</i>	Canadian tick-trefoil
<i>Euphorbia</i>	<i>corollata</i>	Flowering spurge

Forbs (cont'd)

<i>Fragaria</i>	<i>virginiana</i>	Common strawberry
<i>Galium</i>	<i>boreale</i>	Northern bedstraw
<i>Gentiana x</i>	<i>billingtonii</i>	Closed gentian
<i>Geum</i>	<i>triflorum</i>	Prairie smoke
<i>Helianthus</i>	<i>maximiliani</i>	Maximilian's sunflower
<i>Helianthus</i>	<i>pauciflorus</i>	Stiff sunflower
<i>Heliopsis</i>	<i>helianthoides</i>	Ox-eye
<i>Heterotheca</i>	<i>villosa</i>	Prairie golden aster
<i>Heuchera</i>	<i>richardsonii</i>	Alum-root
<i>Lathyrus</i>	<i>venosus</i>	Veiny pea
<i>Lespedeza</i>	<i>capitata</i>	Round-headed bush-clover
<i>Liatris</i>	<i>aspera</i>	Rough blazing star
<i>Liatris</i>	<i>ligulistylis</i>	Northern plains blazing star
<i>Liatris</i>	<i>pycnostachya</i>	Gayfeather
<i>Lilium</i>	<i>Philadelphicum</i>	Wood lily
<i>Lobelia</i>	<i>spicata</i>	Rough-spiked Lobelia
<i>Maianthemum</i>	<i>racemosum</i>	False Solomon's-seal
<i>Maianthemum</i>	<i>stellatum</i>	Starry false Solomon's-seal
<i>Mirabilis</i>	<i>hirsuta</i>	Hairy four-o'clock
<i>Monarda</i>	<i>fistulosa</i>	Wild bergamot
<i>Oenothera</i>	<i>biennis</i>	Common evening-primrose
<i>Pedicularis</i>	<i>canadensis</i>	Wood-betony
<i>Phlox</i>	<i>pilosa</i>	Prairie phlox
<i>Physalis</i>	<i>heterophylla</i>	Clammy ground-cherry
<i>Potentilla</i>	<i>arguta</i>	Tall cinquefoil
<i>Pycnanthemum</i>	<i>virginianum</i>	Virginia mountain-mint
<i>Ratibida</i>	<i>pinnata</i>	Gray-headed coneflower
<i>Rudbeckia</i>	<i>hirta</i>	Black-eyed Susan
<i>Sisyrinchium</i>	<i>campestre</i>	Field blue-eyed grass
<i>Solidago</i>	<i>missouriensis</i>	Missouri goldenrod
<i>Solidago</i>	<i>nemoralis</i>	Gray goldenrod
<i>Solidago</i>	<i>ptarmicoides</i>	Upland white goldenrod
<i>Solidago</i>	<i>speciosa</i>	Showy goldenrod
<i>Thalictrum</i>	<i>dasycarpum</i>	Tall meadow-rue
<i>Tradescantia</i>	<i>bracteata</i>	Bracted spiderwort
<i>Veronicastrum</i>	<i>virginicum</i>	Culver's root
<i>Viola</i>	<i>pedatifida</i>	Prairie bird-foot violet
<i>Zizia</i>	<i>aurea</i>	Golden alexanders

Ferns and Fern Allies

<i>Equisetum</i>	<i>arvense</i>	Field horsetail
<i>Equisetum</i>	<i>hyemale</i>	Tall scouring-rush
<i>Equisetum</i>	<i>laevigatum</i>	Smooth scouring-rush

Southern Terrace Forest (FFs59)

Genus	Species	Common Name
Canopy Trees (>10 m)		
<i>Acer</i>	<i>saccharinum</i>	Silver maple
<i>Celtis</i>	<i>occidentalis</i>	Hackberry
<i>Fraxinus</i>	<i>pennsylvanica</i>	Green ash
<i>Populus</i>	<i>deltoids</i>	Cottonwood
<i>Salix</i>	<i>Ingra</i>	Black willow
<i>Tilia</i>	<i>americana</i>	Basswood
<i>Ulmus</i>	<i>rubra</i>	Slippery elm
<i>Ulmus*</i>	<i>americana*</i>	American elm*
Understory Trees		
<i>Acer</i>	<i>saccharinum</i>	Silver maple
<i>Carya</i>	<i>cordiformis</i>	Bitternut hickory
<i>Celtis</i>	<i>occidentalis</i>	Hackberry
<i>Fraxinus</i>	<i>pennsylvanica</i>	Green ash
<i>Ostrya</i>	<i>virginiana</i>	Ironwood
<i>Tilia</i>	<i>americana</i>	Basswood
<i>Ulmus*</i>	<i>americana*</i>	American elm*
<i>Ulmus*</i>	<i>rubra*</i>	Slippery elm*
Shrubs		
<i>Cornus</i>	<i>amour</i>	Silky dogwood
<i>Euonymus</i>	<i>atropurpureus</i>	Wahoo
<i>Prunus</i>	<i>virginiana</i>	Chokecherry
<i>Ribes</i>	<i>americanum</i>	Wild black currant
<i>Ribes</i>	<i>cynosbati</i>	Prickly gooseberry
<i>Ribes</i>	<i>missouriense</i>	Missouri gooseberry
<i>Sambucus</i>	<i>canadensis</i>	Common elder
<i>Sambucus</i>	<i>racemosa</i>	Red-berried elder
<i>Viburnum</i>	<i>lentago</i>	Nannyberry
Vines		
<i>Menispermum</i>	<i>canadense</i>	Canada moonseed
<i>Parthenocissus</i>	<i>spp.</i>	Virginia creeper
Forbs		
<i>Allium</i>	<i>tricoccum</i>	Wild leek
<i>Anemone</i>	<i>quinquefolia</i>	Wood-anemone
<i>Arisaema</i>	<i>triphyllum</i>	Jack-in-the-pulpit
<i>Aster</i>	<i>cordifolius</i>	Heart-leaved aster
<i>Aster</i>	<i>ontarionis</i>	Ontario aster
<i>Aster</i>	<i>pubentior</i>	Flat-topped aster
<i>Campanula</i>	<i>americana</i>	Tall bellflower
<i>Caulophyllum</i>	<i>thalictroides</i>	Blue cohosh
<i>Circaea</i>	<i>alpina</i>	Small enchanter's nightshade
<i>Circaea</i>	<i>lutetiana</i>	Canada enchanter's nightshade
<i>Cryptotaenia</i>	<i>canadensis</i>	Honewort

Genus	Species	Common Name
<i>Dicentra</i>	<i>cucullaria</i>	Dutchman's-breeches
<i>Enemion</i>	<i>bitermatum</i>	False rue-anemone
<i>Erythronium</i>	<i>albidum</i>	White trout-lily
<i>Galium</i>	<i>aparine</i>	Cleavers
<i>Galium</i>	<i>triflorum</i>	Three-flowered bedstraw
<i>Geranium</i>	<i>maculatum</i>	Wild geranium
<i>Geum</i>	<i>canadense</i>	White avens
<i>Hydrophyllum</i>	<i>virginianum</i>	Virginia waterleaf
<i>Impatiens</i>	<i>capensis</i>	Touch-me-not
<i>Lilium</i>	<i>michiganense</i>	Michigan lily
<i>Maianthemum</i>	<i>canadense</i>	Canada mayflower
<i>Osmorhiza</i>	<i>claytonii</i>	Clayton's sweet cicely
<i>Phlox</i>	<i>divaricata</i>	Blue phlox
<i>Polygonatum</i>	<i>biflorum</i>	Giant Solomon's-seal
<i>Ranunculus</i>	<i>abortivus</i>	Kidney-leaf buttercup
<i>Rudbeckia</i>	<i>laciniata</i>	Goldenglow
<i>Sanguinaria</i>	<i>canadensis</i>	Bloodroot
<i>Sanicula</i>	<i>gregaria</i>	Gregarious black snakeroot
<i>Smilacina</i>	<i>racemosa</i>	Racemose false Solomon's-seal
<i>Smilacina</i>	<i>stellata</i>	Starry false Solomon's-seal
<i>Smilax</i>	<i>lasioneura</i>	Carriion-flower
<i>Stachys</i>	<i>palustris</i>	Woundwort
<i>Thalictrum</i>	<i>dasycarpum</i>	Tall meadow-rue
<i>Thalictrum</i>	<i>dioicum</i>	Early meadow-rue
<i>Trillium</i>	<i>cernuum</i>	Nodding trillium
<i>Trillium</i>	<i>flexipes</i>	Drooping trillium
<i>Uvularia</i>	<i>grandiflora</i>	Yellow bellwort
<i>Viola</i>	<i>spp.</i>	Violet
Grasses, Rushes and Sedges		
<i>Calamagrostis</i>	<i>canadensis</i>	Bluejoint
<i>Carex</i>	<i>amphibola</i>	Ambiguous sedge
<i>Carex</i>	<i>pedunculata</i>	Long-stalked sedge
<i>Carex</i>	<i>sprengelii</i>	Sprengel's sedge
<i>Carex</i>	<i>radiata</i>	Stellate sedge
<i>Cinna</i>	<i>arundinacea</i>	Stout woodreed
<i>Elymus</i>	<i>hystrix</i>	Bottlebrush grass
<i>Elymus</i>	<i>virginicus</i>	Virginia wild rye
<i>Elymus</i>	<i>wiegandii</i>	Canada wild rye
<i>Glyceria</i>	<i>striata</i>	Fowl manna-grass
Ferns and Fern Allies		
<i>Matteuccia</i>	<i>struthiopteris</i>	Ostrich-fern

*Plant disease resistant varieties.

Appendix C: Methods for Controlling Non-native Invasive Plant Species

Crown vetch (*Securigera varia*)

Mechanical control can be done by pulling the plant by hand or with equipment such as a shovel. Plants can resprout from root fragments, so try to remove as much of the plant as possible. Additional control methods may be necessary. Follow Minnesota Department of Agriculture [noxious weed disposal](#) (link is external) guidance. Mowing several times a year can reduce the population, but will likely not eliminate it. Mow repeatedly from May to October to prevent flowering. Do not mow if the plants have produced seeds as mowing will spread the seeds. In areas with native grasses, prescribed burning in late spring for several successive years can encourage the native grasses and increase their ability to compete with crown vetch. Crown vetch can resprout after burns so continue to monitor the population.

Herbicide control can be done using systemic herbicides which are taken up by plants and move within the plant, which can kill leaves, stems, and roots. Spot spray with aminopyralid before the plant begins to flower. Spot spray with clopyralid from May to October while the plant is actively growing. Spot spraying during the growing season with herbicides containing 2,4-D, glyphosate, or triclopyr can also be effective. <https://www.dnr.state.mn.us/invasives/terrestrialplants/herbaceous/crownvetch.html>

Milestone applied at either bud or fall growth stage provided excellent control one year after treatment. However, only the fall herbicide application continued to provide good crown vetch control two growing seasons following treatment. Milestone applied at either 5 or 7 fl oz/A will provide good to excellent control when applied late summer or fall. Establishing a competitive plant community is critical to maintain long-term control of the weed. Follow-up herbicide applications may be necessary to control seedlings emerging from the soil seed bank or mature plants that survive treatment.

<https://www.techlinenews.com/articles/2015/long-term-control-of-crown-vetch-at-a-wisconsin-wildlife-refuge?rq=crown>

Mugwort (*Artemisia vulgaris*)

Mugwort is a perennial with an extensive rhizome system. Shoots emerge during the spring, and flowering occurs from July to late September. A single plant can, depending on its environment, produce up to 200,000 seeds. The small seeds (~1mm in diameter) are largely wind dispersed. Seed production does not seem to be a major factor in the spread of mugwort populations, however, and some biotypes do not produce viable seed. Instead, mugwort spreads largely through vegetative expansion and the anthropogenic dispersal of root propagules.

Pulling is ineffective, and may even promote growth by leaving residual rhizome fragments in the soil. Mugwort tolerates mowing, and even sustained mowing over two years will not fully eradicate mugwort stands, but can significantly reduce it.

Glyphosate applied in late summer or early fall will suppress mugwort the following year but generally not eradicate it. **Triclopyr** and **clopyralid** are more selective herbicides that effectively control mugwort. Mowing in combination with spot-spraying may provide the best control, whereby plants are mowed before they flower, then spot-sprayed in late summer.

http://nyis.info/invasive_species/mugwort-draft/

Birdsfoot trefoil (*Lotus corniculatus*)

Birdsfoot trefoil forms dense mats that choke out most other vegetation. It is especially problematic in prairies and disturbed open areas. Prescribed burns increase seed germination making it difficult to manage in native prairies.

Mechanical control alone is fairly effective at reducing this species, but will also eliminate desirable plants. More effective is a combination of mowing or burning and chemical application. The most effective herbicide is aminopyralid (e.g. Milestone), and clopyralid (e.g. Transline at 0.4 - 0.75%) is also effective. Note that both herbicides will also kill native plants in the pea family and may affect some other species. Do not apply either herbicide directly to water or to areas where surface water is present. Both remain in soil for up to one year depending on application rate. Overspray or drift to desirable plants should be avoided.

Dr. Mark Renz, University of Wisconsin found that Milestone at 7 fl oz/A provided good to excellent control in either June or October, and was significantly better than Transline® herbicide at 1 pint per acre applied in June (TechlineNews). Milestone applied at 5 fl oz/A was more effective when applied in October compared to June and provided similar control as Milestone at 7 fl oz/A at this application timing.

Glyphosate at a 1-2% solution is effective but will kill everything it touches so should be used judiciously.

Trefoil species can also be reduced by grazing.

References: <http://mipncontroldatabase.wisc.edu/Default.aspx>,
<http://www.dnr.state.mn.us/invasives/terrestrialplants/herbaceous/birdsfoottrefoil.html>
<https://www.techlinenews.com/articles/2013/managing-birdsfoot-trefoil-lotus-corniculatus?rq=trefoil>

Canada thistle (*Cirsium arvense*)

While native thistles are not generally problematic, exotics such as Canada thistle are clone-forming perennials that can greatly reduce species diversity in old fields and restoration areas (Hoffman and Kearns 1997). A combination of chemical and mechanical control methods may be needed. Chemical control is most effective when the plants are in the rosette stage and least effective when the plants are flowering. A broadleaf herbicide such as 2,4-D can be used if native grasses are present. It is most effective when applied 10-14 days before the flowering stems bolt. It is applied at rate of 2-4 lb/acre using a backpack or tractor-mounted sprayer or in granular form. Dicamba could also be used, with the advantages that it can be applied earlier in the spring at a rate of 1 lb/acre. Plants that do not respond to treatment or that are more widely dispersed could be controlled mechanically.

Mechanical control, involving several cuttings per year for three or four years, can reduce an infestation, if timed correctly. The best time to cut is when the plants are just beginning to bud because food reserves are at their lowest. If plants are cut after flowers have opened, the cut plants should be removed because the seed may be viable. Plants should be cut at least three times throughout the season. Late spring burns can also discourage this species, but early spring burns can encourage it. Burning may be more effective in an established prairie, where competition from other species is good, than in an old field, where vegetation may not be as dense.

Sweet clover (*Melilotus spp*)

White and yellow sweet clover are very aggressive biennial species that *increase* with fire. Where sweet clover is found, it should be controlled in conjunction with treatment that attempts

to eliminate smooth brome, if prairie restoration occurs. Sweet clovers are common plants in agricultural areas, so if restoration is implemented, the project area should be surveyed for this species on an annual basis. Often times, following initial brush removal and/or burning, a flush of weedy annuals and biennials such as sweet clover can occur. Well-timed mows and burnings are usually adequate to control these species. Mowing the site, as is typically prescribed for prairie restoration maintenance, should occur when all plants on the site (including sweet clovers) are approximately 12 inches in height. Sweet clover can bloom even at a height of 6 inches, but if it is burned or mowed in the following year in the late spring, it should be controlled. On steep sites, brush cutting can be substituted for mowing. Individual plants or small populations can be removed by hand-pulling. If seed production occurs, prodigious amounts of seed can be produced and spread, so pull before seeds appear or bag seed producing plants. Competition from native species also helps control sweet clovers and other weedy annuals and biennials.

To some extent, **common burdock** and **common mullein** can be treated similarly to sweet clover, since they are both exotic, biennial forbs that are typically found in disturbed areas or restoration projects.

Spotted knapweed (*Centaurea stoebe*)

Knapweed is a perennial species that has become a troublesome prairie invader. Of all the typical prairie weeds, spotted knapweed is probably the most difficult to manage. It cannot be controlled with burning—like sweet clover it actually increases with fire. Hand-pulling individuals or small groups of individuals can be effective for small infestations, and is often a good volunteer group task. However, knapweed has a fairly large tap root and can be difficult to pull. Pulling is typically more difficult when soil is hard (dry), clayey, or compacted, but easier when soil is wet (following a rain), sandy, and friable.

If knapweed populations are large, a bio-control (knapweed beetles--weevils) is recommended. Knapweed beetles (weevils) are released during the summer. Weevils can be purchased online and they are sent via the mail. Knapweed populations should be monitored each year to keep a record of the effectiveness of the bio-control. Weevils are effective for long-term control, but not a good short-term control option. Spot treatment with a systemic herbicide such as milestone or transline can be effective for short-term control.

Applying herbicide to prairie restoration areas should be done with care. Remnants with high diversity should be spot treated, not broadcast-treated. It is recommended to treat first with the least impactful chemical, monitor to see if that works, and then try another if it does not work. Degraded and highly disturbed areas can be treated a little less gently, perhaps using broadcast applications. Always follow the product label when using any chemical for weed control. Treatment should be done before the target plants form seed, so late spring and early summer are best. Professional pesticide applicators are required for herbicide treatment.

Garlic mustard (*Alliaria petiolata*)

Garlic mustard is a non-native biennial forb of woodlands and woodland edges that is very invasive and aggressive. Following the introduction of just a few plants, populations can rapidly increase and a dramatic “explosion” of garlic mustard plants can occur. In some areas it can form monotypic stands that crowd out other species, while recent studies have shown that in

other locations it may simply occupy open ecological niches. Nevertheless, garlic mustard can be very invasive in woodlands, and it is recommended to monitor and remove it as soon as it is detected (early detection and rapid response). Garlic mustard also produces a flavonoid (root exudate) that suppresses mycorrhizal inoculation. Thus species that are mycorrhizae dependent, like oaks, will become stunted and easily out-competed by garlic mustard. The flavonoid persists in the soil years after garlic mustard plants are removed, which is a good reason to keep woodlands garlic mustard-free.

Probably the best way to control garlic mustard is to closely monitor your site, and if garlic mustard is found, hand pull it before it spreads. Hand-pulling should occur before siliques (seed pods) form. Once siliques form, removed plants should be bagged and transported from the site, since the plant may have enough energy in the stem and root to make viable seeds, even though it is not growing in the ground. If bagging and transporting are not an option, making weed piles is an option, but prepare to deal with garlic mustard plants in the future at each pile. Garlic mustard plants produce hundreds of seeds per plant—they are very prolific. When pulling garlic mustard plants, take care to remove the entire root, since they may re-sprout if part of the root is left in the ground. This can be difficult, since roots are “S-shaped” and tend to break off at ground level.

Chemical control is not recommended except in cases where garlic mustard is growing in large monocultural patches. In such cases, a systemic herbicide may be appropriate. Glyphosate is non-specific, and will kill any actively growing plant. One technique that has been effective is applying a water soluble herbicide during warm days in the winter, when no snow cover or only a thin snow cover exists. Garlic mustard rosettes (first year plants) remain green mostly all year round, and can be killed during the winter when nearly all other plants are dormant. Another successful technique is to use an herbicide specific to broadleaved plants, like triclopyr (“Garlon”), but one that is water soluble, which can be dispensed with a backpack sprayer or the like; this will not kill grasses or sedges.

There are studies underway by the Minnesota DNR and University of Minnesota that show good potential for bio-control of garlic mustard via an exotic weevil (<http://www.legacy.leg.mn/projects/biological-control-european-buckthorn-and-garlic-mustard>). The testing phase is complete, but the approval process still needs to be performed. If approved, this method could revolutionize garlic mustard control. However, whether it will be effective or not on a landscape scale is yet to be determined.

Non-native cool season grasses

Non-native cool season grass include smooth brome, Kentucky bluegrass and reed canary grass. They emerge early in the growing season in southern Minnesota before most native plants are up, go dormant during the hot summer months, and are then actively growing again in the cool fall weather. By getting a head-start on the growing season over native species they can spread and outcompete them. They reproduce by both seeds and underground stems (stolons and rhizomes). Late spring burning (e.g. late May), followed by seeding with native species, can reduce the cool season grasses, especially if burns are done in consecutive years. Late spring burns can be a good tool for on-going maintenance, but will be only partially effective and can be very hard on native forbs.

Where cool season grasses are more abundant, more aggressive control methods with herbicides will be needed. The grass would be mowed in late spring, before seeds are produced, and again as needed to prevent seed production, but not past mid-August. The goal is to have vigorous short growth in the fall. After native plants are dormant, e.g. mid-October, the cool-season grasses can be safely treated with glyphosate. The grass can similarly be treated in early spring (April) before natives are up. A grass-specific herbicide, especially clethodim, can be used if there is a concern for native forbs. That herbicide may be less effective than glyphosate so more treatments may be needed.

Reed canary grass is extremely difficult to eradicate and requires repeated treatment over a period of one to three years. It is important to monitor and manage small patches as they occur. Wick-application is a method that can be used for small patches. It is done in early June is a very effective means of control that does not harm adjacent species.

Appendix D. Recommended work specifications for restoration activities

1. For all tasks, follow best management practices to minimize negative impacts including but not limited to: soil compaction, rutting, and other soil disturbances; herbicide drift and non-target impacts; disturbance to nesting birds and other wildlife.
2. Follow best management practices to avoid bringing weed-seed onto the site. ***All equipment coming from another site should be cleaned prior to entering this site.*** Personal gear, especially boots and laces, must be cleaned off before arriving at the project site. Material cleaned from equipment and clothing should be properly transported in sealed containers and disposed of offsite.

Herbicide and Applicators

1. Contract herbicide applicators must have a current Minnesota Commercial Applicators License issued by the Minnesota Department of Agriculture. All weather guidelines specified in the product label will be followed for pesticide applications. Application supervisor and applicators are responsible for pesticide coverage, placement, and efficacy.
2. Aquatic formula is required when applying within 100 feet of a wetland or water body.
3. The least persistent effective pesticides available will be used. Pesticides must be registered for the specified use by the Environmental Protection Agency (EPA) and the Minnesota Department of Agriculture (MDA). The safety of employees, the public, non-target organisms, and the environment will be given full consideration in the selection and use of any pesticide.
4. Neonicotinoid pesticides are not permitted.
5. Use, storage, handling, or disposal of a pesticide, rinsate, pesticide container, or pesticide application equipment must be done in a manner (M.S. 18B.07 subd.21):
 - a) consistent with labeling
 - b) that doesn't endanger humans, and damage agricultural products, food, livestock, fish, wildlife or beneficial insects
 - c) that will not cause unreasonable adverse effects on the environment.
6. All treatment sites will be posted as specified by the pesticide label, and as required by state guidelines.
7. Records of pesticide application must be completed for each use and records maintained according to state guidelines. Records must be submitted at the time of invoicing.
8. Conduct spot treatments rather than broadcast applications whenever possible.
9. Choose bio-control over pesticides when available.
10. Spray in **early morning or evening** when bees and other pollinators are less active.
11. Avoid windy days (wind speeds less than 10 mph) and ensure a rain-free period of at least 3 hrs after application.
12. Monitor pesticides for dispersal by drift, erosion, or runoff.
13. Prevent herbicide drift to non-target plants. Use wick application or physical barriers where needed.
14. Follow DNR Operational Order 59 (Pesticides and Pest Control) and other appropriate state guidelines.

Tree & Shrub Control

1. Species to control include buckthorn, Tartarian honeysuckle, Siberian elm, black locust, mulberry, Amur maple, peashrub, Scotch pine, and any other species not native to Minnesota that are considered invasive.
2. Cutting method: Cut stems as close to the ground as possible. Person cutting must also treat stumps. To minimize misses, cut no more stems than can be easily remembered. Then stop and treat.
3. Use dye with herbicide so contractor and FMR can see what was treated.
4. Herbicide application: Use **dauber** applicator for stump treating. **Foam applicator** is desired for foliar application.
5. Approved herbicides include Garlon 3a and other triclopyr-based herbicide or glyphosate unless otherwise approved. Oil-based herbicide is not permitted unless prior approved.
6. Brush burning: Where brush burning occurs. stack brush in openings where heat will not damage standing tree trunks or branches. Avoid making brush piles where native woodland or prairie vegetation is well established. Seek disturbed areas, non-native vegetation or stumps of cut brush/trees. To minimize burn piles, brush can be stacked and burned at same time as cutting if conditions for burning are suitable. Otherwise burn piles in winter.

Forest management practices to protect pollinators & control erosion

1. Contractors must follow MN State BMPs for pollinators
https://files.dnr.state.mn.us/natural_resources/npc/bmp_contract_language.pdf
2. Avoid broadcast spraying of pesticides when other effective means of control are available; encourage the use of spot treatments
3. When managing for legacy elements (patches within a treatment area that retain native plant community representation), select areas to include as many plants as possible that produce pollen and nectar
4. Minimize impact to spring ephemerals
5. Retain standing dead and downed logs where possible to serve as nesting habitat for bees, as well as feeding habitat for beetle and hoverfly pollinators whose larvae are saproxylic.
6. When clearing brush on a slope, use trunks of larger brush or small trees (e.g. 4 to 6-inch diameter), laid horizontally across the slope to help reduce erosion. Logs should be minimum length of 4 feet, longer is better.

Appendix E. Future Considerations and Ecological Impacts

A. Fire Suppression

The application or withdrawal of ecosystem functions, processes, and components will have varying affects. Sometimes these affects are subtle and sometimes they are overt. They can be acute or chronic. As is so oftentimes the case, there are complex interactions between species and amongst abiotic features that result in changes to or even shifts in ecosystems. For example, periodic fires were very important parts of natural processes prior to settlement. Fire kills small woody seedlings that might otherwise grow into mature trees and shrubs, thus keeping the understory of woodland and the ground layer of savannas open. The resulting open areas allow wildflowers, grasses, sedges, and ferns to thrive. When fires occurred historically, a very diverse and varied herbaceous ground layer flourished under woodlands and savannas, with hundreds of species occurring. The lack of fire over the last 150 years has negatively impacted native woodlands and savannas. In broad terms, woodlands have succeeded and are currently succeeding to forests, with savannas and prairies succeeding to woodlands.

B. Disease

1. Oak Wilt

Oak wilt is a very serious fungal disease affecting oak trees that results in tree mortality. Once oak wilt fungus becomes established in one tree, it can move through common root systems to adjacent trees of the same species – red oaks to other red oaks, and white oaks to other white oaks – forming of an “infection center.” Infection centers spread rapidly through red oaks and slowly through white oaks. Bur oaks are intermediate in spread rate. Oak wilt can be controlled primarily through reducing and preventing the wounding of trees.

Overland spread of oak wilt by insects can be prevented by following these guidelines on when to prune and when to paint.

High Risk Period: Don't wound or prune during April, May and June. If trees are accidentally wounded, or pruning is unavoidable, cover the wounds immediately or within minutes using one of the preferred materials such as water-based paint or shellac.

Low Risk Period: July through October. The tree's vascular system begins shutting down during this period and appears to be better able to prevent fungal growth. However, infections may rarely occur due to weather conditions and insect populations. Covering wounds is optional.

Safe Period: November through March. This is the preferred time for pruning since the fungal pathogen and insect vectors are inactive.

Tree climbing irons should never be used on living oak trees, even during the “safe period.”

Control

Wounded oak trees (e.g., storm damage) are more susceptible to oak wilt, since beetles carrying fungal spores on their bodies are attracted to the scent of fresh wounds and become disease vectors.

To slow the underground spread of the fungus, root barriers are required. The most cost-effective method of creating root barriers is with a vibratory plow – a large, modified backhoe that pulls a vibrating blade through the ground. The blade typically extends five-feet deep into the soil, cutting roots as it moves. This procedure can be more or less disturbing to the soil and plant community, so deciding whether or not to root-cut should include an analysis of the costs and

benefits. Also, vibratory plows will not operate on slopes that are too steep or soils that are too wet or too hard. It is not recommended on the steep slopes of a site, but rather on relatively broad, flat areas. Access for a vibratory plow must be considered and a 10-foot wide lane must be available for machine use.

An alternative method is chemical injections into individual trees, which is used in situations where trees are of high value and/or vibratory plowing is not an option. The downsides of using chemicals is that they are more expensive, they only treat individual trees, not groups of trees, and injections must be repeated every two years to be effective.

Most of the time, oak wilt will affect red or pin oaks, and not affect bur and white oaks. This situation is usually tolerable, since red and pin oaks are somewhat invasive in woodlands and savannas, and reducing tree density helps to restore woodlands and savannas. However, if the bur and white oaks become infected, control measures should be assessed as soon as possible. Sometimes there will be no good control options, due to steepness of slopes and presence of outcropping bedrock, etc. Removing wilting red and pin oaks (after control lines are in place, if feasible) is recommended, and properly disposing of the wood, since it can produce spore mats that can spread the disease to any nearby oaks. If there is a high amount of spores in an area, the likelihood of overland infection goes up, even for bur oaks and white oaks.

In some circumstances, monitoring and replanting, with a different tree species or a diversity of tree species is the only solution. See Appendix B for a list of appropriate tree species for the Protected Property.

2. Bur Oak Blight

Bur Oak Blight (BOB) is a relatively new fungal disease recently discovered in Minnesota, and confirmed in several counties, including Ramsey and Hennepin; so it could potentially occur in Dakota County. This disease kills trees, but moves much more slowly than Oak Wilt. It only affects bur oaks, which is a concern in areas containing valuable bur oaks. BOB seems to be influenced by the frequency of rainfall, with more rainfall resulting in conditions more suitable for the disease. Symptoms occur on leaves during July and August, with large, brown, wedge-shaped necrotic lesions forming. Sometimes leaf veins also turn brown. One of the best ways to diagnose the presence of this disease is by examining bur oaks during the winter. Normal bur oaks drop all of their leaves during the winter. If the leaves are retained (even a few), this may indicate that the tree is infected with BOB. The disease overwinters in leaf petioles and spreads throughout the crown of the tree and potentially into other nearby trees over the span of several years. Mortality can result, but often trees that die are located next to ones that are unaffected, so the rate of spread is relatively slow. Control of this disease cannot be attained through raking and burning of fallen leaves, since many leaves remain attached to the tree over winter. However, periodic site-wide burning would reduce the spore load, since many fallen leaves bear fungal spores. Researchers are supporting the use of fungicide injections since the protection provided by a single injection seems to last for several years.

3. Dutch Elm Disease

Dutch Elm Disease (DED) is caused by a fungus, which like oak wilt, kills trees and is transmitted via root grafts from tree to tree. Even though it has been active in Minnesota for decades, it has not disappeared and continues to infect and kill many elm trees every year. This should not significantly affect site management, unless large trees die and create large canopy

gaps. Gaps will induce a flush of understory plants, which may be dominated by buckthorn; so the sites should be monitored and managed appropriately. It may not be necessary to replace dead elms with new plantings, since native seedlings will sprout in the gaps. Researchers are searching for and propagating individual trees that are resistant to DED, which may restore lost American elms, as well as replace dying ash trees. Some DED-resistant elms are available now, but these are hybrids of Asian species, which may not be desirable, and are often difficult to obtain. It will be many years before native genotype, DED-resistant elms become commercially available.

C. Non-native and over-populated native animals

1. Earthworms

No species of earthworms were native to the northern part of the U.S., since the last glaciation over 10,000 years ago. During the last century, “litter dwelling,” “soil dwelling,” and “deep burrowing” species of have been introduced – primarily as cast-off bait from anglers. Since then, they have become established and are very invasive in our native woodlands and forests. These species move into new areas in waves, one species following another, with ultimately the largest worms, night-crawlers, invading and becoming established. Where soils/systems have evolved without them, these earthworm species, contrary to popular opinion, are not good for the soil – tunneling into the top layers of soil and consuming large amounts of leaf litter (duff). The result of their activities is a net soil compaction and a marked increase in the duff turnover rate (the time it takes for the litter layer to be decomposed and turn into humus). Where there used to be several inches of the light, fluffy duff layer in native forests and woodlands, there is now only a trace of duff or often none at all, with compacted, bare soil often prevalent. This situation can result in increased erosion and nutrient runoff and lead to detrimental impacts for nearby lakes and streams. The lack of duff layer and soil compaction have negative ramifications on native forb populations, especially spring ephemerals that evolved under conditions that required thick, fluffy duff layers.

2. White-tail Deer

Another factor of the woodland decline is over-browsing/over-grazing. Areas that were pastured by cattle or sheep received heavy grazing pressure that was previously unknown. Native grazers (primarily bison and antelope) would move around and not concentrate in one area for long periods of time. This allowed a very diverse forb layer to thrive. With the introduction of cattle in the last century and a half, that grazing pattern changed. Cattle will concentrate their grazing much longer and their impacts are much greater. Many native forbs simply cannot survive this type of grazing pressure.

Today, deer browsing, not grazing, has a more significant negative impact on woodlands. Deer populations in the Metropolitan Area have significantly increased over the last century, due to direct and indirect causes. The conversion of native forest, woodland, savanna, and prairie, first to agricultural land and then to more “suburbanized landscapes,” has favored deer. Forest fragmentation and managing for large gaps and residential lots, with linear woodlands, has greatly increased the suburban “edge effect.” Deer prefer areas with large amounts of long, linear forest/woodland edge that can be used as open areas to feed and wooded areas for cover. Active

vegetation management for deer hunting by wildlife managers has also increased deer abundance. Deer prefer to feed on many native forbs, shrubs, and tree seedlings. Although deer will eat buckthorn and honeysuckle, they do not prefer them if given the choice. This combination of factors greatly increases the browsing pressure on the few natives that can survive earthworm and buckthorn infestations. The lack of oak regeneration, typical of such woodlands, is one result of these conditions.

The synergistic effect of four factors: fire suppression, earthworm infestation, buckthorn/honeysuckle invasion, and high deer browsing pressure, has resulted in oak woodland decline. Although difficult to remediate, this decline can be improved and possibly reversed by implementing appropriate management activities.

3. Emerald Ash Borer

Emerald Ash Borer (EAB) is a small beetle from Asia that was recently introduced to the United States, first showing up in Michigan and Maryland in the 1990s (via packing material), and now in Minnesota since 2009. EAB is a wood boring insect whose larvae feeds on the inner bark and phloem of ash trees and kills them. All native species of ash are susceptible, including black, green, red, and white, as well as many planted cultivars. Primary damage is caused by larvae as they feed and produce galleries within the phloem and outer sapwood. Tree mortality occurs within one to three years of initial attack. For more information on the life cycle, symptoms, and control of EAB, see the Minnesota Department of Agriculture website:

www.mda.state.mn.us/en/plants/pestmanagement/eab.aspx.

EAB is now widely established in Minnesota, especially in the Twin Cities metro area. Though all properties with ash trees will be affected, one small bit of hope for a natural control of EAB is cold temperatures. According to Lee Frelich, Director of the University of Minnesota Center for Forest Ecology, “winter mortality of EAB is definitely temperature dependent.” A recent study in Minnesota showed that five percent of insect larvae die at 0 degrees Fahrenheit (F), 34 percent at -10 degrees F, 7 percent at -20 degrees F, and 98 percent at -30 degrees F. However, since the larvae overwinter under the bark and are insulated, air temperatures need to be slightly colder to have the measured effect, and larvae need to be exposed for prolonged periods of time for mortality to occur.

Another potential method of biological control is with three species of Asian wasps. These wasps are tiny and stingless, about the size of a gnat. In their native China, they parasitize the larvae and eggs of emerald ash beetles, which reduce EAB populations over the long term. EAB will never be eradicated by wasps since there will always be a level of population that does not get parasitized, but the wasps have the potential to keep EAB in-check.

Proper sanitation is an important strategy for slowing the spread of EAB. Sanitation is the prompt removal and appropriate disposal of dead and dying ash trees that are symptomatic for EAB, when EAB is known to occur in the vicinity (within 15 miles). Unfortunately, this strategy does not usually eradicate the insect.

For more information on the life cycle, symptoms, and control of EAB, see the Minnesota Department of Agriculture website: www.mda.state.mn.us/en/plants/pestmanagement/eab.aspx.

D. Climate Change

With the advent of global climate change, conditions for plant communities are changing. By the end of the century, scientists believe that much of Minnesota will not be conducive for the growth of boreal pine or boreal mixed forests. The climate of the Twin Cities will be more like that surrounding Sioux Falls, South Dakota, or Oklahoma City, Oklahoma. Minnesota is expected to receive the same average amounts of precipitation or slightly more, but yearly distributions will be different. More rain is expected during the winter months and less rain during the summer months. The result will be a sort of “savannafication” of the region. By facilitating the movement of plants from more southerly and westerly regions of Minnesota, degradation of natural areas may be mitigated or averted. By promoting healthy oak woodland, oak savanna, and prairie ecosystems, the potential negative shift from unsustainable land management expectations and serious loss of diversity to better outcomes can occur by focusing on strategies emphasizing resistance and resilience. Appropriate actions could mimic, assist, or enable ongoing natural adaptive processes, such as species dispersal and migration, population mortality and colonization, changes in species dominance and community composition, and changing disturbance regimes.

E. Misuse by visitors

As described in earlier sections, misuse of the site’s natural areas by visitors and occupants has contributed to their current degraded state. Dumping of trash and yard waste and overuse of erosion-sensitive areas continues to cause issues on the site. Some of these activities are both taking away from the natural beauty and decreasing the habitat value of the units, and can exacerbate erosion in the long term by preventing native plant establishment.

The woodlands on the north side of the site are plagued by the greatest number of examples of this behavior. Besides being heavily bisected by a number of spur trails, the units are full of trash, and erosion caused by foot traffic is damaging the sandstone bluff, especially in Unit P. Curbing these behaviors will be difficult, but will go a long way towards helping to restore the natural communities on site. Visitors should understand the benefits of natural areas, both for their own enjoyment and for the habitat and ecosystem services they provide. Beyond that, an understanding of how human uses can affect and degrade these areas will be important.

Ultimately, education toward encouraging behavior changes will be necessary to lessen or halt these behaviors. Leveraging the expertise of local partner organizations can help accomplish this goal. For example, LCPC, FMR, and other organizations host workshops and educational events to educate community members on good land use practices that will benefit water quality and ecosystem health. Signage, site ambassadors, and continuing restoration and educational events on site are just a few strategies to help change visitor behavior.

Appendix F: General historical land management at Bruce Vento Nature Sanctuary

Year/Season	Unit	Activity	Work Entity
2001 – 2005 Yearly	All	Trash removal, native species plantings	Urban Roots
2006-Present Yearly	All	Invasive species removal: buckthorn, crown vetch, burdock, spotted knapweed, reed canary grass Seed collection Native plantings	SPPR volunteers
2006 – Present Yearly	All	Invasive species removal: buckthorn, crown vetch, burdock, spotted knapweed, reed canary grass	Urban Roots
2006 – Present Yearly	All	Trail clearing, invasive removal, sand removal, prairie maintenance	SPPR staff
2016 – Present Yearly	All	Buckthorn removal – pulling, cutting, piling	Mississippi Park Connection
2018	B1, E, H, N	Prairie maintenance: spot sprays, native plug planting	SPPR/contractors
2018	F, M, L	Prairie restoration: broadcast sprays, prep burn, native seeding	SPPR/contractors
2020	A1, A2, B2, F, J, K, Ponds	Invasive species removal: burdock, purple loosestrife	FMR / LPCP