# Mississippi River Corridor
# Restoration Site Analysis

*Prepared For:*

Flint Hills Refinery
Friends of the Mississippi River
CF Industry
Dakota County
The City of Rosemount

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Resilient Communities Project

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## Table of Contents

## Introduction

Our group has been asked to depict the current state of the Mississippi River Greenway, specifically the site known as N2. The whole greenway is located between Pine Bend Trail, and the Mississippi River, in Rosemount, MN (Township, Range, Section: T115N, R18W, 18). The assessment will help determine goals for the restoration of the Mississippi River Greenway.

The greenway is divided into four restoration sites; N1 - N4. This document contains a description of the greenway as a whole, and the specific site of N2. The assessment includes a detailed description of the vegetation, soils, and geology of N2; the greenway as it currently sits; and historical data depicting previous states of the area. Also included are Conceptual Ecological Models describing the site, and the greenway's reaction to ecological drivers. A division of three units comprises the site of N2. Unit one is the largest land area, containing a brome field, and patches of sumac. Units two and three are the north woodlands and south woodlands respectively. Both woodland areas are forested and include the presence of the invasive buckthorn.

This analysis led to the formation of nine goals for restoration. Five of these goals are site-specific for N2, and four are landscape-scale goals for the restoration of the entire greenway. This analysis will also be used in the planning, implementation, and monitoring processes of the restoration.

## Motivation for Restoration

Partners involved in the Mississippi River corridor restoration include Don Kern from Flint Hills Resources, Scott Dohman from CF Industries - both property owners within the corridor - Karen Schick, a consultant with Friends of the Mississippi River, Eric Zweber with the Community Development Department of Rosemount, MN, and Dakota County Parks. Some of these partners have worked together on restorations in the past, but they would like to unite on this project in an effort to create an unfragmented corridor that provides habitat for native species.

At the panel discussion on Wednesday October 1, 2014 Eric and Scott explained that CF industries wanted to build four new buildings on their property, a task that is generally illegal due to the areas proximity to the river. Rosemount decided that in exchange for allowing CF Industries to build, the company had to provide funding for restorations that support the environment, and provide a service to the community. Scott explained that he has been spending about $30,000 annually for the past eight years to restore areas within his property because the community needs to know that the company intends to be good stewards of the land. Don alluded to that notion as well, stating that as an oil refinery, Flint Hills often gets a bad reputation, even though they are one of the most ecological refineries in the country. Flint Hills invest in restoration projects so the public recognizes them as a company that cares about the environment and natural resources.

Friends of the Mississippi River have participated in many restorations around the metro. Karen has knowledge about similar restoration sites, and implementation practices to offer the project in an effort to unite all areas of the corridor. Eric Zweber and Dakota County Parks are interested in the restoration as a service to the community as well. An aesthetic pleasure will be experienced by community members as they admire the restorations from the future bike trail. Community members will also experience added ecological benefits in the form of improved air, soil, and water quality, as well as improved habitat that supports native plant and animal species - especially the bird populations that the partners specifically mentioned they would like to see more of. Undertaking this restoration is important to all of the partners involved.

## Parcel Information

**Owner, property address:**
Flint Hills Resources
12555 Clark Rd
Rosemount, Dakota County, MN 55068

**Township, range, section:** T115 N, R18W, 18

**Size of site:** approximately 10 acres

**Watershed:**
Major watershed: Mississippi River
Sub-watershed: Vermillion River

**Watershed Management Organization:** Vermillion River Watershed Joint Powers Organization (VRWJP)

# GREENWAY LANDSCAPE ASSESSMENT

## Greenway location

The Greenway is located near Rosemount, along the top of the Mississippi River bluffs. The total piece of land is comprised of four different ownership sectors. Flint Hills Resources owns the largest part followed closely by CF Industries Sales. County of Dakota and Union Pacific railroad own the smallest portions of the future greenway. Flint Hills Resources runs the Pine Bend oil refinery, the largest in Minnesota, located just a few miles away. There are 6 nodes of interest for restoration work along the greenway. While the funds haven't been attained for all of the parcels of land, the partners hope to eventually see the entire greenway restored and feature a trail for visitors to enjoy.

## Historic and current land use

The current site of the greenway is home to interspersed Oak Woodlands, and Prairie. Most of the center area of the corridor is dominated by the site of CF industries. Topographical maps show that the western portion of the corridor is at about a 900-foot elevation level, but slopes downward towards the river, losing nearly 200 feet of elevation and remaining around 700 feet at the bottom. Most of the corridor is not public, with the exception of the area within Dakota County Park. Flint Hills and CF Industries are required to have a buffer zone around their companies in case of an accident at the refinery or fertilizer plant, making the location an excellent place to restore plant and animal habitats .

Aerial and topographic images show how the corridor has been used since 1937. Most of the flat, farmable area was being used for agriculture in ‘37. The bluffs were interspersed with oak woodlands stretching towards the river. The north side of the bluffs in the west of the corridor near the curve in Pine Bend Trail were lacking vegetation on the north side, indicating that erosion was likely. About five small homesteads were interspersed throughout the greenway (Aerial Image, 1937). By 1953 the center of the corridor was beginning to be used for industrial purposes. A large section of oaks had been cleared for an open field, and a road led from Pine Bend Trail to the banks of the Mississippi. The structure of the agricultural fields in the east of the corridor had expanded into one large block of crops with Oak Woodlands surrounding it. The other agricultural fields were still in tact. It is evident that the shoreline of the Mississippi River had been reconfigured over the years (Aerial Image, 1953). Aerial photos from 1964 show many changes: Pine bend Trail had been altered slightly to encompass a homestead in the west of the corridor. The current N2 site has ski slopes running down the bluffs for recreational purposes. The sites where N3 and N4 lie were still encompassed in agriculture as of 1964, but the other agricultural areas that had been within the corridor are no longer present. The center area of industrialization had been largely expanded into the agriculture fields and Oak woodlands (Aerial Image, 1964). By 1970 the area where CF Industries now lies had been interspersed with vegetation, more so than in ‘64. A previous agricultural field to the west of CF Industries was converted to a place for two large storage units to sit. Just north-west of the storage area is a distinguishable body of water near the river that had formed over the previous six years. Some of the vegetation on the eroding western bluffs had begun to grow back, though not a large amount (Aerial Image, 1970). Since 1970 the agricultural fields stopped being used, and turned to prairies comprised mainly of brome grass. CF Industries has done some remodeling, and reintroduced Oaks into an area along the shore that had been cleared. The shore line remains nearly identical to 1970 figures.

## Regional Context

The greenway proposed through our Rosemount restoration site will connect the existing Dakota County Mississippi Regional Trail, which currently follows the Mississippi River from South St. Paul to Inver Grove Heights and from Nininger Township to Hastings. Eventually the trail will connect 27 miles along the Mississippi River from South St. Paul to Hastings. The trail largely follows the Mississippi River Bluffs, characterized by hilly topography and a mix of public and private property comprised of residential, industrial, and natural areas.

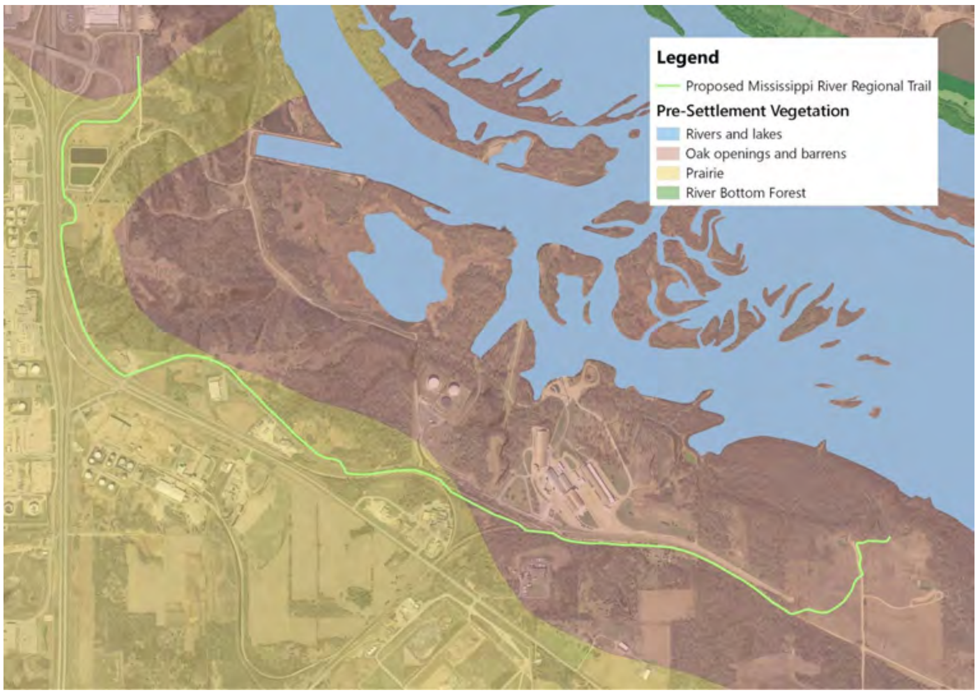
## Geology and soils

The geology and soils of Dakota County were strongly influenced by the movement of glaciers across the landscape during the Quaternary Ice Age. The result of this glacial movement is a range of topography and soils throughout Dakota County, with hilly topography in the western and northwestern parts of the county, level to gently rolling outwash plains in the central and eastern parts of the county, and terraces separated by steep escarpments along the Mississippi River (USDA SCS 1983). Soils in these areas were largely formed by glacial till and outwash, with some areas containing weathered bedrock and alluvium.

Underlying Dakota County are sedimentary rocks deposited 600-400 million years ago, when the area was covered by shallow oceans. The lower layers primarily consist of sandstone and shale, and are major aquifers of Dakota County. The upper layers consist of sandstone, shale, and limestone. Where at the surface, these layers were eroded considerably during glacial advancement and have since experienced much weathering. Glacial till makes up much of the upland areas, and was deposited during Wisconsin Glaciation, ending approximately 10,000 years ago. Due to this geologically recent glacial period, soils of much of Dakota County are considered geologically young, with higher fertility than older, mature soils (USDA SCS 1983).

## Vegetation

Due to both anthropogenic and natural drivers, the Rosemount Greenway Corridors vegetation cover types have changed drastically from pre-settlement conditions. Before European settlement, the southwestern border of the corridor up to the northwestern corner was prairie (Map 1). The northeastern side of the corridor, bordering the river, was mostly oak openings, woodlands, and barrens.




**Map 1**: Pre-settlement Vegetation

Post settlement, much of the land that had been prairie was converted to agricultural lands and homesteads. Some woodland and barrens were also converted to agriculture, and later, to industry (Flint Hills Oil Refinery, CF Industry) and recreational use (archery range, downhill skiing).

These conversions have lead to major changes in vegetation. In the present day, much of the land that was used for agricultural purposes is now uncultivated and invaded with smooth brome (*Bromus inermis*) and other non-native and native species. There are still remnants of oak woodlands and savannah, especially on the bluffs going down to the river. There is a mesic hardwood forest system throughout the northwestern portion of the bluffs in the corridor, with some upland prairie above the bluffs. Additionally, common buckthorn (*Rhamnus cathartica*) has infiltrated the hardwood forests.

## Human Drivers of Ecological Change

The Rosemount Greenway Corridor has been and continues to be a multi-use area and is influenced by several different human drivers of ecological change. The three most important of these in the planning area are land conversion to agricultural and industry, pollution, and the introduction of non-native species (see Appendix C for CEM).

The conversion to agriculture can lead to poor soil and water quality due to the influx of contaminants from herbicides, insecticides, and fertilizer. It can also decrease the amount of organic material left in the soil. Industrial activities and the addition of the railroad increase the risk of spills of oil, chemicals, metals, and fuel, as well as increasing carbon dioxide outputs. All of these inputs decrease the soil and water quality, making it difficult for native flora and fauna to thrive. The conversion of land to agricultural fields and industrial sites also isolates ecosystems from each other, creating smaller and fewer ecosystems, known as habitat fragmentation. This leads to the decrease of native species due to barriers in dispersal and a reduction in available habitat. This also decreases survival rates of endangered and less abundant species.

Pollution from the CF factory, Flint Hills Oil Refinery, nearby roadways, and residential areas all pose a risk to soil and water quality. They can alter soil and water through atmospheric deposition and from run-off of wastes and contaminants such as oils, metals, polycyclic aromatic hydrocarbons, organic matter and nitrogen. This contamination can decrease native species abundance and allow invasive species to thrive.

The introduction of non-native species plays a large role in the degradation of the Rosemount Greenway Corridor. Non-native species can become invasive and take over the landscape by capitalizing on poor soil and water conditions that other native plants cannot tolerate or competing with the native plants directly. The introduction of non-natives, such as common buckthorn (*Rhamnus cathartica*) and smooth brome (*Bromus inermis*) in the Rosemount Greenway Corridor, can impact all the ecosystems in the corridor. The spread of non-native species and the decrease of native species leads to lower biodiversity, which affects species interactions between plants, animals, and insects.

# SITE ASSESSMENT

## Site Specific Historic and Current Land Use

The majority of the site is covered in prairie dominated by brome grass, but the periphery consists of oak openings and barrens. The 2013 USGS topographical map shows that the site is flat, with a sudden slope in the north (Topographic Map 2013). 2012 aerial photos show a number of features: The south-western edge of the site is bordered by Pine Bend Trail, and a row of trees. Near the road a bike trail is intended to be built. There is another small road within Flint Hills property that borders the site on the south-eastern edge; the Northern area is bordered by thick Oak Barrens, that slope downward dramatically; the center is prairie with islands of sumac shown as dark patches (Aerial Image, 2012).

By analyzing photos of the site since 1937, it was found that the N2 area has been used in a number of ways. 1937 Aerial images show that the site was bordered by forest in the north and east, but the majority of N2 was being used for agriculture. It is seen that Pine Bend Trail already existed at the time (Aerial Map, 1937), though without the tree border, which didn't emerge in aerial images until 1940. By 1953, there were trails running along the tree line at the north of the site, leading through the forest, and towards the river (Aerial Image, 1940). These trails were likely for the use of the ski slope which ran down the bluff and towards the river at the time. The previously thin trails became an actual road by 1964, and another road was constructed perpendicular to Pine Bend Trail (Aerial Image, 1964), the latter being the road that now makes up the south-eastern border of the site. 1970 aerial photos show that at the end of that road, an area has been cleared for industrial use, and the tree border along Pine Bend Trail has gotten much thicker. Since 1970 that cleared area has been re-vegetated, but the road leading to it extends into the forest. The road that had been constructed for the ski slope is no longer present by 2012 (Aerial Image, 2012).

## Site Vegetation

The N2 site had mostly one type of pre-settlement vegetation ecosystem: oak openings and barrens. It is worthy to note that N2 is on the cusp of where prairie historically turned to oak openings, so there was presumably an ongoing tension between the two ecosystems. Before 1937, the land was converted to agriculture and later became a homestead. There were few trees in the southern portion of the site until 1964, when the vegetation along the Pine Bend Trail became more abundant (Aerial Image, 1964). By 1970 there were patches of forested areas in the South, which remain there today.

Currently, the vegetation is much different than pre-settlement times. Much of the site is overtaken by smooth brome (*Bromus inermis*) with patches of other invasives such as spotted knapweed (*Centaurea maculosa*) and spiny plumeless thistle (*Carduus acanthoides).* There are large islands of smooth sumac (*Rhus glabra*) scattered throughout the field. There are some remnant oaks (*Quercus alba, Quercus macrocarpa*) and conifers (red pine, *Pinus resinosa*) in the oak woodland areas, but these areas also have common buckthorn (*Rhamnus cathartica*) and an introduced, possibly hybridized honeysuckle (*Lonicera sp.*). The pre-settlement expanse of oak barrens is mostly gone and has been replaced by a habitat more suitable as a southern dry prairie. See Appendix A for a full site species list.

## Landscape context

The site is owned by Flint Hills Resources and is located in the northwest portion of the greenway. Historical land use includes agriculture fields and even a ski slope for recreation. Currently, the old ski slope can be recognized due to the absence of trees on the hill. A service road runs through our site which connects to the adjacent main road. The site has been unmanaged with the exception a row of cedars intentionally planted alongside the road which serve to shield the site from view. This is an assumption made based on the security and trespassing warnings we saw while visiting the site. Our site features an amazing view looking over the hill towards the Mississippi. The site is within proximity to the highway such that the noise from the highway can be heard.

## Rare Features

The Minnesota County Biological Survey indicates that many plant and animal species near the site are either state, or federally declared as rare or aggregate. A list of those species are presented in Appendix B. One interesting geological feature of the site is the presence of the bluffs in the north. The site sits at about 900 feet of elevation, but slopes downwards dramatically towards the Mississippi. Flint Hills had previously utilized the bluff as a skiing hill for employees. There are also small divots in the at the north-west corner of the site, reaching up to one-foot deep.

## Geologic History

Geological and topographical conditions at the site were as expected. The Dakota County Soil Survey states that the area is well drained prairie composed of sandy and gravely soils with mainly 2 - 6 percent slopes, but reaching 30 percent in some areas.

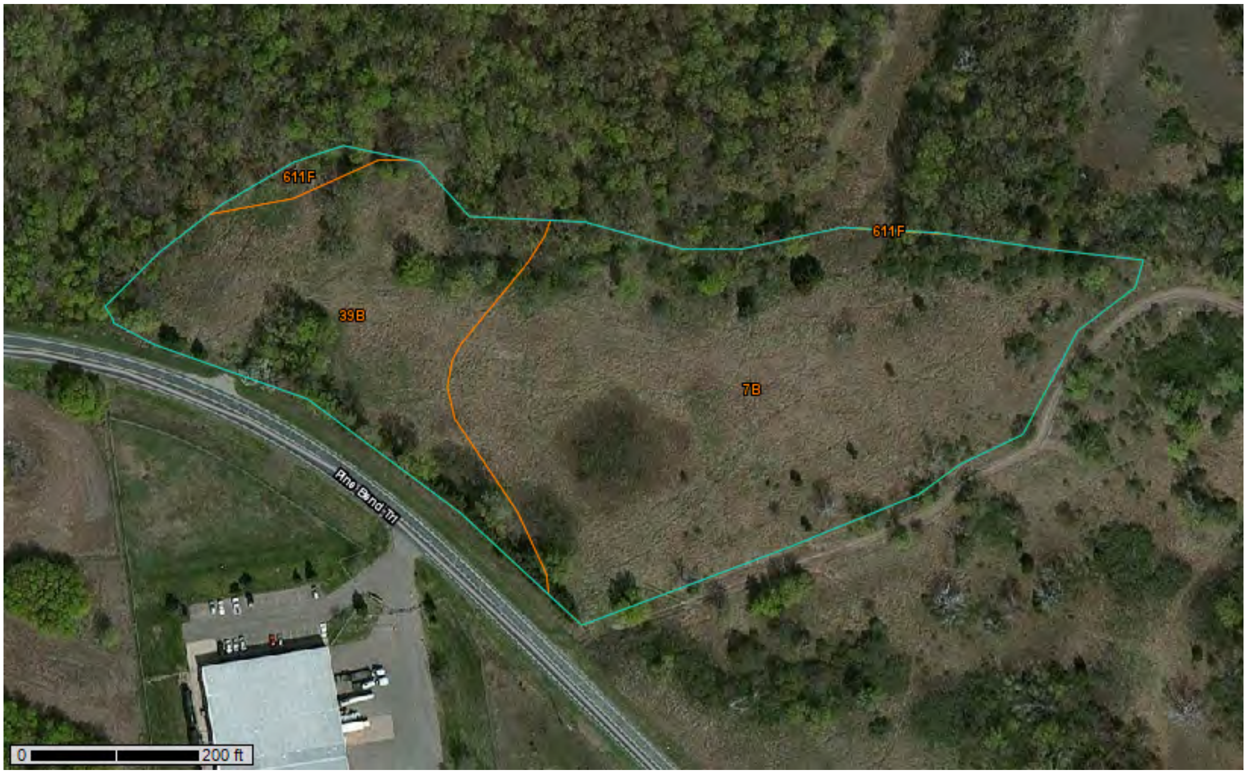
This was consistent with actual conditions found at the site. Material in the soil accumulated over different glacial ages, and was deposited as outwash and glacial till as the ice melted (USDA SCS 1983).

Topographical maps don't show any sudden changes to the topography. The site is at about 900 feet of elevation - the tallest point before the bluffs begin to slope downward.

## Soils

The majority of the soils at the N2 site are loams and loamy sands (Map 2, Table 1). In the western part of the site, 2.8 acres are covered by deep, well-drained, and moderately permeable Wadena loam. These soils formed on level to moderately steep outwash plains and are underlain by dark yellowish brown and brown sand. In the eastern portion of the site, 5.9 acres are covered by deep, excessively drained, and rapidly permeable Hubbard loamy sand, formed in sandy sediments on outwash plains and terraces. The N2 areas covered by Wadena loam and Hubbard loamy sand are relatively level in topography. Along the northern woodland border of the site, approximately 1 acre is covered by deep, excessively drained, and rapidly permeable Hawick loamy sand, formed in loamy sediments over sandy outwash (USDA SCS 1983). Along this border are a variety of native and non-native tree and shrub species; this border also is where a downward slope, surrounding and going out from the N2 site, begins.

The approximate depth for each soil type is 60 inches.



**Map 2:** Soil map of N2 (USDA NRCS Web Soil Survey).

**Table 1:** Soil types, N2 Mississippi Greenway Site

| Soil code | Acres | Soil Name | Slope | Hydric | Water erodibility |
|---|---|---|---|---|---|
| 7B | 5.9 | Hubbard loamy sand | 1-6% | N | L |
| 39B | 2.8 | Wadena loam | 2-6% | N | M |
| 611F | 0.9 | Hawick loamy sand | 25-50% | N | H |

The elevation of the site is relatively constant, save for the slope occurring along the northern border of the site. No evidence of erosion was observed for this site.

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## Restoration Units


**Map 3:** Restoration Units

## Restoration Unit 1: Brome Field

**See Appendix A for all Restoration Unit Plant Species Lists*

This unit is a large part of the N2 site. It reaches from the western border of the site, across the expanse of the site to the dirt road, which is the eastern border. It is fairly homogenous in terms of vegetation. Smooth brome (*Bromus inermis*) is the dominant species, with large patches of smooth sumac (*Rhus glabra*). There are a few trees in the field, although they do not dominate the canopy. The dirt road supports quite a few invasive species, such as bird's-foot trefoil (*Lotus corniculatus*) and spotted knapweed (*Centaurea maculosa*) possibly due to deposition by vehicles.There is little change in elevation, however there is a large out-washed area in the southwestern corner of the site, to the east of Unit 3. There is quite a bit of disturbance here, with divots as deep as one foot and the presence of spiny plumeless thistle (*Carduus acanthoides*). The soils in this unit are Hubbard loamy sand on the east half and Wadena loam on the west half.

**Image 1**: Brome Field from the North **Image 2**: Smooth Sumac in Unit 1

**Restoration Unit 2: North Woodland**

**Image 3**: North Woodland

This unit is on the north border of site N2. It follows along the ridgeline of the bluff and perpendicular to the ski slopes, but there is no noticeable elevation change within the unit. The canopy is dominated by eastern cottonwoods (*Populus deltoides*) and several oak species. The subcanopy is heavily dominated by a cultivated lilac (*Syringa* sp.), which is growing and suckering prolifically along the northwest border of the unit. A possibly hybridized, non-native honeysuckle (*Lonicera* sp.) and common buckthorn (*Rhamnus cathartica*) are also very abundant throughout the unit. The native riverbank grape (*Vitis riparia*) grows throughout the understory, along with virginia creeper (*Parthenocissus quinquefolia*) and a species of raspberry (*Rubus* sp.). The soils are comprised of Hubbard loamy sand on the east half and Wadena loam on the west half.


**Image 4**: Overlooking the ski slopes

**Restoration Unit 3: South Woodland**

Unit 3 covers much of the southern border of the site.  There is a line of eastern redcedars (*Juniperus virginiana*) and cottonwoods (*Populus deltoides*) along the road, that may have been planted since 1973, when the last aerial photograph shows that there are no trees along the road.  The western side of the unit is a larger patch of forested woodland, dominated by canopy trees such as boxelder (*Acer negundo*) and more cottonwoods (*Populus deltoides*). The subcanopy has a high abundance of common buckthorn (*Rhamnus cathartica*) and a non-native hybridized honeysuckle *(Lonicera sp.*). The ground level is dominated by the natives virginia creeper (*Parthenocissus quinquefolia*) and riverbank grape (*Vitis riparia*) The soil type is Wadena loam, with a very small Hubbard loamy sand portion in the east.

**Important human drivers and ecological effects**

The biggest direct human driver ecological changes on our site include land conversion, pollution, and recreational use (see Appendix D for CEM). These drivers can be more easily pinpointed to a period of history connected to the site. The conversion of land to agricultural fields caused loss of habitat, contaminants by use of fertilizers and soil disturbance. These stressors can be linked to effects such as erosion, decreased quality of soil and water and loss of native vegetation. Drivers such as invasive species and climate change can also be linked to human drivers, but over a longer period of time or could have been controlled with management on site. Climate change is a global problem that every place is experiencing. It can cause more severe weather such as long droughts or rapid flooding. Climate change can make native vegetation unfit to grow in places it would usually thrive. These stressors have caused erosion, loss of vegetation with seed sources, and encourage spread of brome grass where native vegetation can no longer survive.

## Greenway Landscape SMART Goals

1. *Reduce the cover percentage of smooth brome grass (*Bromus inermis*) by 90% in 10 years.*

*Bromus inermis* is an invasive grass that grows via rhizomes. It can be managed by fire and herbicide applications. It should be reduced to promote diverse native vegetation and extensive prairie systems. It can be effectively managed and should be reduced as much as possible, which is why the reduction percentage is high. Management of brome grass should be feasible in 10 years over the entire corridor.

2. *Reduce the cover percentage of common buckthorn (*Rhamnus cathartica*), by 80% in 15 years.*

*Rhamnus cathartica* is an invasive tree/shrub that produces large amounts of viable seed. It can be managed by both pulling it and cutting with stump treatments. It is present in all restoration units and should be reduced to promote native vegetation, especially at the ground level and subcanopy level. Eradicating buckthorn is a slow process, hence why it will take at least 15 years to reduce the cover percentage by 80% over the entire corridor.

3. *Increase the number of visiting song-birds in the corridor by 50% in 10 years.*

The Minnesota Audubon Society has recognized the Mississippi River as an important bird area that is critical for conservation. Additionally, the partners have addressed their hope of creating restored habitat for songbirds. Prairie songbirds have been declining in Minnesota and by providing diverse vegetation with different heights of grasses/forbs, sub-canopies and canopies, we could increase the percentage of songbirds that visit the corridor. We can survey bird populations using sight surveys.

4. *Stabilize eroding slopes by increasing native vegetative cover by 70% in 2 years.*

Stabilizing slopes decreases erosion caused by loss of vegetation and vegetative diversity. This will improve soil quality on and down the bluffs, as well as improve water quality. Smooth brome grass has been used for erosion control in areas where it is native, but seeing as it is an invasive that we would like to reduce by 90%, it will not be of use in the restoration of the corridor. Increasing the native vegetation cover by 70% should stabilize soils. The specified period of time should be shorter because erosion will occur if the site is unvegetated. Plants don’t need to be at full size to help with soil erosion, so it should be vegetated as quickly as possible.

## N2 Site SMART Goals

1. *Detect 30 different bee species over entire prairie unit on site in 10 years.*

Site 2 is currently very homogenous and does not currently support the variety of pollinators needed to support a native prairie ecosystem. The reduction of brome grass and the rejuvenation of diverse native vegetation should also restore pollinators to the area. Before we restore pollinators, we need to manage the brome grass and restore native prairie vegetation. We can measure the number of pollinators by using insect netting and observational sampling techniques.

2. *Establish an actively used habitat for upland prairie bird species - particularly the rare Grasshopper Sparrows, Western Meadowlarks, and Henslow's Sparrows - within 10 years.*

The partners have shown interest in increasing the number of birds and other wildlife in the area. Increasing the number of ground-nesting birds on the prairie of Site 2 will take longer than other restoration actions. To be able to increase the number of ground-nesting birds, we need to first reduce the brome grass and increase the native vegetation and pollinators. Also, according to Minnesota Audubon, there are 29 ground nesting birds in the metro area, 16 of which are of conservation concern. Not all species will nest on Site 2, but making sure we have a good diversity of birds, especially some of conservation concern, is important. We will survey bird populations using sight surveys.

3. *Establish 80% native vegetation typical of a southern dry prairie in 5 years.*

We will measure this goal by observing the percentage of plant species belonging to native vegetation; it is not achieved until at least 80% of the species within the area are native, allowing habitats to reestablish. The time frame for this goal is five years because there are some tree/shrub species that will take longer to reach maturity. To achieve this goal we will need to remove invasive brome grass and reseed with mixes that are more suitable for a southern dry prairie ecosystem.

4. *Reduce the cover percentage of smooth brome grass (*Bromus inermis*) by 90% in 5 years.*

*Bromus inermis* is an invasive grass that grows via rhizomes. It can be managed by fire and herbicide applications. It has completely overtaken much of Site 2 (cover class 5) and should be reduced to promote diverse native vegetation and extensive prairie systems. It can be effectively managed and should be reduced as much as possible, which is why the reduction percentage is high. Management of brome grass should be feasible in 5 years.

5. *Reduce the cover percentage of common buckthorn (*Rhamnus cathartica*), by 90% in 10 years.*

*Rhamnus cathartica* is an invasive tree/shrub that produces large amounts of viable seed. It can be managed by both pulling it and cutting with stump treatments. It is present in all restoration units and should be reduced to promote native vegetation, especially at the ground level and subcanopy level. Eradicating buckthorn is a slow process, hence why it will take at least 10 years to reduce the cover percentage by 90%.

## SOIL AND LANDFORM MODIFICATIONS

### Trail Construction Considerations

#### Trail Alignment

N2 will be different than the other restoration sites because a kiosk is planned for the overlook in addition to the bike path running next to the road. While it is unknown if the path connecting the kiosk will be a loop or just one path leading to and from the kiosk, we do know the construction will affect the restoration more than the other sites. The main path will run just inside the treeline (see Map 4) with the additional path spurring from it to the overlook. N2 is a beneficial site for the paths due to the views overlooking the valley and the minimal variation in elevation. Due to the small elevation change on site, erosion will not a be a concern on N2. The main concern regards construction and compaction, further detailed in the next section.

**Map 4:** Trail Construction Pathways

**Timelines and Minimizing Adverse Impacts**

To help ensure a successful restoration, restoration plans must be integrated with the trail construction plans. Since it is unknown when the trail construction is scheduled, there are two possible general scenarios: the restoration will begin before trail construction, or the restoration will begin after the trail construction. The difference in scenarios will affect supplies and timing.

*Scenario 1: Pre-Construction Restoration.* The restoration beginning before trail construction will have a profound effect on plans and the supplies needed for restoration. If seeding has already taken place, the trail construction will effectively reverse part of this process. Since there is either a trail spur or loop that will extend to the far northeast corner of the site above the historic ski slopes, there is a potential for damage to the site. After trail construction, the area surrounding the trail that had the most traffic will need to be reseeded, which will increase costs. Thus, we recommend there be a budget for extra seed and manpower costs. Alternatively, seeding could be postponed in the sites where the trail will be built in anticipation of construction. This may save money on seed, but could leave areas open for invasive brome grass and other species to reestablish.

Since the construction will remove the top 6 to 12 inches of soil, this soil needs to be deposited on or off site. It is possible that this soil can be used to grade the site around the trail or fill in the out-washed and eroded areas in Restoration Unit 1. The construction should not be active while restorationists are doing prescribed burns or broadcasting herbicides.

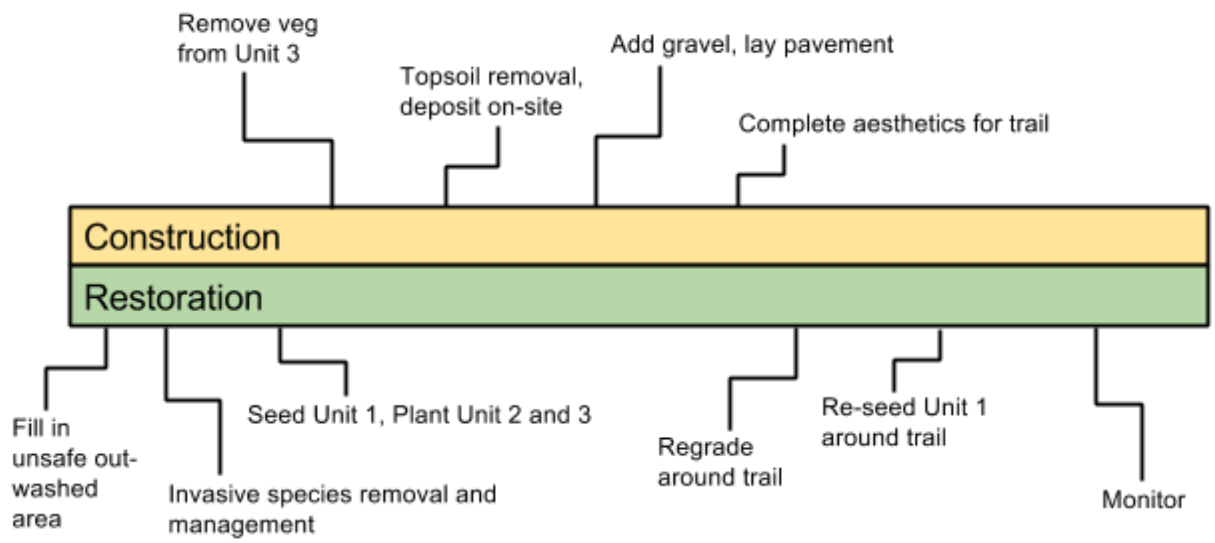


**Image 5**: Pre-Construction Restoration Timeline

*Scenario 2: Post-Construction Restoration.* In terms of efficiency and cost effectiveness, it would be best if restoration efforts began post trail construction. The topsoil that is removed for paving the trail can be used on-site to fill in the out-washed and eroded area in Restoration Unit 1 and the construction team can grade this area to eliminate the safety hazard for trail users. Restorationists will still need to work with the trail planning team and the construction crew to choose how the path will cut through the remaining woodland vegetation in Unit 3. The construction team can be trained to remove buckthorn effectively while making a path through Unit 3.

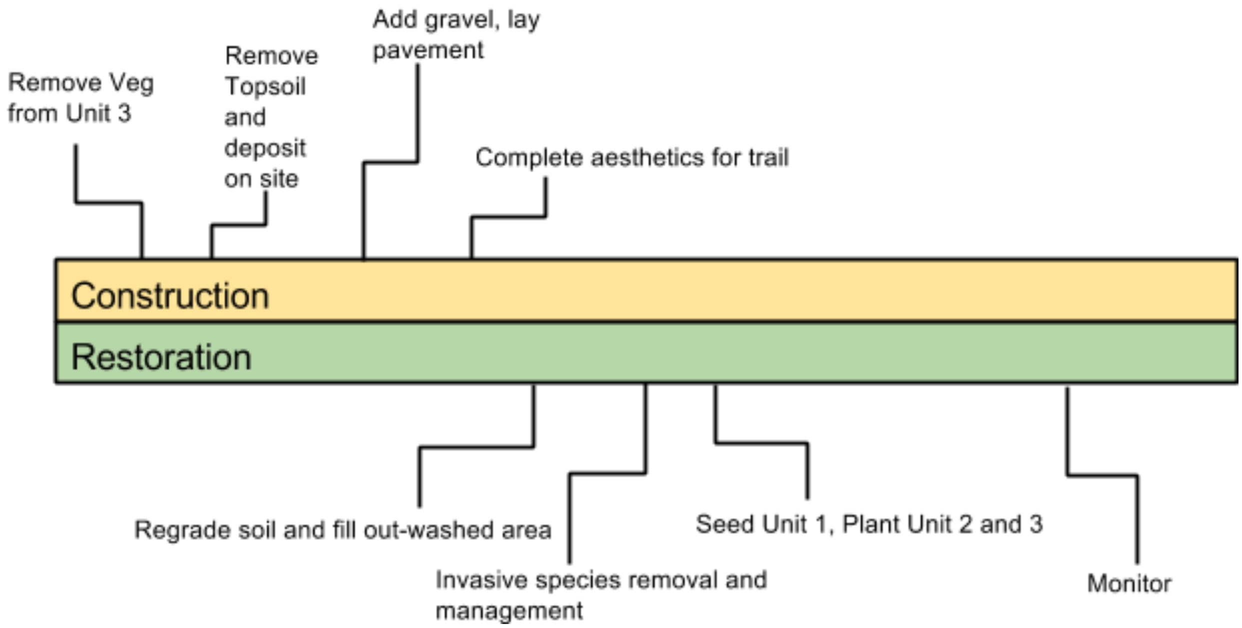



**Image 6:** Post-Construction Restoration Timeline

The trail construction could negatively affect the restoration of the site through soil compaction and disturbance, native tree removal, and the possible introduction of invasive species. In order to minimize the adverse effects of the construction, several measures must be taken by both the restoration and construction teams. Soil compaction should be avoided by earth-moving vehicles using alternate routes, staying close to the area that is being excavated for the trail, and being efficient. Efforts should be taken to decrease the amount of foot and vehicle traffic by construction and restoration teams. Since the trail is going to be on the inside of the tree line, it is likely some trees and woodland vegetation in restoration Unit 3 will need to be removed. We suggest removing as little native vegetation as possible, while still keeping the path on track. Removal of large canopy and subcanopy trees should be avoided, while invasive buckthorn should be targeted for removal. The restoration team should flag trees they want to keep prior to construction. Also, to decrease the spread of invasive species on the site, all equipment and footwear should be cleaned before entering the site, as invasive species are often spread by vehicles and humans.

### Soil Erosion

Neither wind, nor water erosion is currently a problem within the site of N2, although the adjacent bluffs will most likely be the site of erosion, if it occurs at all. N2 is a flat area, with a high elevation compared with it's surrounding area. The soils throughout the site are composed of a variety of loamy sands, and are quite permeable throughout, allowing moisture to penetrate the soil, instead of running off and causing erosion. In addition to the ideal soils throughout N2, vegetation is abundant, except on the dirt road. The dirt road area, free from vegetation, does not pose much erosion risk because the site is so flat. The water that falls on the road will either infiltrate, or run off the sides of the road and into the surrounding vegetation to be infiltrated. The rest of N2 is covered in abundant prairie grasses in the center, and woodlands along the periphery, and does not currently pose an erosion risk. The bluffs adjacent to N2 along the northern border slope steeply downward, and though they are covered in vegetation, it is the most likely site of erosion surrounding N2. The area used to be used as a private skiing hill for Flint Hills employees. The areas where the ski slopes were located are bare of the tall wooded vegetation that surrounds the rest of the bluffs, but prairie grasses are present throughout the slope, and erosion does not pose a large risk in the area as long as that vegetation remains. A large area of the N2 site will be left bare after the brome grass is removed, but before the native vegetation replaces it. Again, being that the site is flat and the soils are very permeable, erosion is not a large risk, even with bare soils exposed. The surrounding tall vegetation will help create a wind barrier to keep seeds where they are placed, and they will establish before erosion has the potential to occur.

Careful consideration will be taken throughout the restoration to ensure no erosion occurs, and if a risk of erosion is ever observed, there are actions that can be taken to amend the problem. Vegetation will not be removed at all on the bluff adjacent to N2, to ensure the soil is never left bare, and erosion doesn’t occur. If amendments to the vegetation occur at all, it will be limited to additions, without the removal of what is currently there. If erosion is ever observed along the ski slopes where it is most likely to occur, the soft engineering technique that uses live fascines would be the best management practice used to amend the erosion. A source of dormant branches can be found within the surrounding oak woodlands, and the ski slope would likely erode into a gully that would allow the live fascines to be arranged in a narrow downward sloping pattern. Erosion is currently unlikely anywhere else on the site, except possibly on the dirt road that runs along the eastern border of the site. To avoid erosion in this area, or if erosion is ever noticed, the road could be eliminated. Transplants in cardboard boxes could be planted along the dirt road to avoid wind disturbance, and eventually enough vegetation will be established to eliminate the risk of erosion along the road entirely.

## Soil Conditions and Amendments

All three soil types on N2--Wadena loam, Hubbard loamy sand, and Hawick loamy sand--are of the Mollisol order, which is characterized by a deep A horizon high in organic matter and thus highly suitable for plant growth.  Correspondingly, aerial images since 1937 indicate an agricultural presence on the site until the 1960s. Since then, the site appears to have been left uncultivated, allowing enough time so that the impacts of cultivation on the soils are now largely undetectable. Indeed, field samples during the site assessment indicated a dark A horizon down to approximately 10 to 15 inches throughout the site. This, along with continuous plant cover observed across the site, suggests the site is well-suited for plant growth and therefore restoration. As such, no soil amendments, such as fertilizer or compost, are recommended.

Although fairly uniform in topography, few areas on the site were observed having abrupt depressions, with a depth to around 1 ft, that could be hazardous to recreational use on the site. These should be made level with the surrounding topography. Depressions could be filled with soil excavated during construction of the bike path.

## SITE MONITORING AND EVALUATION PLAN

### Goal Monitoring Summaries, Parameters, and Interpretation

***See Appendix E for detailed monitoring protocols**

***Goal 1: Detect 50% increase in bee abundance over entire N2 prairie unit in 10 years.***

Due to the current dominance of *Bromus inermis* and low abundance of native forbs in the prairie unit of N2, it is likely that few bees are visiting the site. Bees are important in prairie restorations, as many prairie plants need pollination for seed production (Reed 1993). Bees also aid in pollinating agricultural crops in the surrounding landscapes and region. Bee abundance is positively correlated bee diversity and can thus provide an indication of how suitable a habitat is for bees (Ward et al. 2014) .

The monitoring protocol for this goal, adapted from the Xerces Society (Ward et al. 2014), involves multiple 15-minute observations, occurring two times during the middle of the growing season (July-August), of bees. While these observations do not span the entire range of bee activity (May-September), this streamlined monitoring protocol is sufficient in determining a habitat's suitability for bee pollinators. Additionally, this method requires relatively minimal bee identification training, is non-destructive to bee populations, is time- and cost-effective, and can accurately estimate the abundance and diversity of bees on a site (Ward et al. 2014).

***Goal 2: Establish an actively used habitat for upland prairie bird species - particularly the rare Grasshopper Sparrows, Western Meadowlarks, and Henslow's Sparrows - within 10 years.***

Three indicator species will be observed on four occasions each year to determine if the restoration was successful at providing an actively used habitat for upland prairie bird species. Grasshopper Sparrows, Henslow's Sparrows, and Western Meadowlarks are three rare upland prairie bird species that have seen declines in recent years (Audubon Minnesota). Their populations will be observed at two different locations of N2 in unlimited radius 4-minute auditory point counts, four times each year in June, between 5:30 am and 9:00 am. During point counts the total number of indicator species observed will be recorded, and the approximate location of each species within the site will be displayed on a map of the site. The averages of these four observation dates each year will be compiled into a bar graph and compared to previous years to determine if there have been concerning increases or decreases in populations between years. Each of the four maps indicating the approximate location of the indicator species will also be compiled every year to determine where the birds are thriving the best, and if there are areas within the site where the birds are not thriving at all, determining if further modifications on the site will be necessary.

This monitoring protocol is cost effective, and can be achieved in a timely manner, though the populations of these species tend to fluctuate, and determining if a viable population has been established could take the whole ten years. The advantages to the protocol are that monitoring only takes place once each week in the month of June, it can be achieved by just one person, and the whole site visit will take only about 15 minutes factoring in the walking time. The company that enacts the monitoring on N2 will not need to pay their employee for more than an hours work, four times each year. The disadvantage to this protocol is that rare Minnesota bird species are being monitored, and their populations have a tendency to fluctuate. If an average of just three Western Meadowlarks, or Grasshopper Sparrow's are observed in any given year within ten years, and twenty Henslow's Sparrows, the restoration will be considered a success. However, it could take the full ten years to determine whether the site yet has a suitable upland prairie habitat.

A quality data set will be collected, and then displayed on maps and bar-graphs so restorationists can determine if further modifications are necessary within the site. It is highly recommended that the same monitor take the point counts each time, ensuring that any discrepancies made by the monitor are accounted for. The monitor should also try to be in the exact same location (Map 6), at the same time of day - between 5:30 and 9:30 am - on each monitoring date, so fluctuations in populations are not seen due to differences in the location or time of day. While monitoring, a map of the site will be at hand so the monitor can quickly record which of the three indicator species was detected, and the approximate location where it was. The monitor will also need a timepiece to determine when the four minutes are up, and must be quite knowledgeable about the birds being monitored, so they are accurately detected.

After the birds are recorded onto maps and bar graphs the information can be interpreted to determine if further restoration actions are necessary. If the maps show areas where bird activity has consistently been very low, it could indicate that the prairie restoration may need improvements in those areas. If none, or very few of the indicator species are observed on the site within ten years, it will indicate that the upland prairie habitat necessary for these birds has not yet been established, and further modifications on the site will be necessary.

***Goal 3: Establish 80% native vegetation typical of a southern dry prairie in 5 years.***

The goal will be measured by monitoring species composition based on standard practices of species composition sampling using percent cover in quadrats and site-wide plant surveys (Galatowitsch, 2012). The vegetative structure of canopy trees and smooth sumac patches will be measured using aerial images. The vegetative composition surveys will take place twice a year in the late spring and late summer for the first five years to identify plants when they are flowering or fruiting. The aerial photographs will be taken once a year in the summer months (when all trees and shrubs are leafed out with normal color) for 5 years, and then once every 3 years for 6 years. See Appendix E for a detailed monitoring protocol.

Plant species composition and richness are good indications of site condition and are biologically relevant. The proportions of cover are estimated visually and provide good information on species richness and the overall abundance of species, while being relatively quick to estimate. It is a non-destructive, sensitive, and easily measured parameter. However, challenges such as low accuracy, inconsistent surveyors, and large data sets could complicate data analysis. Comprehensive, site-wide species composition surveys will be done to augment data and provide a better sense of invasive and endangered species presence.

Aerial images are useful for identifying and visualizing changes in vegetative structure. The total area and change in patch size of canopy trees and smooth sumac can be measured in all restoration units. Aerial photographs are taken just once a year and require little time are non-destructive. However, subcanopy or ground layer vegetation is difficult to measure reliably using aerial images and taking aerial images can be costly.

Data is collected for the purpose of monitoring ecological change. After data from the vegetation composition and structure monitoring is interpreted and the appropriate statistical tests are performed (see Appendix E), the data can be used to make decisions about the site and plan future actions. If there are low numbers of native species or certain functional groups absent in the surveys, this could indicate that there was not enough viable seed in the seed mix, seed did not germinate, the seed mix ratios are not correct, or invasive species have not been sufficiently reduced. The absence of native species and functional groups could decrease the likelihood that the goals of increasing pollinators and bird species will be accomplished. Depending on the timing, measures may need to taken to remove more invasive species, rethink the seed mix, or reseed.

***Goal 4 and 5: Reduce the cover percentage of smooth brome grass (*Bromus inermis*) by 90% in 5 years* and *common buckthorn* (Rhamnus cathartica) by 90% in 10 years.**

Invasive species overtaking beneficial and native vegetation can be detrimental to a restoration project and therefore must be monitored closely. As they are directly correlated to the success of species composition, a similar monitoring program will be used. Quadrants of 40m by 40m will be measured and documented to perform a vegetation survey, specifically seeking and recording locations of populations of *Bromus inermis* and *Rhamnus cathartica*. The vegetation survey will take place twice a year. The first survey will be performed in spring to monitor the invasive species finding early in the season and the second will take place in fall in order to monitor how the populations have changed over the growing season. These vegetation surveys will be performed for a minimum of five years to ensure any lingering populations are under control. See appendix E for more information on this protocol.

Vegetation surveys would be a successful tool for this goal because it would be performed at the same time as the surveys for goal 3, establishing native vegetation. This monitoring practice would cause minimal impact on the landscape. Given the surveyor only needs to account for two species of plants, the practice should be timely and accurate. Challenges include thoroughness, as it will not be as obvious as large drifts of similar species, and survey accuracy which could include quadrants measured differently at each survey.

The data collected can help inform decisions. A potential variable based on new information could be the amount of times per a year a survey is conducted. If the restoration site is seeing large jumps between surveys, it would indicate that more surveys need to be performed. Oppositely, if the goal is reached after the first few years, it would indicate our practices have become successful and less monitoring will be necessary in the future. Surveying populations on a quadrant system also has a spatial benefit. The survey will not only tell the restorationist  populations, but also where these populations are found. With this system, the restorationist will be able to see which parts of the restoration sites are doing well and which need the most amount of work to become successful.

## Logistics

**Schedule**

The following are approximations of dates for monitoring activities. It is possible that data could be collected from the invasive species and vegetation composition monitoring on the same days. Pollinator surveys will occur once at the beginning of July and once at the end of August each year. Monitoring indicator bird species will occur once each week in the month of June (a total of four times). Vegetative structure will be monitored in the middle of July. Vegetative composition will be monitored twice each year in the beginning of June and in the beginning of September. Invasive species monitoring will take place twice each year, once in the spring, and once in the fall.

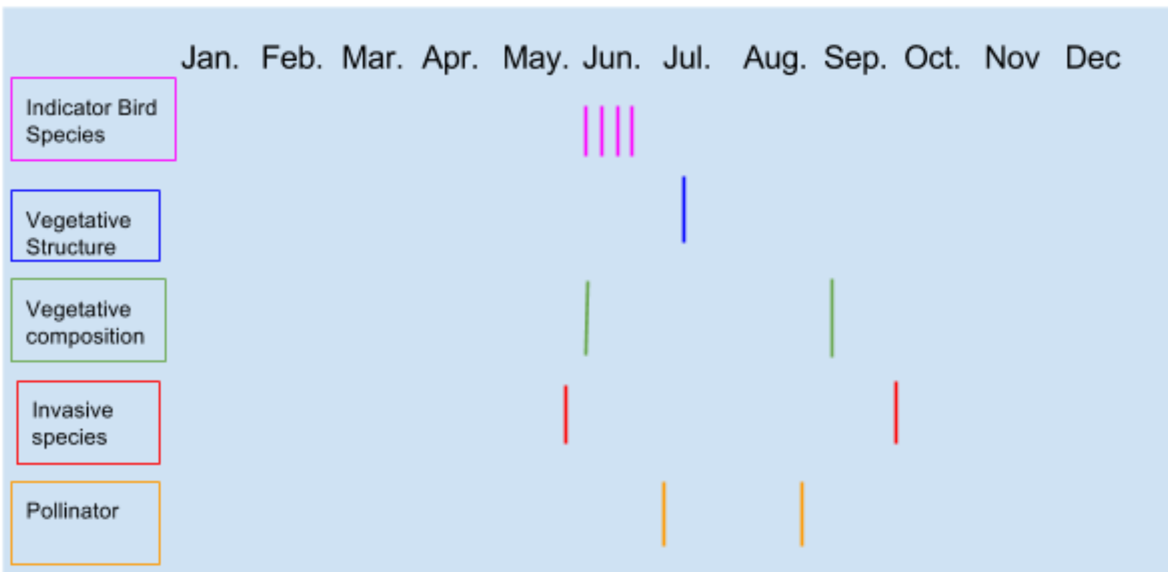



**Table 2:** Restoration Monitoring Schedule

## Cost Estimates

**Goal 1:**

Personnel: Staff (1) x Time (1 hour) x Days (2 per year) x Salary ($15.00/hr) x Years (10) = $300.00

Materials

Thermometer: $5.00
Data sheets: $10.00
Monitoring protocol: $0.00
Clipboard: $10.00
Pencils/pens: $5.00

Long measuring tapes: $25.00
Flags or stakes to mark transect start and end: $20.00
Camera or phone with high quality camera: provided
Total = $75.00

*Total for 10 years: approx $375.00*

**Goal 2:**
Personnel: Staff (1) x Time (1 hour) x Days (4 monitoring dates) x Monitoring period (10 years) x Salary ($15 per hour) = $600

Materials:
Clipboard: $10.00
Pencils/pens: $5.00
Printout of site map: $0.00
Timepiece (phone or watch): Provided
Total: $15.00

*Cost of monitoring for 10 years: approx $615.00*

**Goal 3:**

Personnel
Volunteers for vegetation composition monitoring: Volunteers will not be paid, but they will need to go through a week long training lead by staff.

Staff (1) x Time (40 hours) x Salary ($15 per hour) x 1 year = $600.00

-OR-

Contractor for vegetation composition monitoring: Twice a year, a team of two will need to collect data for three days for vegetation composition monitoring.

Staff (1) x Time (24 hours) x Salary ($15 per hour) x 5 years = $1,800.00

Contractor for aerial images monitoring for 11 years = 7 photographs x $300.00 per photograph = $2,100.00

Total: $2,700.00 - $3,900.00

Materials
Gleason and Cronquist: $74.00
Hand Lens (2-4): $20.00 to $40.00
Survey Markers: 30 x $10.00 each = $300
Flags: $10.00
Quadrat Marker: $15.00

Total: $419.00 - $439.00

*Cost of monitoring for 10 years: approx $3,119.00 - $4,339.00*

**Goal 4:**

Personnel
Volunteers for vegetation composition monitoring: Volunteers will not be paid, but they will need to go through a week long training lead by staff.

Staff (1) x Time (40 hours) x Salary ($15 per hour) = $600.00

Total: $600 per year for 5 years

Materials
Survey Markers: 30 x $10.00 each = $300
Flags: $10.00
Quadrat Marker: $15.00
Total: $415.00

*Cost of monitoring for 10 years: approx $3,415.00*

**Total Projected Cost for 10 years of monitoring: $7,524.00- $8,744.00**
*Note: Total projected cost may be less if invasive species monitoring and vegetation composition monitoring can be completed on the same days with already trained volunteers.

## Data management

There are several intentional steps that need to be taken to ensure quality data sets for all goals. The main goals should be to minimize data loss, collect data accurately, and facilitate data use.

The first step in this process is to provide sufficient training to all volunteers and paid workers who are helping survey the sites. These volunteers and workers need to be trained on plant, bird, and pollinator identification. Volunteers should only be used if they have previous experience in the subject. All people working on the site, even paid workers, should be oriented to the site and trained with the proper monitoring protocols to ensure understanding and compliance. In the case of plant identification, if plants are unknown, they should be collected and pressed for identification off-site.

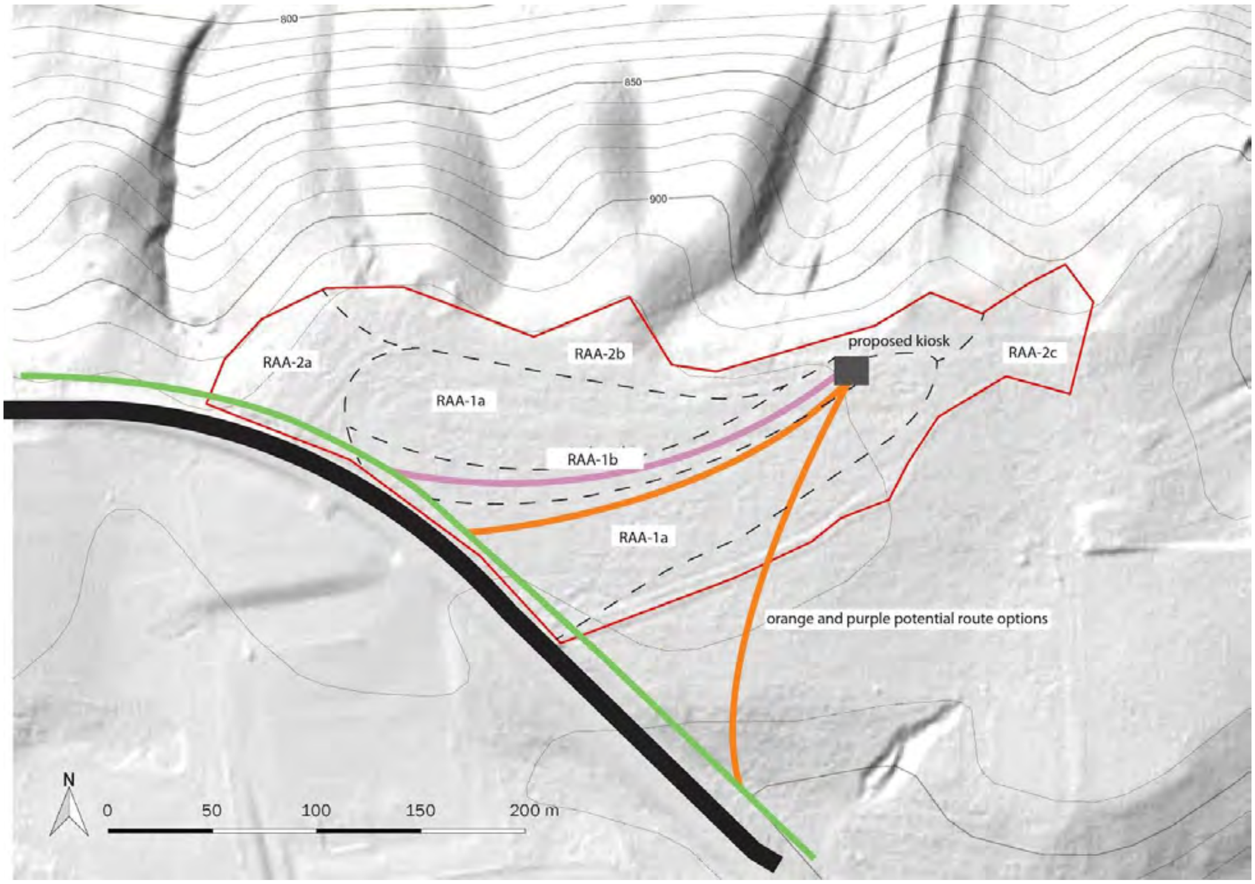
All field data will be collected on pre-made data sheets. Surveyors must be diligent in their collection of information. The names of each surveyor should be on the data sheets so they can be referenced if there is a question about the data.  Often, data can be misinterpreted or recorded incorrectly. To reduce this risk, data sheets should be immediately copied with a copier and digitized. No field data sheet should ever be thrown away, but they should be filed in a specialized data folder for each parameter. Digitized information should be saved on a computer, an external hard-drive, and in the cloud. There should be one designated person from the restoration team who checks the data every 6 months to ensure that it has not been lost and can update field sheets to represent taxonomic and site changes.

Photographs provide visual records and are a great way to monitor site conditions. They can also help with bird and plant identification.  Make sure all cameras are cleared of previous site/survey pictures before going out in the field and pictures are stored in the appropriate folders, labeled with the date, time, subject matter, and survey area. They should be stored in the same way as digitized data sheets.

It is always possible that quadrat markings could be vandalized or lost due to weather events. Take GPS coordinates at each corner of four different quadrats of the vegetation composition survey and at each bird observing site. If markings are lost, they can be replaced. Surveyors need to be prepared for this and take extra flagging and markers with them.  They should also be prepared for all weather events and plan clothing and equipment appropriately.

## REVEGETATION/VEGETATION MANAGEMENT

### Restoration Action Areas




**Map 5: Restoration Action Areas:**

RAA1a: dry prairie
RAA1b: forb enhanced dry prairie
RAA2a: oak savanna
RAA2b: dense woodland/oak savanna
RAA2c: oak savanna

### Description and Rationale

Site N2 was originally delineated into three restoration units, Unit 1: Brome Field, Unit 2: North Woodland, and Unit 3: South Woodland. The Restoration Action Areas (RAAs) are closely related to these unit delineations. The general revegetation strategies are to establish vegetation typical of southern dry prairies and oak savanna and reduce invasive species like smooth brome grass and buckthorn, in addition to non-native woody plants and weeds.

Restoration Action Area One is very open and currently dominated by smooth brome. The revegetation plan is to plant this area (RAA1a) as a southern dry prairie. Historically, this area of the site was prairie and because it is relatively devoid of trees and already has some native prairie species, it should be restored as a southern dry prairie. There are also plans to build a trail spur out to a kiosk to overlook the Mississippi River and the woodland/oak savanna areas. It makes sense to leave this middle area and area around the trail and kiosk more open to create a view. We suggest enhancing the area five feet on either side of the trail and the kiosk (RAA1b) to increase aesthetic value while attracting pollinators. Restoring these two areas of land as described will help reach all five of the site goals. In order to establish vegetation typical of a southern dry prairie, any invasive or woody species must be reduced substantially. Planting prairie species with high pollinator value will attract native bees to the site and these native species will also provide suitable habitat for upland prairie bird species.

Restoration Action Area Two is most effectively split into three parts, A: the western unit, B, the northern unit, and C, the eastern unit. RAA2a was originally in Restoration Unit 1- Brome Field and was slated to be restored as prairie. However, upon closer examination, it is surrounded by woodland species which suggests it could be best restored as an oak savanna, with good grass and forb density and less dense sub-canopy trees. RAA2b is a natural woodland border with remnant oak savanna and dry-mesic oak woodland species. RAA2c also has a natural woodland border and could best transition into the southern dry prairie area of RAA1 by planting species typical of an oak savanna. These restoration action areas will help reach site goals related to invasive species reduction and establishing actively used habitat for upland prairie bird species. It will also establish habitat typical of oak savanna.

Site N2 has remnant plant populations and invasive species, which advocates for both active and passive revegetation strategies. RAA1 has the most active revegetation plan due to the strong presence of smooth brome grass (cover class 6). In order to reduce the smooth brome populations, herbicide will need to be broadcasted across the entire area. Glyphosate, the most effective herbicide for smooth brome reduction, is not species specific and will kill all plants on site. There are some remnant native prairie plant populations on this site, but without the removal of smooth brome, they have little chance of thriving and the goal of establishing 80% native vegetation typical of a southern dry prairie in 5 years will not be reached. This area will need to be completely seeded. RAA2 has a combination of both active and passive revegetation. Areas that have smooth brome will need broadcast herbiciding and seeding with native plants, as with RAA1. However, there are also remnant populations of native woodland edge prairie species and native *Quercus sp.* (oak) and sub-canopy trees like *Prunus* *virginiana* (chokecherry) and *Prunus pennsylvanica* (pin cherry) that should be kept and can be used as sources for seed, either to be collected or left to naturally regenerate. These seed sources are within RAA2 and have good contact with areas that will be restored to oak savanna. The management of invasive species will promote the establishment of these native species.

## Restoration Action Area One

### Extant Vegetation for RAA1a and RAA1b

See Appendix A for complete list of species found in the prairie. The area is dominated by brome grass, the biggest inhibitor for native species growth. Sumac is present in two masses. These two species will be the most difficult to control due to vigorous growing in addition to close proximity in surrounding landscapes. Appendix G details directions for control. The removal of brome grass and control of sumac is essential to the success of the dry prairie restoration.

### Site Preparation for RAA1a and RAA1b

The center of N2 is currently dominated by smooth brome grass (*Bromus inermis)*, an unwelcome weed species that has invaded the area. To create the prairie habitat within this action area that supports native prairie plant species, as well as an abundance of pollinator and bird species, the weeds within this area must be destroyed. The woody species above 3/8 inch diameter will be controlled using the cut and treat method, in the spring of the first year. The woody species below 3/8 inch will be controlled using the spot spray method. The smooth brome grass and remaining weed species will be controlled using a broadcasting treatment of glyphosate herbicide in the autumn of the first year of restoration as described in Appendix G. The broadcast treatment will be applied using a handheld boom after a single mowing to reduce weed surface area. This will control the majority of weeds and brome grass within the prairie.

**Table 3:** RAA1 A & B Site Prep Action Timeline

| Year | Season | Activity |
|---|---|---|
| 1 | Late summer/ Early Fall | Broadcasting |
| 1-2 | Monthly, beginning late spring/ early summer | Basal bark treatment of sumac |
| 2-3 | late spring/ early summer | Hand pulling of new sumac shoots |

### Revegetation Actions for RAA1a and RAA1b

The Prairie Restoration Action Area (RAA1) is divided between dry prairie and enhanced forb areas. The divide is due to the recreational use of the site. A five foot buffer along the trail leading to the kiosk will be the forb enhanced area. The remainder of action area one will be dry prairie. The forbs featured in the seed mix for the dry prairie (1a) will be used in drifts in the enhanced area (1b). Using a similar palette of forbs will ensure a cohesive look among the two areas.

The design of the prairie restoration action area seed mix is based on pollinator value due to goal #1, successional stage for year-round success, and overall aesthetics in response to the recreational use of the trail. Each species chosen incorporates at least two of the three qualities listed above. See Appendix F for seed mix species selection, lbs/acre, and cost/acre.

RAA1 A and B will be seeded using both seeds collected during year one from the site, and a customized seed mix (Appendix F). Some mature seed will be collected from this RAA before the broadcasting glyphosate treatment in year one. These seeds will be collected only from the following sources: white heath aster *(Symphyotrichum ericoides)* and whorled milkweed *(Asclepias verticillata).* The rest of the seeds will be obtained from Prairie Moon Nursery, a nearby seed supplier. These seeds were selected for the very high, to high pollinator value, and range of successional stages, as well aesthetic value. The seeding will occur in the spring on a nice day about halfway through May. This seeding date allows for the longest establishment time before winter. At the time of seeding a mechanized broadcast seeder will be used to seed the main site of RAA1 A and B, in combination with an auger, which constantly rotates the seed, allowing them to be evenly dispersed (Williams, Ch. 4). Using the broadcast seeding technique will allow the seeds to be dispersed at the intended rate, and allow the seeds an adequate amount of sunlight for germination.

The enhanced area (RAA1b) will include additional seeds that will be implemented by hand casting of seeds into drifts. This will be done from the path under the scenario it has been constructed before the restoration or from where the path will eventually be constructed. The location of the person casting seeds is important in controlling the size and relationship to the path of the drifts. Each drift of an individual specie should be hand casted separately and should be no larger than 20 sq ft to ensure variety and interest as the recreationalist uses the path. Hand casting will give the drifts an organic shape instead of a formal grid shape that drilling would create. Broadcasting would mix the species too much and eliminate the large swath of forbs that drifts are typically shaped from.

**Vegetation Management of RAA1a and RAA1b**

**Year One**

Mowing will be used to manage vegetation in the long term. Mowing often in the first year can significantly reduce weeds, while maintaining the newly established native prairie vegetation. In the first growing season, none of the vegetation will be allowed to get higher than 12-18 inches. Once at about boot height, all vegetation within RAA one will be mowed to a 4-6 inch height. This will achieve a reduction in weedy species, but without damaging the newly planted native seedlings. Mowing will take place about every three weeks for the first year (Williams Ch. 6). The only species that will not be mowed is sumac. Basal bark application will be practiced in later spring or early summer in areas that population of sumac is not yet contained. See appendix G for details on sumac control.

**Year Two**

During year two, vegetation should not be mowed until it reaches a height of at least 12 inches, to avoid damage to newly established natives. Spot mowing or hand pulling of weeds in patches could also help minimize damage to the desired vegetation, though it is essential that weed treatment occur before the weeds are allowed to set seed (Williams Ch. 6). The sumac population will be sprayed with the basal bark application once in the late spring or early summer if necessary (Pleasant Valley Conservancy). Suckers should be treated or pulled by hand.

**Year Three**

Mowing should not be necessary in year three and beyond if the establishment of native prairie has been successful. The threat of a weed canopy establishing in year three would signify that a stand evaluation should be conducted. If less than one native plant per square foot is observed, it would be necessary to broadcasting herbicide throughout the site again, and start vegetation efforts over (Williams Ch.6). Basal bark sumac treatment should not be necessary due to the small amount of species that will be removed from the prairie stand. Any root suckering can be pulled by hand.

**Long-term Management**:

Prescribed burns are a long term management practice for prairies because their ecosystems are fire dependant. Dry prairies accumulate enough litter to burn approximately every ten years. The burn should take place early in the season to control cool season grasses, but leaving native species unharmed (MN DNR).

The first step to a prescribed burning is creating a ten to fifteen foot buffer that acts as a fire wall via mowing (MN DNR). This will protect the other restoration action areas. After the burn, the prairie plants will come back stronger and produce more flowers and seeds. The year following a burn, the prairie emerge from dormancy sooner. The blackened soil heats up faster than soil that was not burned the previous year. A prescribed burn can also help control movement of the oak savanna (MN DNR). If it begins to come over into the prairie, the burn will stop it. Note the buffer is important to stop the burn from reaching the oak savanna restoration area (RAA2-a,b,c).

**Restoration Action Area Two**

We've identified three main areas throughout our site (2A, 2B, and 2C; Map 10, Table 4) that would be suitable for oak savanna restoration. The edges of these sites all have some well-developed canopy and subcanopy species; however, we did not see a notable amount of natural regeneration of these species, likely due to invasive plants, such as buckthorn and honeysuckle, outcompeting them for light and other growth resources. Thus, we recommend woody plants are purchased from a nursery and planted following proper site preparation (e.g., removal of invasives). The woody plants we've selected for these areas are based on data from reference sites with relatively minimal human disturbance (DNR MBS Plant Community Guide, 2005). We also recommend seeding the area with woodland edge/prairie species after the reduction of the invasive smooth brome grass.


**Map 6:** Restoration sub-units for restoration action area 2 (RAA2).

**Table 4:** Approximate area of sub-units in RAA2.

| **Section** | **Area (ft^2)** | **Acres** |
|---|---|---|
| RAA2a | 21,000 | 0.5 |
| RAA2b | 43,500 | 1 |
| RAA2c | 108,000 | 2.5 |
| *Total* | 172,500 | 4 |

**RAA2a**

**Extant Vegetation**

This area is dominated by smooth brome grass and other weedy species (hoary alyssum, catmint) in the northwest and center, along with some native species such as giant goldenrod (*Solidago gigantea*), canada goldenrod (*Solidago canadensis*) and white snakeroot (*Eupatorium rugosum*). The southeast corner is a mixture of non-native woody species such as siberian elm (*Ulmus pumila*) and amur maple (*Acer ginnala*) and native woodies such as cottonwood (*Populus deltoides*), eastern redcedar (*Juniperus virginiana*), and boxelder (*Acer negundo*). In the subcanopy, there is native pin cherry (*Prunus pennsylvanica*) and the invasive common buckthorn. Many of these species are not typical of oak savannah and some are invasive and/or weedy. All invasive and weed species should be managed and/or removed to allow native vegetation to flourish. Most vegetation that is not typical of oak savanna should be removed in phases. We suggest phasing the removal of larger trees because many of these trees act as screening from the road are aesthetically pleasing.

**Site Preparation**

Since smooth brome is dominant in this restoration area (cover class 6), one of the first steps in restoration is to manage the amount of smooth brome present on the site. This will be accomplished by broadcasting a high concentration glyphosate herbicide. See Appendix G for specific details regarding the treatment of smooth brome. The use of herbicide is recommended because smooth brome is a perennial grass that regenerates not just from seed, but from underground roots. Mowing before seed set will not be enough to obtain a significant reduction in the amount of smooth brome. The broadcasting should not include the populations of goldenrod in the northeast of the RAA.

Broadcasting smooth brome areas with glyphosate will also control other weedy or undesirable grasses, broadleaves, and woodies. Therefore, if broadcasting misses weedy patches or if you are applying herbicides around areas of desirable species, such as white snakeroot (*Eupatorium rugosum*), spot-spraying these patches with glyphosate should be sufficient for control.

There are many native and non-native woody species in this action area. Buckthorn is the most invasive of the species on the site, although other shrubs and trees should be removed to promote a true oak savanna plant community. See Appendix G for specific details regarding the treatment of buckthorn and other woody shrubs and trees. We suggest the phased removal of the eastern redcedar along the roadside because they are not a naturally occurring species in the oak savanna community (MN DNR, 2005). We recommend removing 2 to 3 trees every 3 years for a 10 year period. We also recommend the removal of the following species: buckthorn, siberian elm, amur maple, and boxelder. In addition, the stumps of trees near the bike trail should be removed by either pulling them out if they are small enough, or using a stump grinder.

**Table 5:** RAA2a Site Prep Action Timeline

| Year | Season | Activity | Acres |
|---|---|---|---|
| 1-3 | Early Spring | Buckthorn Hand Removal | 0.25 |
| 1-10 | Fall | Phased Removal of Eastern Redcedar | 0.1 |
| 1-3 | Fall | Cut Stump and Treat Woodies | 0.25 |
| 2-3 | Fall | Treat resprouts and seedlings | 0.25 |
| 1-2 | Spring | Spot spray weeds | 0.5 |
| 1 | Late Summer | Mow Smooth Brome | 0.5 |
| 1 | Fall | Broadcasting Brome with Glyphosate | 0.5 |

**Revegetation Actions**

**Oak Savanna**

Oak savannas are a threatened plant community of the midwest, with less than 0.01% of communities remaining (NRCS 2003). RAA2a provides a suitable opening (approximately 0.5 acres) from the surrounding forest edges for an oak savanna planting. Trees for oak savannas are typically planted in a density of 25 trees per acre, with spacing between trees no less than 30 ft (NRCS 2003). For savannas, oaks are typically planted in clusters or blocks, rather than evenly distributed across an area (NRCS 2003). For RAA2a we recommend planting two clusters of bur oaks (*Quercus macrocarpa*), each with 6 potted plants. One cluster will be in the northern portion of RAA2a and another in the southern portion. Clusters should be far enough away from surrounding forest canopy trees as to not be impeded by shading of the canopy. Spacing of trees within each cluster should be at least 30 ft; the clusters do not require uniform spacing. See Map 11 for an example spacing. Oaks should be planted following the burning of established prairie vegetation. After planting, the oak savanna should not be burned until oaks have reached a diameter-at-breast-height of 6 inches (NRCS 2003).

**Woodland edge**

Along the woodland edges of RAA2a, we recommend planting a mix of shrub-layer and sub-canopy trees typical of the area (MN DNR MBS 2005). For these layers, we've selected northern red oak (*Quercus rubra*), basswood (*Tilia americana*), black cherry

(*Prunus serotina*), American hazelnut (*Corylus americana*), Missouri gooseberry (*Ribes missouriense*), and pagoda dogwood (*Cornus alternifolia*). Many of these species produce berries and can serve as a food source for birds and other wildlife. For RAA2a, 7 of each species will be planted within 20 ft of the forest edge at roughly even spacing along the edge. Most of these species do well under partial shade; however, hazelnut should be planted farther from the edge to receive more sun. The exact distance from the edge and order in which the species are planted may be alternated to create a natural-appearing edge. Potted plants from Out Back Nursery (Hastings, MN) will be used (see Appendix F).

**Map 7**: Planting example for oak savanna in RAA2a.

### Prairie Vegetation

The design of the seed mix for the ground cover of the oak savanna action areas is based on pollinator value due to goal #1, successional stage for year-round success, species presence in oak savanna plant communities, price, and overall aesthetics. See Appendix F for seed mix species selection, lbs/acre, and cost/acre.

The customized seed mix was chosen from the ‘Woodland Edge South and West’ seed mix worksheet from the MNDOT website. Since there will be more shade than an open prairie, the woodland edge seed mix provides a good mix of sun and partial shade plants. Many of the forbs chosen have a medium to high pollinator value, such as wild bergamont (*Monarda fistulosa*), giant purple hyssop (*Agastache scrophulariaefolia*) and many of the aster species. Species such as lead plant (*Amorpha canescens*), smooth aster (*Aster laevis*), little bluestem (*Schizacyrium scoparium*), big bluestem (*Andropogon gerardii*), and indian grass (*Sorghastrum nutans*) are indicative of dry savanna plant communities and southern mesic-dry oak forests (MN DNR, 2005). Some species, such as prairie rose (*Rosa arkansana*), were not chosen because the nursery was out of stock. Prairie rose was then replaced by smooth wild rose (*Rosa blanda*). In other cases, the preferred species were too expensive. We recommend planting Pennsylvania sedge (*Carex pennsylvanica*) if there are funds available.

RAA2a will be seeded using both seeds collected during year one from the site, and a customized seed mix (Appendix F), as with RAA2. Some mature seed will be collected before the broadcasting glyphosate treatment in year one. These seeds will be collected only from the following sources: white heath aster *(Symphyotrichum ericoides)* and whorled milkweed *(Asclepias verticillata).* The rest of the seeds will be obtained from Prairie Moon Nursery, a nearby seed supplier. The seeding will occur in the spring on a nice day about halfway through May. This seeding date allows for the longest establishment time before winter. At the time of seeding a mechanized broadcast seeder will be used to seed the main site, in combination with an auger, which constantly rotates the seed, allowing them to be evenly dispersed (Packard and Mutel, 1997). Using the broadcast seeding technique will allow the seeds to be dispersed at the intended rate, and allow the seeds an adequate amount of sunlight for germination.

**Table 6:** RAA2a Revegetation Action Timeline

| Year | Season | Activity |
|---|---|---|
| 1 | Spring--May | Seeding |
| 2 | Spring | Plant 12 potted bur oak (*Q. macrocarpa*) saplings |
| 2 | Spring | Plant 7 potted plants each for species described for woodland edge |

**Vegetation Management**

**Year One**
Prairie vegetation and weed species will be managed in the first few years by frequent mowing. In the first growing season, the area will be mowed at a height between 4 and 6 inches after the vegetation reaches 12-18 inches. It should be mowed once every 3 weeks from early May through September (Packard and Mutel, 1997). Persistent perennial or biennial weeds can be spot-sprayed when natives are dormant.

**Year Two**
In the second growing season, the prarie should be mowed once a month if weedy vegetation persists. Do not set the mowing height anywhere below 12 inches to ensure native prairie plants are not harmed (Packard and Mutel, 1997). If there are persistent perennial or biennial weeds, especially if it is smooth brome, they can be spot-sprayed, pulled by hand, or spot-mowed just before flowering to prevent seed dispersal.

Potted plants will be planted in the spring during the second year, following the initial removal and control of woody plants. During planting, the root balls of the potted plants should be scarified or cut with a knife or pruner, going vertically along 4 sides and the bottom of the root ball. This will stimulate lateral root growth. Plants should then be placed in a hole twice as wide and the same depth as the root ball. Once the plant is at ground level, backfill the sides of the hole with soil and saturate the backfill and root ball with water. Plants should then be watered as needed but never oversaturated. A test for moisture is to place a thumb 1" into the soil; if the soil feels moist, no moisture is required (Out Back Nursery 2014). Following planting, plants should be mulched to control for weeds and improve soil moisture. Plants should be monitored throughout the growing season for weeds. Any weeds surrounding the plants should be hand-pulled.

**Year Three**
Mowing should not be necessary in year three and beyond if the establishment of native prairie has been successful. The threat of a weed canopy establishing in year three would signify that a stand evaluation should be conducted. If less than one native plant per square foot is observed, it would be necessary to broadcast herbicide throughout the site again, and re-seed with the seed mix.

Planted woody species should be monitored for surrounding weed growth. Any weeds surrounding the plants should be hand-pulled.

**Long-term Management**
Prescribed burns are a long term management practice for oak savannas since their ecosystems are fire dependent. After a burn, dry prairie plants in the groundstory should

emerge from dormancy sooner and come back stronger and produce more flowers and seeds. The blackened soil heats up faster than soil that was not burned the previous year (MN DNR). It also reduces the amount of plant disease and debris and maintains habitat for wildlife. We recommend a burn regime of once every 3 to 5 years for 10 years of management. Frequency may be increased if there are many undesirable sprouting woody plants. The first burn should happen the spring after the third growing season to stimulate warm-season prairie grasses. In subsequent years, we recommend burning in the fall to stimulate forbs for pollinators (NRCS, 2009). Burning should not occur until plant bur oaks reach a diameter-at-breast-height of 3 to 6 inches, as their bark will not be developed enough to tolerate burning (NRCS 2003). A firebreak should be mowed along the edges of the woodland to prevent fire from moving outside the burn area, as in RAA1a.

## RAA2b

### Extant Vegetation

This area is more densely wooded than the other restoration action areas. The woodland edge is comprised of giant and canada goldenrod and white heath aster (*Symphyotrichum ericoides*), which are all native species and a good remnant plant population and seed source. The understory is part native, part non-native plant species, with a majority of the shrubs being the non-native honeysuckle and lilac species, mixed with chokecherry (*Prunus virginiana*). There is a large variety of canopy trees, such as bur oak (*Quercus macrocarpa*), red oak (*Quercus rubra*), black walnut (*Juglans nigra*), cottonwood (*Populus deltoides*) and even red pine (*Pinus resinosa*). Keeping as much native understory, canopy, and woodland edge species as possible is a priority. Non-natives and invasives should be removed.

### Site Preparation

This restoration action area is one of the few where smooth brome is not a problem and will hopefully not become a problem if other areas are managed. Therefore, herbicide will not need to be broadcasted. It will be advantageous to use a foliar spot spray on any herbaceous weeds that are on the site and were missed in the site evaluation. See Appendix G for instructions on how to spot spray weeds.

This restoration action area has a large amount of invasive and non-native subcanopy trees. There is a thicket of lilac on the southwest side of the site that may have been planted there when the site was a homestead. Although lilac grows well in the Minnesotan climate, it is usually considered an ornamental plant and should be removed to promote a transitional woodland and oak savanna ecotone. There are also many non-native hybrid honeysuckles and invasive buckthorn which should be removed.  Any siberian elm should also be removed from the site because it is potentially invasive. We recommend keeping other native groundstory shrubs like virginia creeper because they are native and widespread amongst the entire Rosemount Greenway. Chokecherry and riverbank grape (*Vitis riparia*) should also be kept because they are species common in dry savanna ecosystems (MN DNR, 2005). Removal and treatment of trees and shrubs is covered in Appendix G.

**Table 7:** RAA2b Site Prep Action Timeline

| Year | Season | Activity | Acres |
|---|---|---|---|
| 1-3 | Early Spring | Buckthorn Hand Removal | 1 |
| 1 | Fall | Cut Stump and Treat woodies | 1 |
| 2-3 | Fall | Treat resprouts and seedlings | 1 |
| 1-2 | Spring | Spot spray weeds | 1 |

**Revegetation Actions**

**Oak savanna**

Refer to RAA2a for an explanation of bur oak plantings.  For RAA2b, bur oaks will be planted in 3 clusters of 2 and 3 trees per cluster along the prairie edge (see Map 12 for planting example), following the spacing requirements described in RAA2a.  The plantings should not occur where the kiosk trail is proposed, but could border the kiosk trail for aesthetic enhancement.

**Map 8:** Bur oak planting example for RAA2b.

**Woodland edge**

Refer to RAA2a for an explanation of shrub-layer and sub-canopy plantings in southern dry-mesic oak forests. For RAA2b, three plants from each of the following species will be planted: red oak (*Quercus rubra*), basswood (*Tilia americana*), black cherry (*Prunus serotina*), American hazelnut (*Corylus americana*), shagbark hickory (*Carya ovata*). These were selected because they all do well in full sun, which will be provided by the south-facing woodland edge. Trees and shrubs should be planted within 20 ft of the forest border, as described in RAA2a, and not intersect the proposed kiosk route.

**Table 8:** RAA2b Revegetation Action Timeline

| Year | Season | Activity |
|---|---|---|
| 2 | Spring | Plant 8 potted bur oak (*Q. macrocarpa*) saplings |
| 2 | Spring | Plant 3 potted plants each for species described for woodland edge |

**Vegetation Management**

**Please refer to RAA1a for short term and long term vegetation management plans.**

## RAA2c

**Extant Vegetation**

This area is dominated by smooth brome grass and non-native honeysuckle. There are weedy thickets of non-native honeysuckle mixed with boxelder along the old service road. There are also herbaceous weed species along the road such as spotted knapweed (*Centaurea maculosa*), bird's-foot trefoil (*Lotus corniculatus*), and canada thistle (*Cirsium arvense*). Invasive and weedy species should be managed and removed and replaced with native southern dry prairie and oak savannah species. The land adjacent to the eastern side of site N2 is very similar to this restoration area in terms of invasive species. Because this land acts as a seed source, we suggest treating and removing invasive species such as honeysuckle and common buckthorn on the adjacent land.

**Site Preparation**
Since smooth is dominant in this restoration area (cover class 6), one of the first steps in restoration is to manage the amount of smooth brome present on the site. This will be accomplished by broadcasting a high concentration glyphosate herbicide. See Appendix G for specific details regarding the treatment of smooth brome. The use of herbicide is recommended because smooth brome is a perennial grass that regenerates not just from seed, but from underground roots. Mowing before seed set will not be enough to obtain a significant reduction in the amount of smooth brome.

Broadcasting smooth brome areas with glyphosate will also control other weedy or undesirable grasses, broadleaves, and woodies. Therefore, if broadcasting misses weedy patches or if you are applying herbicides around areas of desirable species, spot-spraying these patches with glyphosate should be sufficient for control. The spotted knapweed, bird's-foot trefoil, and canada thistle are the likeliest candidates for foliar spot-spraying.

Although there are naturally spread out trees and plant communities typical of the layout of an oak savanna, most of these species are not native or typical of that community. We recommend reducing and/or removing all buckthorn, siberian elm, grey birch (*Betula populifolia*), and eastern red cedar. Removal and treatment of trees and shrubs is covered in Appendix G.

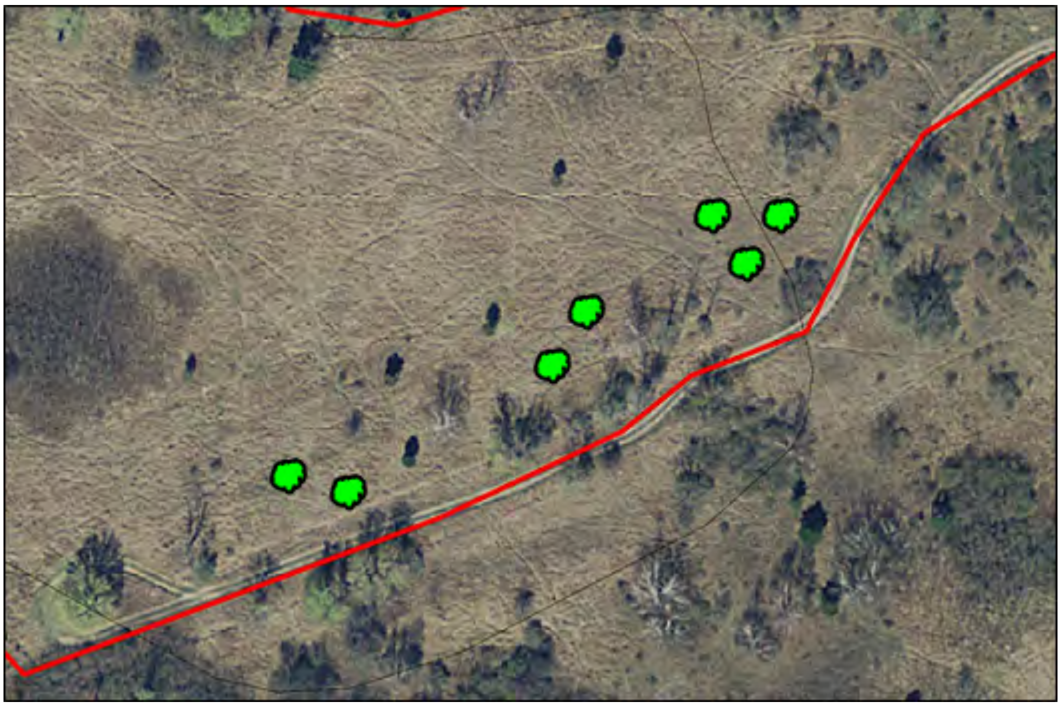
**Table 9:** RAA2c Site Prep Action Timeline

| Year | Season | Activity | Acres |
|---|---|---|---|
| 1-3 | Early Spring | Buckthorn Hand Removal | 1 |
| 1-3 | Fall | Cut Stump and Treat Woodies | 1 |
| 2-3 | Fall | Treat resprouts and seedlings | 1 |
| 1-2 | Spring | Spot spray weeds | 1.5 |
| 1 | Fall | Mow Smooth Brome | 1.5 |

| | | | |
|---|---|---|---|
| 1 | Fall | Broadcasting Brome with Glyphosate | 1.5 |

**Revegetation Actions**

**Oak savanna**
Refer to RAA2a for an explanation of oak savanna plantings. Here oaks will be planted in three clusters of two and three plants (Map 13).



**Map 13:** Example oak planting arrangement for RAA2c.

**Prairie Vegetation**
Please see RAA1a: Vegetation Management for justification and methods. The seed mix and seeding methods are the same.

**Table 10:** RAA2c Revegetation Action Timeline

| Year | Season | Activity |
|---|---|---|
| 1 | Spring--May | Seeding |
| 1 | Spring | Plant 7 potted bur oak (Q. macrocarpa) saplings |

## Vegetation Management

**Please refer to RAA1a for short term and long term vegetation management plans.**

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# Appendix A: Rosemount Greenway Corridor Site N2
# Plant Species List

Surveys of Site N2 Vegetation were taken on Saturday, September 20th.

Cover Class description for individual species based on Braun-Blanquet cover/abundance scale:

<5% and only 1 individual - **R**
<5% and few individuals - **+**
<5% - Cover Class **1**
5-25% - Cover Class **2**
25-50% - Cover Class **3**
50-75% - Cover Class **4**
75-100% - Cover Class **5**

### Unit 1 - Brome Field

| Non-Native | Scientific Name | Common Name | Cover Class | Comments |
|---|---|---|---|---|
| | | | | |
| **Groundstory** | | | | |
| | *Arctium minus* | Common Burdock | + | |
| | *Asclepias verticillata* | Whorled Milkweed | + | |
| *x* | *Berteroa incana* | Hoary alyssum | + | |
| *x* | *Bromus inermis* | Smooth Brome | 5 | |
| *x* | *Carduus acanthoides* | Spiny Plumeless Thistle | 1 | southwest washed out area |
| *x* | *Centaurea maculosa* | Spotted Knapweed | 1 | along the road |
| *x* | *Cirsium arvense* | Canada Thistle | 1 | |
| | *Eupatorium rugosum* | White Snakeroot | + | |
| | *Lotus corniculatus* | Bird's-Foot Trefoil | 1 | along the road |
| *x* | *Nepeta cataria* | Catnip | + | |
| | *Parthenocissus quinquefolia* | Virginia Creeper | 1 | |
| | *Plantago rugelli* | Blackseed Plantain | + | |
| *x* | *Rubus sp.* | Rubus species | 1 | |

| | | | | |
|---|---|---|---|---|
| | *Setaria sp.* | Foxtail/Bristle Grass | 1 | |
| | *Solidago canadensis* | Canada Goldenrod | 2 | |
| | *Solidago gigantea* | Giant Goldenrod | 2 | |
| *x* | *Sonchus arvensis* | Field Sowthistle | 1 | |
| | *Symphyotrichum ericoides* | White Heath Aster | + | |
| *x* | *Verbascum thapsus* | Common Mullein | + | |
| | *Vitis riparia* | Riverbank Grape | 1 | |
| | | | | |
| **Understory** | | | | |
| | *Rhamnus cathartica* | Common Buckthorn | 1 | |
| | *Rhus glabra* | Smooth Sumac | 2 | two large patches--south middle and north middle sections |
| *x* | *Syringa sp.* | Lilac | 1 | possibly planted |
| *x* | *Ulmus pumila* | Siberian Elm | 1 | |
| | | | | |
| **Canopy** | | | | |
| | *Acer negundo* | Boxelder | 1 | |
| x | *Betula populifolia* | Grey Birch | 1 | |
| | *Juniperus virginiana* | Eastern Redcedar | 1 | |
| | *Populus grandidentata* | Bigtooth Aspen | 1 | |
| | *Quercus alba* | White Oak | 1 | |

## Unit 2 - North Woodland

| Non-Native | Scientific Name | Common Name | Cover Class | Comments |
|---|---|---|---|---|
| | | | | |

| | | | | |
|---|---|---|---|---|
| **Ground Layer** | | | | |
| | *Parthenocissus quinquefolia* | Virginia Creeper | 1 | |
| | *Rubus sp.* | | 1 | |
| | *Solidago canadensis* | Canada Goldenrod | 1 | |
| | *Solidago giganteum* | Giant Goldenrod | 1 | |
| | *Symphyotrichum ericoides* | White Heath Aster | + | |
| | *Vitis riparia* | Riverbank Grape | 1 | |
| | | | | |
| **Understory** | | | | |
| x | *Lonicera sp.* | Honeysuckle | 2 | |
| | *Prunus virginiana* | Chokecherry | 1 | |
| x | *Syringa sp.* | Lilac | 2 | |
| | | | | |
| **Canopy** | | | | |
| | *Fraxinus sp.* | Ash | R | |
| | *Juglans nigra* | Black Walnut | R | |
| | *Juniperus virginiana* | Eastern Redcedar | 1 | |
| | *Pinus resinosa* | Red Pine | R | |
| | *Populus deltoides* | Cottonwood | 1 | |
| | *Quercus macrocarpa* | Bur Oak | 1 | |
| | *Quercus rubra* | Red Oak | 1 | |
| x | *Rhamnus cathartica* | Common Buckthorn | 1 | |
| x | *Ulmus pumila* | Siberian Elm | 1 | |

## Unit 3: South Woodland

| Non-Native | Scientific Name | Common Name | Cover Class | Comments |
|---|---|---|---|---|
| | | | | |
| **Ground Layer** | | | | |

| | | | | |
|---|---|---|---|---|
| | *Ambrosia psilostachya* | Cuman Ragweed | + | |
| | *Parthenocissus quinquefolia* | Virginia Creeper | 1 | |
| | *Rubus sp.* | | 1 | |
| | *Vitis riparia* | Riverbank Grape | 1 | |
| | | | | |
| **Understory** | | | | |
| x | *Lonicera sp.* | Honeysuckle | 2 | |
| | *Prunus pennsylvanica* | Pin Cherry | + | |
| x | *Rhamnus cathartica* | Common Buckthorn | 3 | |
| | | | | |
| **Canopy** | | | | |
| | *Acer negundo* | Boxelder | 1 | |
| | *Acer sp.* | Maple | R | |
| | *Fraxinus sp.* | Ash | 1 | |
| | *Juniperus virginiana* | Eastern Redcedar | 2 | |
| | *Populus deltoides* | Cottonwood | 2 | |
| x | *Ulmus pumila* | Siberian Elm | 1 | |

**Appendix B: Rare and Aggregate Plant and Animal Species** *Minnesota County Biological Survey, 1997*

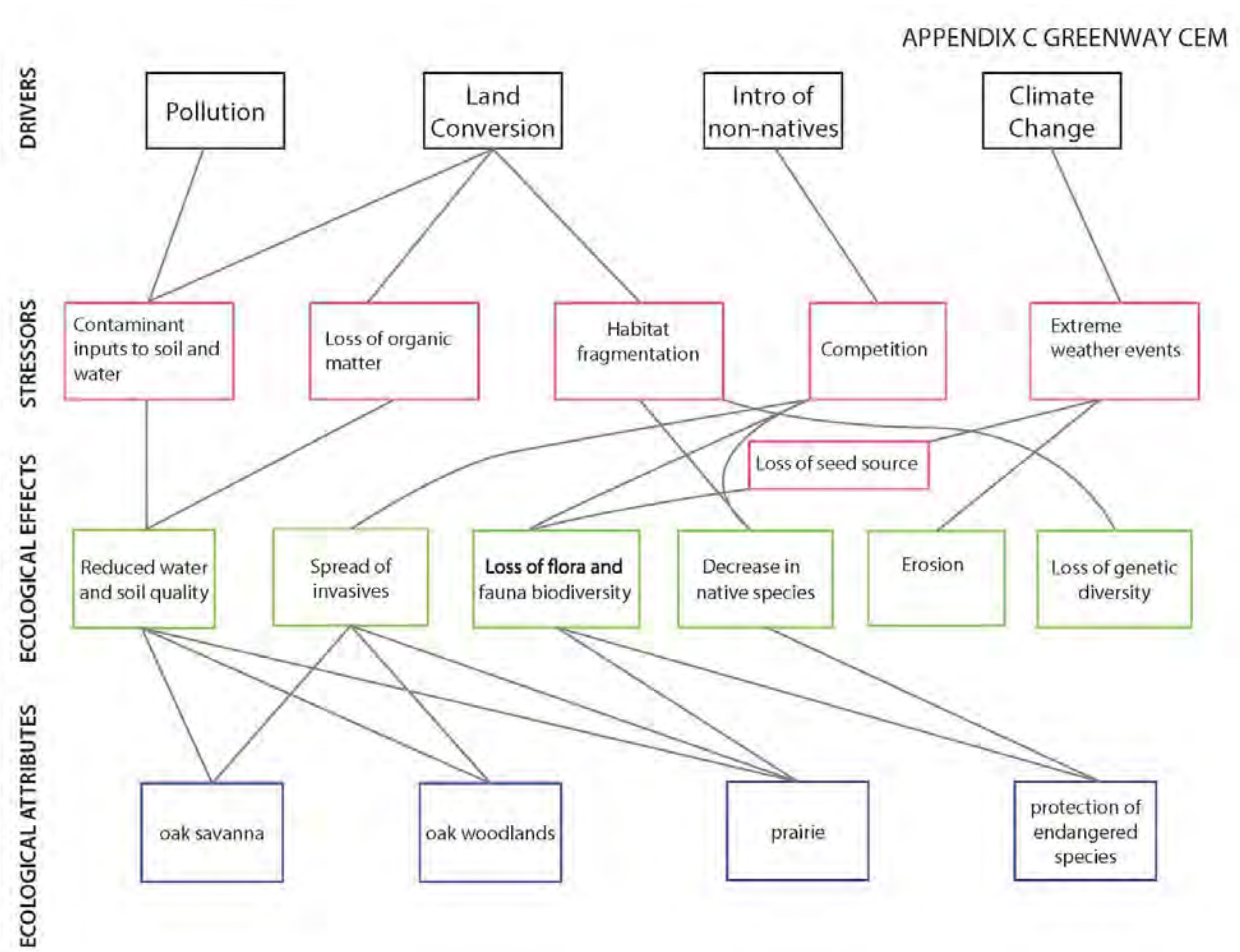
★ **Plants, federally- or state-listed**

| | |
|---|---|
| Eared false foxglove * | *(Agalinis auriculata)* |
| Sea-beach needlegrass | *(Aristida tuberculosa)* |
| Tuberous Indian-plantain | *(Arnoglossum plantagineum)* |
| Clasping milkweed | *(Asclepias amplexicaulis)* |
| Sullivant's milkweed * | *(Asclepias sullivantii)* |
| Plains wild indigo | *(Baptisia bracteata* var. *leucophaea)* |
| Kitten-tails | *(Besseya bullii)* |
| Sterile sedge | *(Carex sterilis)* |
| Hill's thistle | *(Cirsium hillii)* |
| Twig-rush | *(Cladium mariscoides)* |
| James' polanisia | *(Cristatella jamesii)* |
| Small white lady's-slipper | *(Cypripedium candidum)* |
| Big tick-trefoil | *(Desmodium cuspidatum* var. *longifolium)* |
| Rattlesnake-master | *(Eryngium yuccifolium)* |
| Beach-heather | *(Hudsonia tomentosa)* |
| Creeping juniper | *(Juniperus horizontalis)* |
| Prairie bush clover | *(Lespedeza leptostachya)* |
| Rock sandwort | *(Minuartia dawsonensis)* |
| Rhombic-petaled evening primrose | *(Oenothera rhombipetala)* |
| Clustered broomrape | *(Orobanche fasciculata)* |
| One-flowered broomrape * † | *(Orobanche uniflora)* |
| American ginseng | *(Panax quinquefolius)* |
| Tubercled rein-orchid | *(Platanthera flava* var. *herbiola)* |
| Hair-like beak-rush | *(Rhynchospora capillacea)* |
| Tall nut-rush | *(Scleria triglomerata)* |
| Whorled nut-rush | *(Scleria verticillata)* |
| Ovate-leaved skullcap | *(Scutellaria ovata)* |
| Snow trillium | *(Trillium nivale)* |
| Valerian | *(Valeriana edulis* var. *ciliata)* |

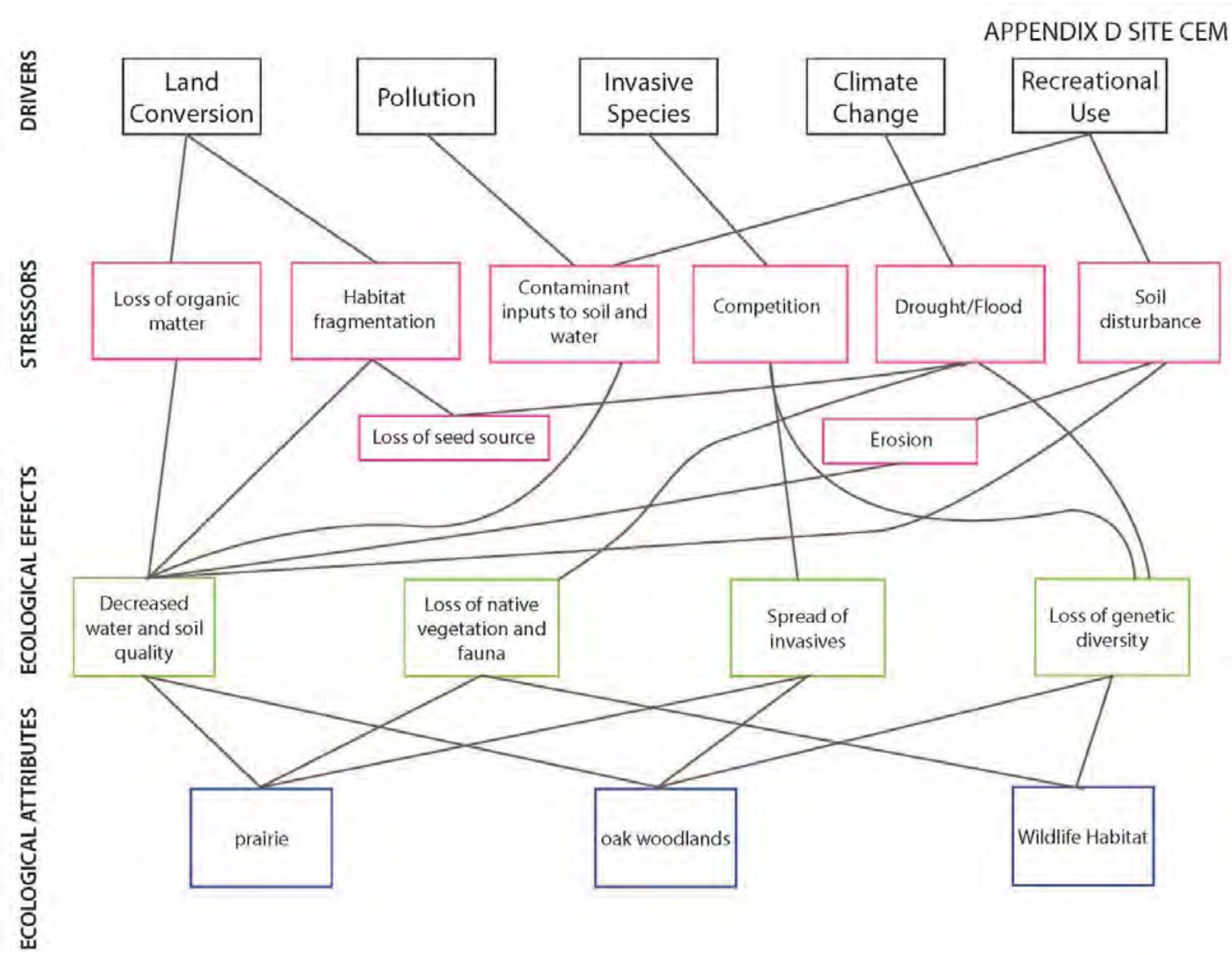
♦ **Animals, federally- or state-listed**

| | |
|---|---|
| **Mammals** | |
| Plains pocket mouse * † | *(Perognathus flavescens)* |
| Eastern spotted skunk * † | *(Spilogale putorius)* |
| **Birds** | |
| Red-shouldered hawk | *(Buteo lineatus)* |
| Cerulean warbler | *(Dendroica cerulea)* |
| Acadian flycatcher | *(Empidonax virescens)* |
| Peregrine falcon | *(Falco peregrinus)* |
| Bald eagle | *(Haliaeetus leucocephalus)* |
| Loggerhead shrike | *(Lanius ludovicianus)* |
| Hooded warbler | *(Wilsonia citrina)* |
| **Reptiles** | |
| Wood turtle | *(Clemmys insculpta)* |
| Racer | *(Coluber constrictor)* |
| Timber rattlesnake | *(Crotalus horridus)* |
| Blanding's turtle | *(Emydoidea blandingii)* |
| Gopher snake | *(Pituophis catenifer)* |
| **Fish** | |
| Blue sucker | *(Cycleptus elongatus)* |
| Paddlefish | *(Polyodon spathula)* |
| **Molluscs** | |
| Mucket mussel | *(Actinonaias ligamentina)* |
| Rock pocketbook mussel | *(Arcidens confragosus)* |
| Elephant-ear mussel | *(Elliptio crassidens)* |
| Ebonyshell mussel | *(Fusconaia ebena)* |
| Yellow sandshell mussel | *(Lampsilis teres)* |
| Black sandshell mussel | *(Ligumia recta)* |
| Wartyback mussel | *(Quadrula nodulata)* |
| Pistolgrip mussel | *(Tritogonia verrucosa)* |

## Appendix C: Greenway CEM



# Appendix D: Site CEM



# Appendix E: Monitoring Protocols

## Goal 1: Bee Monitoring Protocol

The goal of this protocol is to visually observe bee abundance throughout the site. Observations will occur twice per year, once at the beginning of July and once at the end of August, as this is the window of most bee activity. Surveys should occur when weather conditions are warm, sunny, and calm. The best time to survey is during the middle of the day, between noon and 4 pm.

During the survey, two sets of transects will be set up as shown in Map 5. Typically, only one pair of transects is used per site, but given the large size of our prairie unit, we chose two pairs of transects to increase our sample size.

A measuring tape will be used to measure out 100 ft transects, and flags will be placed on the ends of each transect. An observer will then start a stopwatch and begin walking along the length of one transect, looking for bees within a 3 ft wide strip along the transect. The goal is to make it to the other end of the transect, recording visiting bees, within 7.5 minutes. Specifically, the observer will record a hash mark for each bee observed on a reproductive flower part for more than 0.5 s. The observer should note whether the bee is a honey bee or a native in a table similar to Table 3. If the timer goes off before the transect is completed, the observer should quickly move towards the end and take a rough count of the native bees and honey bees. While surveying, the observer should be sure that his or her shadow is not in the line of sight, as this can make spotting bees difficult. These steps should be repeated for each transect.

Before or after the survey, the observer should note the date and time at which the survey occurred, the weather conditions (i.e. clear, partly cloudy, or bright overcast), and air temperature. Dominant plants in bloom should also be noted.

If possible, baseline surveys should occur before the restoration begins. Surveys should then be performed each summer during the restoration, for up to ten years. Abundance data can then be averaged across the two transects pairs for each survey date and regressed over time to see changes.

| Transect | Start time | End time | # Native bees | # Honey bees |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

**Table 11:** Example data sheet for bee observations.


**Map 5:** Locations of 100 ft transects for bee monitoring.

## Goal 2: Avian Population Monitoring Protocol

Increases in indicator bird populations will indicate that the restoration was successful at providing habitat for a wide range of upland prairie bird species. Monitoring the restoration site for birds will be done by taking auditory 4-minute point counts of indicator species four times each year in the month of June. Grasshopper Sparrows, Western Meadowlarks, and Henslow's Sparrows will be used as the indicator species that will be monitored. Averages of each indicator species population will be displayed on bar graphs so differences can be seen year by year. The approximate location of the birds will also be displayed on maps of the site so areas with the highest concentrations of birds can be observed for their specific traits, to help guide further efforts for increasing bird populations if necessary.

Grasshopper Sparrows, Western Meadowlarks, and Henslow's Sparrows will be monitored to help determine if the restoration has been successful at providing a population of bird species on the site. These three species were chosen because their populations are declining in Minnesota, and they thrive in upland prairie grasslands (Audubon Minnesota). Great River Bluffs state park in Minnesota had a population of Henslow's Sparrows consisting of between 19 and 23 singing males when they were studied between 1987 and 1989. Since then populations at the park have fluctuated, getting as low as one singing male at one point, but Afton State Park has also recently seen populations of the Henslow's Sparrows (MN DNR, 2014). This signifies that observing a population of about 10 singing males, and a total population of about 20 Henslow's Sparrows on the site at any one point within 10 years would indicate the establishment of a suitable habitat for Henslow's Sparrows. The Minnesota Breeding Bird Survey found an average of 2.9 Grasshopper Sparrows on 65 of 82 routes (Pfannmuller, 2014), indicating that observing about three of the Grasshopper Sparrows on the site each year would be average for Minnesota, though other conservation programs are currently working to increase the numbers of Grasshopper Sparrows from a total population of 6,000 birds to 13,000 birds (Pfannmuller, 2014). If a population of six Grasshopper Sparrows are observed on the site in any given year within ten years it will indicate not only that this site is suitable for upland prairie birds, but also that populations of the Grasshopper Sparrows in Minnesota are increasing. The Western Meadowlarks have seen decreases of 8.09% each year since 1966. In the western, and central plains regions of Wisconsin, Western Meadowlark populations fluctuated between 32.2 and 133.7 total birds depending on the region observed (Faanes, 1981), though since populations of the species have decreased much since then, observing a total population of about three Western Meadowlarks on the site at any given year within ten years will indicate the success of providing sufficient habitat for the Western Meadowlarks. Being that each of these birds has a tendency to fluctuate in population year by year, observing the designated population of these upland prairie bird species at any given point within ten years will indicate that the site has been restored to a thriving upland prairie, with the ability to provide habitat for upland prairie bird species. If the designated number of these indicator species (>20 Henslow's Sparrows, >3 Grasshopper Sparrows, and >3 Western Meadowlark) has occurred on the site within ten years, monitoring will be cut back to every-other year, to ensure populations are continuing to be upheld. If the designated populations are not observed, monitoring will continue to occur every year until designated populations are observed.

Monitoring of the indicator species on the site will occur at approximately the same date and time each year. One study found that using 4 minute auditory point counts in a 100 meter radius yielded the best results when used in open grassland areas much like N2 (Jean-Pierre L. et al., 1995). The whole site of N2 is about ten acres, meaning that only about one, 100 meter radius point count would be necessary. Though given the presence of less open area along the periphery of the site, N2 will instead be divided down the middle so about 5 acres remains on either side (Map 6). The monitor will take unlimited radius point counts from the center of each 5 acre plot, listening for the call of the indicator species, for four minutes, recording both the approximate location of the indicator species, and the total abundance of each of the three indicator species. To ensure a quality data set, monitors will take point counts of indicator species four times in June of each year, being that all three of the indicator species are present in Minnesota by June (Dechant, 2003), (Pfannmuller, 2014), (Faanes, 1981). The point counts will also be taken at about the same time each morning - between 5:30 am and 9 am for best results - and if avoidable they will not be conducted in weather that is not ideal (Tsipoura et al.). If the weather is not ideal, the point count will be done as soon as possible, within the same week of June, but seven days should occur between each of the point counts (Tsipoura et al.).

Averages of the indicator species observed on each of these four occasions will be recorded in a bar graph every year, and maps depicting the approximate location of each bird within the site will be compiled. Taking the average of indicator species observed on four different days will yield more accurate results than taking the data on only one day each year, and accounts for possible population fluctuations on any given day. Averages of yearly populations will be displayed on bar graphs and compared to previous years. This will help determine if the populations are improving at all, or if further restoration actions must be taken so a suitable prairie habitat can be established. For much the same reason, the approximate location of each indicator species will be displayed onto maps during each of the four point-counts in June. Every year this data will be compiled and compared to the maps of previous years to determine where the highest numbers of indicator species gather within the site, and if there are areas within the site where the habitat may not be as suitable as it could, allowing restorationists to take further action in these locations.

**Map 6:** This map depicts two 5-acre plots where auditory, 4-minute point counts of indicator species will occur, four times each year in the month of June. Monitors will take point counts from the exact same stations on each monitoring date (labeled in map)

## Goal 3: Prairie Vegetation Monitoring Protocol

### Vegetative Composition--Quadrat Sampling

To obtain informative vegetative composition data, you must sample from quadrats within the site. Quadrats are permanently marked, fixed points that can be used to record species presence and abundance (Galatowitsch, 2012). The size of the quadrats for an herbaceous sampling area, such as the southern dry prairie target ecosystem, should be 1 m². Since site N2 is rather homogenous in terms of ecosystem strata, quadrats will be set up on a grid system, with each gridline being 40 meters apart and the quadrats placed on the southeast corner of the two intersecting grid lines (see Map 7). The quadrats will be permanently marked with low profile survey markers in the upper northwest corner (where the grid-lines intersect) and flags in the lower southwest corner. Survey the vegetation twice a year for five years, starting with the year after it was seeded or planted. Plants should be surveyed when they are flowering and/or fruiting, so surveys should be performed in the late spring and late summer.

Find quadrats by using a GPS to locate the first quadrat. Quadrats should be permanently marked with two survey markers. Place a 1 m² quadrat marker with its west side connecting the two markers. When doing the survey, visit each plot and record every taxa found to species level and the corresponding cover percentage (if herbaceous), rounded to the nearest 1% (see Image 7). If species are trees or shrubs, inventory the number of individuals within the plot. Record all information on Species Composition Data Sheets. Data and observations to record on composition survey sheets include the date of the survey, the surveyors name, scientific names, notes on conditions of plants such as disease and herbivory/predation, and any landscape changes or extreme weather events. If species cannot be identified in the field, you may collect samples to press and identify later. When the survey is complete, digitize all data and save to the computer, an external hard-drive, and the cloud.

### Botanical Survey

To augment the vegetative composition quadrat sampling, botanical surveys of the entire site should be performed at the same time as the quadrat sampling: twice a year for 5 years. Plants should be surveyed when they are flowering and/or fruiting, so surveys should be performed in late spring and late summer. Comprehensive botanical surveys are are necessary because it is possible that some rare or invasive species may be present on the site, but they are not represented in the quadrats chosen for vegetative composition sampling.

First, obtain a list of target species for a southern dry prairie and a southern dry-mesic oak forest from the MN DNR Native Plant Community Classification Handbook. This will speed up the process of identification of plant species. The survey should be thorough and comprehensive over the entire site--each restoration unit should be visited. Surveys should be conducted by walking over the entire site and noting all taxa observed to species level and the corresponding cover percentage rounded to the nearest 1%. This data should be organized by restoration unit. Data and observations to record on botanical survey sheet include the date of the survey, the surveyors name, scientific names, notes on conditions of plants such as disease and herbivory/predation, and any landscape changes or extreme weather events. Digitize all data by saving to the computer, external hard-drive, and the cloud. Note: the California Natural Resources agency (2009) suggests it will take one person an hour to complete an 8 acre comprehensive field survey in a grassland with medium diversity and moderate terrain, with additional time for species identification. Site N2 is approximately 10 acres, so it should take less than a day to survey the entire site.

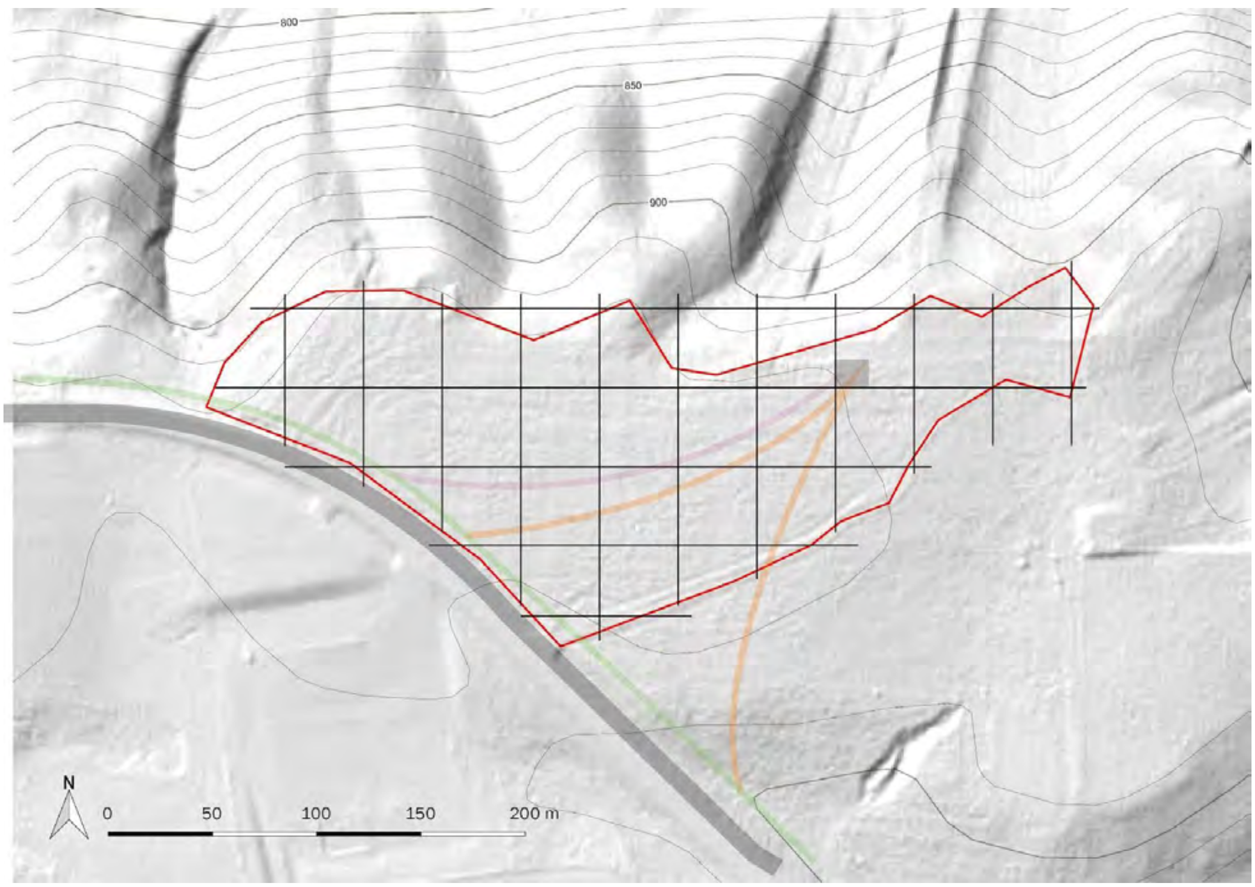
*Equipment for Composition and Botanical Surveys: Gleason and Cronquist, "Manual of Vascular Plants of Northeastern United States and Adjacent Canada", MN DNR plant community species lists, seed mix lists, past surveys, hand lens, clipboard, pencil, plant press, plastic bags, extra survey markers and flags, 1 $m^2$ quadrat marker*

**Vegetative Structure--Aerial Imaging**

It will be advantageous to measure the physical form and space created by plants in our site for all restoration units. There are large islands of smooth sumac (*Rhus glabra*) that, although native, we will attempt to reduce in size.. Aerial images can be a useful tool in visualizing vegetative structure (Galatowitsch, 2012). For these purposes, they can show how the canopies of Unit 2-North Woodland and Unit 3-South Woodland are changing and the change in patch size and frequency of smooth sumac. Take aerial images (scale 1:6000 or 500 ft. per inch) using infrared film (Hoffer, 1984) once a year in the summer months (when all trees/shrubs are leafed out with normal color) for 5 years, and then once every 3 years for 6 years.

**Data Interpretation**

The benchmark for this vegetation goal is to establish 80% native vegetation typical of a southern dry prairie in 5 years. The reason for monitoring and data collection is to test this restoration benchmark. In order to do this, the data must be visualized, analyzed, and interpreted. Vegetation composition data from quadrat sampling will be multivariate and difficult to interpret with raw data. We recommend lumping together functional groups such as grasses, legumes, wildflowers in the Asteraceae family, and other wildflowers for display in tables. The means of cover percentages of samples in each restoration unit can be calculated and compared over time using a bar graph. We also recommend using a regression analysis to determine whether the total native prairie plants parameter is increasing or decreasing significantly. Additionally, ordination can compare the similarity in vegetative composition among quadrats to detect patterns in overall vegetation. The botanical survey analysis will be less involved than the quadrat analysis. Cover percentages for each restoration unit can be compared over time using bar graphs and regression analysis. Vegetative structure is visualized using aerial maps. Species types and cover estimates can be determined from the aerial photographs, presented in tables and bar graphs, and compared with one another using analysis of variance (ANOVA) tests.




**Map 7**: Survey gridlines. All intersection points that fall within the site boundaries will have 1m² quadrats placed in the southeast corner.

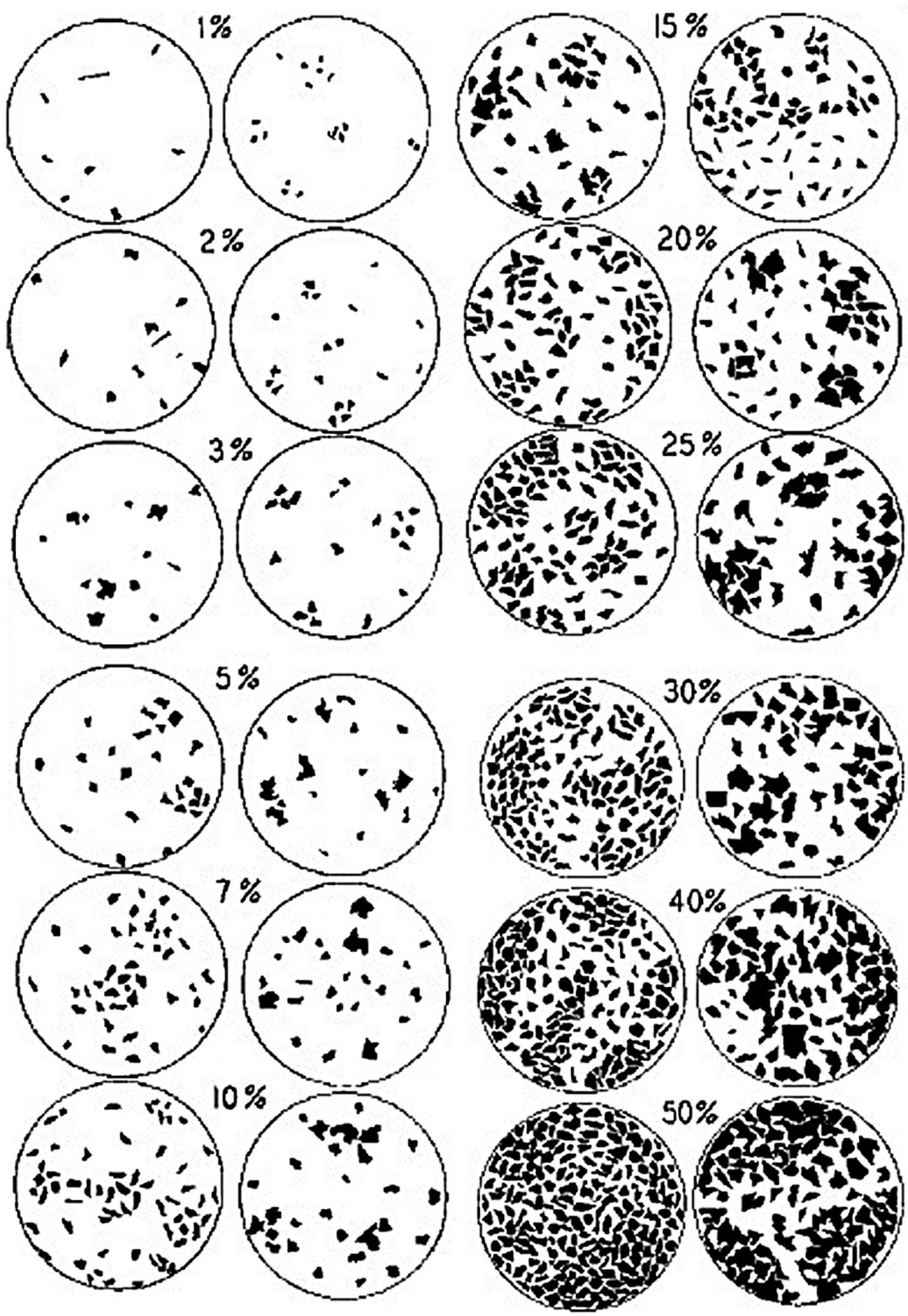
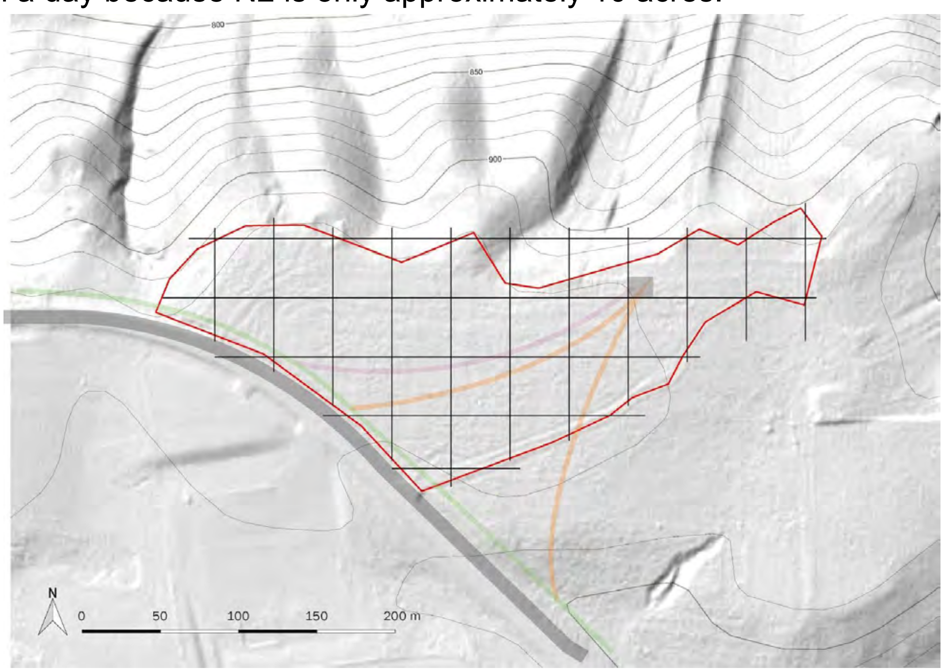



**Image 7:** Reference plots for cover estimation of plant species in 1 m²  quadrats from the USDA Multiple Species Inventory and Monitoring Technical Guide, Version 1.0 (Forest Service, 2006).

## Goal 4: Invasive Species Monitoring Protocols

A vegetation survey will take place in order to record the amount of buckthorn and brome grass on site. This survey will be performed at the same time as the botanical survey to minimize costs and use the same spatial parameters as quadrat sampling in order to record where the populations occur on site.

Training volunteers is step one. Due to the small amount of species to identify, volunteers could do the job after they are taught identification of these two species. Surveyors would walk the entire site, noting populations of invasive species and recording their location within the quadrant system. The quadrant system will help streamline the process and draw attention to areas of the site that need the most help. The walk-through portion of the protocol is important because the entire site needs to be checked for invasives or they will easily become uncontrollable. Data and observations to record include the date of the survey, the surveyors name, populations of Buckthorn and Brome grass found, notes on conditions of plants, and any notable changes in the landscape since the previous survey. Save the information digitally immediately. This can be done using a computer file, external storage or cloud. It is important that the information be saved in two separate places. Since volunteers are being used, three surveyors should go out to compare notes after the walk-through. This should take no longer than a day because N2 is only approximately 10 acres.




**Map 8:** Survey gridlines used to record locations of invasive species population findings

**Data Interpretation:**

Data monitoring invasive species is best recorded over time. After each survey, each quadrant will have information about the populations it contains. We suggest making a graph for each quadrant. With this form of data management, the restorationist can see which quadrants are most and least successful over a few years. The overall trend of the quadrants combined can begin to suggest outside factors that might be influencing the populations. As an overall trend, the restorationist will be able to see if the populations are increasing or decreasing as a whole.

# Appendix F: Seed Mixes, Planting Plans, and Cost Estimates

| **RAA 1A Native Prairie Seed Mix** | | | | | | |
|---|---|---|---|---|---|---|
| **Common Name** | **Scientific Name** | **Cost/lb** | **% of Core List** | **Net Seeds per ft^2** | **lb per acre** | **Estimated Cost per acre** |
| **CORE SPECIES** | | | | | | |
| big bluestem | *Andropogon gerardii* | $12.00 | 10 | 3.9 | 1.06 | $12.74 |
| side-oats grama | *Bouteloua curtipendula* | $18 | 22 | 7.15 | 3.24 | $58.40 |
| blue grama | *Bouteloua gracilis* | $45 | 13 | 8.45 | 0.58 | $25.88 |
| purple prairie clover | *Dalea purpurea* | $45 | 3 | 1.95 | 0.35 | $15.93 |
| nodding wild rye | *Elymus canadensis* | $15 | 25 | 6.5 | 3.4 | $51.05 |
| little bluestem | *Schizachyrium scoparium* | $22 | 27 | 12.29 | 2.23 | $49.05 |
| | **TOTAL** | | **100** | **40.24** | **10.87** | **$213.05** |
| **Common Name** | **Scientific Name** | **Cost/oz** | **% of Core List** | **Net Seeds per ft^2** | **oz per acre** | **Estimated Cost per acre** |
| **GUILD A** | | | | | | |
| prairie sage | *Artemisia ludoviciana* | $40 | 3 | 1.2 | 0.21 | $8.36 |
| aromatic aster | *Aster oblongifolius* | $26 | 5 | 1.0 | 0.85 | $22.21 |
| silky aster | *Aster sericeus* | $40 | 3 | 0.60 | 1.01 | $40.21 |
| bird's foot coreopsis | *Coreopsis palmata* | $20 | 5 | 0.60 | 2.61 | $52.27 |

| | | | | | | |
|---|---|---|---|---|---|---|
| stiff sunflower | *Helianthus pauciflorus* | $40 | 5 | 0.30 | 3.27 | $130.68 |
| dotted blazing star | *Liatris punctata* | $30 | 5 | 0.50 | 3.11 | $93.34 |
| grey-headed coneflower | *Ratibida pinnata* | $5 | 2 | 0.40 | 0.58 | $2.90 |
| black-eyed susan | *Rudbeckia hirta* | $3 | 5 | 1.0 | 0.47 | $1.42 |
| **GUILD F** | | | | | | |
| blue giant hyssop | *Agastache foeniculum* | $10 | 3 | 0.72 | 0.35 | $3.48 |
| pasque flower | *Anemone patens* | $50 | 3 | 0.48 | 1.16 | $58.08 |
| common milkweed | *Asclepias syriaca* | $8 | 3 | 0.18 | 1.96 | $15.68 |
| whorled milkweed | *Asclepias verticillata* | $220 | 3 | 0.42 | 1.66 | $365.90 |
| wild bergamot | *Monarda fistulosa* | $15 | 3 | 0.72 | 0.45 | $6.72 |
| horsemint | *Monarda punctata* | $20 | 3 | 0.84 | 0.41 | $8.13 |
| common evening primrose | *Oenothera biennis* | $6 | 3 | 0.78 | 0.38 | $2.27 |
| large-flowered beard tongue | *Penstemon grandiflorus* | $15 | 3 | 0.42 | 1.31 | $19.60 |
| prairie rose | *Rosa arkansana* | $25 | 3 | 0.06 | 2.90 | 72.60 |
| hoary vervain | *Verbena stricta* | $6 | 3 | 0.60 | 0.93 | $5.60 |
| **GUILD G** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| slender wheatgrass | *Elymus trachycaulus* | $3 | 8 | 0.80 | 5.05 | $15.15 |
| indian grass | *Sorghastrum nutans* | $3 | 5 | 0.70 | 2.54 | 7.62 |
| rough dropseed | *Sporobolus asper* | $3 | 8 | 1.60 | 2.32 | $6.97 |
| prairie dropseed | *Sporobolus heterolepsis* | $8 | 8 | 1.28 | 3.48 | $27.88 |
| **GUILD L** | | | | | | |
| lead plant | *Amorpha canescens* | $15 | 2 | 0.28 | 1 | $14.99 |
| ground plum | *Astragalus crassicarpus* | $30 | 2 | 0.16 | 1.34 | $40.21 |
| partridge pea | *Chamaecrista fasciculata* | $3 | 2 | 0.12 | 1.94 | $5.81 |
| white prairie clover | *Dalea candida* | $3 | 2 | 0.32 | 0.73 | $2.20 |
| **TOTAL** | | | **100** | **31.55** | **40.34** | **$1,030.30** |
| | | | | | | |
| **Total cost per acre for full seed mix:** | **$1,243.35** | | | | | |
| **RAA 1B Native Prairie Seed Mix** | | | | | | |
| aromatic aster | *Aster oblongifolius* | $26 | 15 | 1.0 | 0.85 | $22.21 |
| bird's foot coreopsis | *Coreopsis palmata* | $20 | 10 | 0.60 | 2.61 | $52.27 |
| dotted blazing star | *Liatris punctata* | $30 | 13 | 0.50 | 3.11 | $93.34 |
| black-eyed | *Rudbeckia* | $3 | 8 | 1.0 | 0.47 | $1.42 |

| | | | | | | |
|---|---|---|---|---|---|---|
| susan | *hirta* | | | | | |
| blue giant hyssop | *Agastache foeniculum* | $10 | 8 | 0.72 | 0.35 | $3.48 |
| common milkweed | *Asclepias syriaca* | $8 | 17 | 0.18 | 1.96 | $15.68 |
| large-flowered beard tongue | *Penstemon grandiflorus* | $15 | 10 | 0.42 | 1.31 | $19.60 |
| hoary vervain | *Verbena stricta* | $6 | 9 | 0.60 | 0.93 | $5.60 |
| horsemint | *Monarda punctata* | $20 | 10 | 0.84 | 0.41 | $8.13 |
| | | | 100 | 5.86 | 12 | $221.73 |

| **RAA2 Woodland Edge South and West Seed Mix** | | | | | | |
|---|---|---|---|---|---|---|
| **Common Name** | **Scientific Name** | **Cost/lb** | **% of Core List** | **Net Seeds per ft^2** | **lb per acre** | **Estimated Cost per acre** |
| **CORE SPECIES** | | | | | | |
| big bluestem | *Andropogon gerardii* | $12 | 23 | 6.21 | 1.69 | $20.29 |
| kalm's brome | *Bromus kalmii* | $60 | 25 | 5.63 | 1.91 | $114.86 |
| nodding wild rye | *Elymus canadensis* | $30 | 20 | 3.6 | 1.88 | $56.54 |
| purple prairie clover | *Dalea purpurea* | $45 | 5 | 2.25 | 0.41 | $18.38 |
| little bluestem | *Schizachyrium scoparium* | $22 | 15 | 4.73 | 0.86 | $18.87 |
| Indian grass | *Sorghastrum nutans* | $18 | 12 | 3.78 | 0.86 | $15.44 |
| | **TOTAL** | | **100** | **26.19** | **7.61** | **$244.37** |
| **Common Name** | **Scientific Name** | **Cost/oz** | **% of Core List** | **Net Seeds per ft^2** | **oz per acre** | **Estimated Cost per acre** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **FORBS--ASTERACEAE** | | | | | | |
| prairie sage | *Artemisia ludoviciana* | $40 | 5 | 2.5 | 0.44 | $17.42 |
| smooth aster | *Aster laevis* | $15 | 6 | 1.5 | 1.19 | $17.82 |
| calico aster | *Aster lateriflorus* | $50 | 5 | 2.75 | 0.48 | $23.96 |
| tail-leaved aster | *Aster sagittifolius* | $12 | 6 | 2.55 | 0.82 | $9.87 |
| sweet Joe pye weed | *Eupatorium purpureum* | $15 | 5 | 1.25 | 1.3 | $19.45 |
| stiff sunflower | *Helianthus pauciflorus* | $40 | 2 | 0.12 | 1.31 | $52.27 |
| common yarrow | *Achillea millefolium* | $14 | 2 | 0.8 | 0.2 | $2.74 |
| elm-leaved goldenrod | *Solidago ulmifolia* | $80 | 2 | 0.85 | 0.28 | $22.79 |
| **FORBS--OTHER** | | | | | | |
| purple giant hyssop | *Agastache scrophulariaefolia* | $30 | 5 | 1.5 | 0.7 | $21.08 |
| Clayton's sweet cicely | *Osmorhiza claytonii* | $20 | 2 | 0.15 | 2.61 | $52.27 |
| tall bellflower | *Campanula americana* | $40 | 5 | 2.38 | 0.61 | $24.34 |
| alumroot | *Heuchera richardsonii* | $50 | 6 | 6 | 0.37 | $18.67 |
| wild bergamot | *Monarda fistulosa* | $15 | 6 | 1.8 | 1.12 | $16.80 |
| smooth wild rose | *Rosa blanda* | $20 | 2 | 0.2 | 3.35 | $67.02 |
| early meadow-rue | *Thalictrum dioicum* | $40 | 2 | 0.25 | 1.49 | $59.67 |
| golden alexanders | *Zizia aurea* | $6 | 6 | 1.05 | 4.16 | $24.95 |
| **GRASSES** | | | | | | |
| Sprengel's sedge | *Carex sprengelii* | $30 | 3 | 0.45 | 1.96 | $58.81 |
| switchgrass | *Panicum virgatum* | $3 | 5 | 0.75 | 2.33 | $7.00 |
| prairie dropseed | *Sporobolus heterolepis* | $8 | 5 | 1 | 2.72 | $21.78 |
| **WILDFLOWERS--FABACEAE** | | | | | | |
| lead plant | *Amorpha canescens* | $15 | 4 | 1 | 3.57 | $53.52 |
| Canada milk vetch | *Astragalus canadensis* | $6 | 6 | 1.2 | 3.07 | $18.45 |
| white prairie clover | *Dalea candida* | $3 | 5 | 1 | 2.29 | $6.88 |
| Canada tick trefoil | *Desmodium canadense* | $12 | 5 | 0.5 | 3.96 | $47.52 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **TOTAL** | | | **100** | **31.55** | **40.34** | **$665.07** |
| | | | | | | |
| **Total cost per acre for full seed mix:** | **$909.44** | | | | | |

| **RAA2 Woody plants** | | | | | |
|---|---|---|---|---|---|
| **Common name** | **Scientific name** | **Container Size** | **Quantity** | **Unit Price ($)** | **Total ($)** |
| **Shrub-layer and sub-canopy species** | | | | | |
| Northern red oak | *Quercus rubra* | 5 | 2 | 42.75 | 85.50 |
| Black cherry | *Prunus serotina* | 7 & 2 | 1 each | 74.45 & 21.45 | 95.90 |
| American hazelnut | *Corylus americana* | 10 | 1 | 64.95 | 64.95 |
| Missouri gooseberry | *Ribes missouriense* | 2 | 4 | 21.45 | 85.80 |
| Pagoda dogwood | *Cornus alternifolia* | 7 | 1 | 74.45 | 74.45 |
| Shagbark hickory | *Carya ovata* | 2 | 2 | 21.45 | 42.90 |
| Basswood | *Tilia americana* | 10 | 1 | 134.45 | 134.45 |
| **Savanna** | | | | | |
| Bur oak | *Quercus macrocarpa* | 15 | 2 | 160.54 | 321.08 |
| **Total** | | | | | **905.03** |

# Appendix G: Methods for Invasive and Unwanted Species Removal

## Trees and Shrubs

The most common invasive woody plants on site N2 are common buckthorn, siberian elm, and honeysuckle. The following control measures are meant to control these species, along with woody plants that are recommended for removal because of their low value to the restored landscape or their ability to spread to prairie sites, such as boxelder.

*Chemical Control*

For plants greater than ⅜ inch in diameter, use a cut stump and treat method. Cut the stem with hand saws, chainsaws, or brushcutters, as close to the ground as possible. To prevent re-sprouting, treat with the herbicide Triclopyr (Garlon 4). Mix one part Garlon 4 with 3 parts bark oil/diluent (this achieves a 25% solution) (MN DNR, 2014). Then mix Garlon 4 solution with Hi-Light Blue Indicator Dye (0.5-2 oz. of indicator dye for 1 - 3 gallon tank) and paint on cambium of stump.  The herbicide can be applied with a paint brush or dauber and should be applied within two hours of when the stump was cut, but preferably immediately after cutting.

Buckthorn  that is ⅜ inch in diameter and under can be spot sprayed with a foliar treatment. The most common herbicides to use for foliar sprays are Glyphosate and Krenite S (MN DNR, 1998).  For a foliar spray, make sure to use a lower concentration (2% active ingredient) Glyphosate herbicide (MN DNR, 2014). Mix the herbicide solution with Hi-Light Blue Indicator Dye (0.5-2 oz. of indicator dye for 1 - 3 gallon tank) and apply with a spray wand to reduce overspray. Glyphosate will kill anything green, so this application is best done in the fall when other desirable woody plant species have gone dormant. Resprouts from cut stumps can be managed in this way.

Chemical control measures for woody plants can be done at any time during the year except when there is sap flow, snow, or running water (Packard and Mutel, 2005).  We recommend fall when resources from the leaves are being pulled to the roots.

*Mechanical Control:*

For woody plants that are ⅜ inch in diameter and under, use a weed wrench, hand tool, or hands to pull plants out of the ground manually.  Try minimize soil disturbance by tamping soil back into place after plant has been pulled out. Pulling plants can be done any time of the year, spring through fall, but is easiest to manage when the ground is fairly wet. We recommend this method of removal in the spring, after it leafs out but before it produces fruit.

Buckthorn seeds can remain viable for up to five years in the soil, so it is important to do follow up treatments for five  years.

## Smooth Sumac

Sumac on the N2 site will not be completely removed because it provides habitat, but needs to be controlled or over time it will take over the prairie. For small populations of sumac, basal bark application of 15-20% Garlon 4 in oil applied to uncut stems is the recommendation (Pleasant Valley Conservancy). It can be applied by hand with a spray bottle. Two sprays near the soil line of each stem of sumac is sufficient. The infected plants will begin to turn red within a week of application. By the second week, leaves are wilting and by the third week, the plant is dead. One treatment of any herbicide is not enough, making this process an integrated approach with post planting management. Sumac is particularly difficult to contain because damage to the stem will cause the plant to send up a new shoot from the rhizome. The new shoot must be sprayed within a few weeks of growth to truly contain the sumac populations. The following year, the herbicide must be applied in late spring to early summer. In the case of eradicating the entire population, return a third year for application. On the N2 site, new suckers or shoots should be pulled by hand if necessary.

## Smooth Brome/Non-native Grasses

The broadcast herbicide treatment is necessary in the first year to remove the majority of brome grass. The treatment will occur in the autumn, within 10 days of a killing freeze just before the plants go into dormancy, so that the chemical is translocated to the rhizomes below ground, preventing any regeneration. The best time to spray the glyphosate is between 9 am and 6 pm on a sunny day, with low wind, and less than 80% humidity (Martincich) to ensure that the herbicide is being applied to the plants, and not blown off or evaporated. The broadcasting treatment will occur just after mowing of the brome. Mowing just the one time will not prevent the regeneration of brome grass, though when the glyphosate herbicide is applied immediately following the mowing, it will save on the cost of the herbicide because there will be less brome grass surface area that requires herbicide application, and more of the herbicide will be able to reach the foliage of the brome.The mower will be readily available. The herbicide used in the broadcast technique will be a treatment of “Vegetation Manager Glyphosate 4” applied using a hand-held boom with a flat fan nozzle. It is recommended that the treatment be applied multiple times for perennial weeds that regenerate from roots like the smooth brome, though being that the herbicide will be applied in the fall of the first year, and planting will take place in the spring of the second year, it is unlikely that there will be time for a second broadcasting treatment. In order to achieve the highest rate of brome death during this initial treatment, a high concentration of the formulation will be used. To create a 25 gallon, 5% solution for application, 5 quarts of the herbicide

Glyphosate 4 are to be added to 23 gallons of water. This will create enough of the formulation to cover one acre of land. The process will be repeated ten times, and the intended outcome is to kill the majority (if not all) of the smooth brome grass growing within the restoration action area. In addition to controlling brome grass, Glyphosate 4 can be used to control many of the other weeds within the intended prairie, including; bristle grass (*Setaria sp.),* field sowthistle *(Sonchus arvensis), and* common mullein *(Verbascum thapsus).* The other weeds that can't be killed with the broadcast treatment of Glyphosate 4, will be killed with the spot spraying technique described below.

### Herbaceous Weeds

Herbaceous weeds can be foliar spot-sprayed using a spray wand and backpack sprayer. Broadleaf weeds such as bird's-foot trefoil and canada thistle should be tackled using an herbicide with clopyralid, such as Stinger or Transline (Packard and Mutel, 1997). Mix the herbicide with Hi-Light Blue Indicator Dye (0.5-2 oz. of indicator dye for 1 - 3 gallon tank) in order to see what plants have been sprayed. Be careful not to overspray onto desirable native broadleaf plants if herbicide is being applied after revegetation or in areas where glyphosate has not been broadcasted.  This herbicide should be applied in the spring.