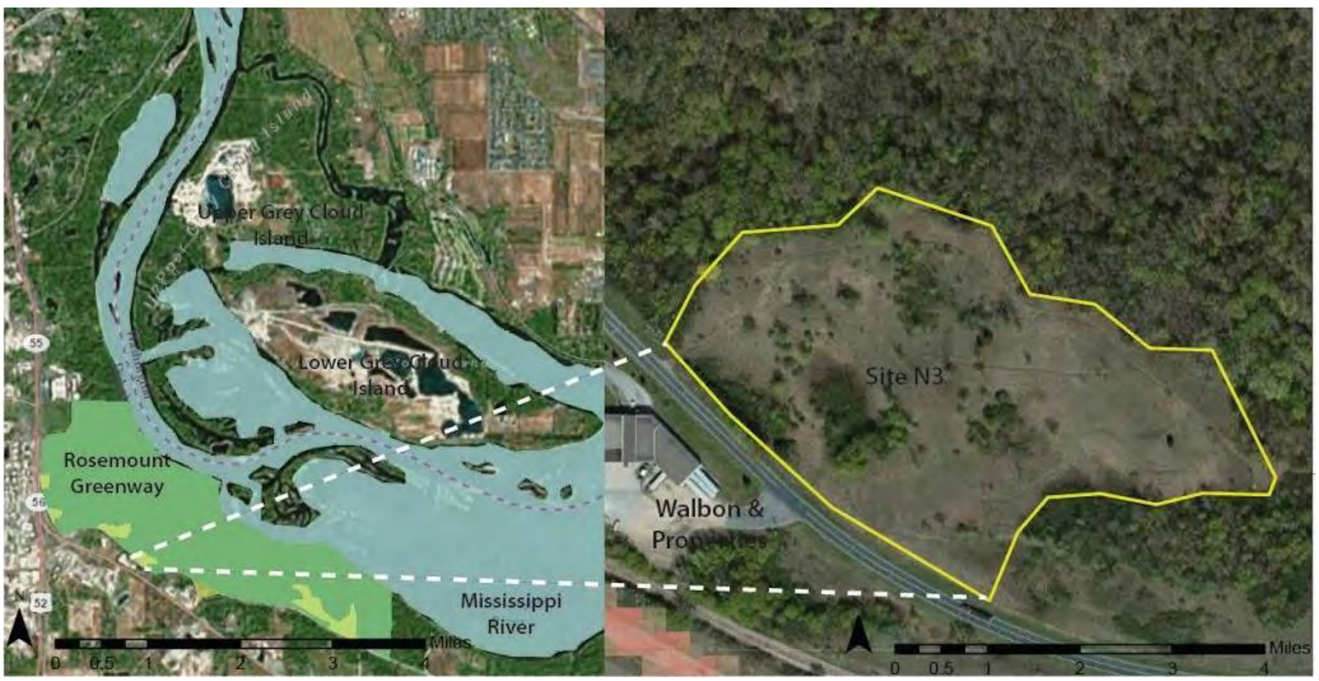
# Rosemount Greenway Restoration Plan

## Site Assessment

## Site N3




**14th December, 2014**

**Submitted by :**
**Group N3 (Cody Madaus, Megan Butler, Niluja Singh)**

Resilient Communities Project

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# Table of Contents

# Part 1 -Site Assessment

## Part 1.1 Greenway (Landscape) Assessment

### 1.Introduction

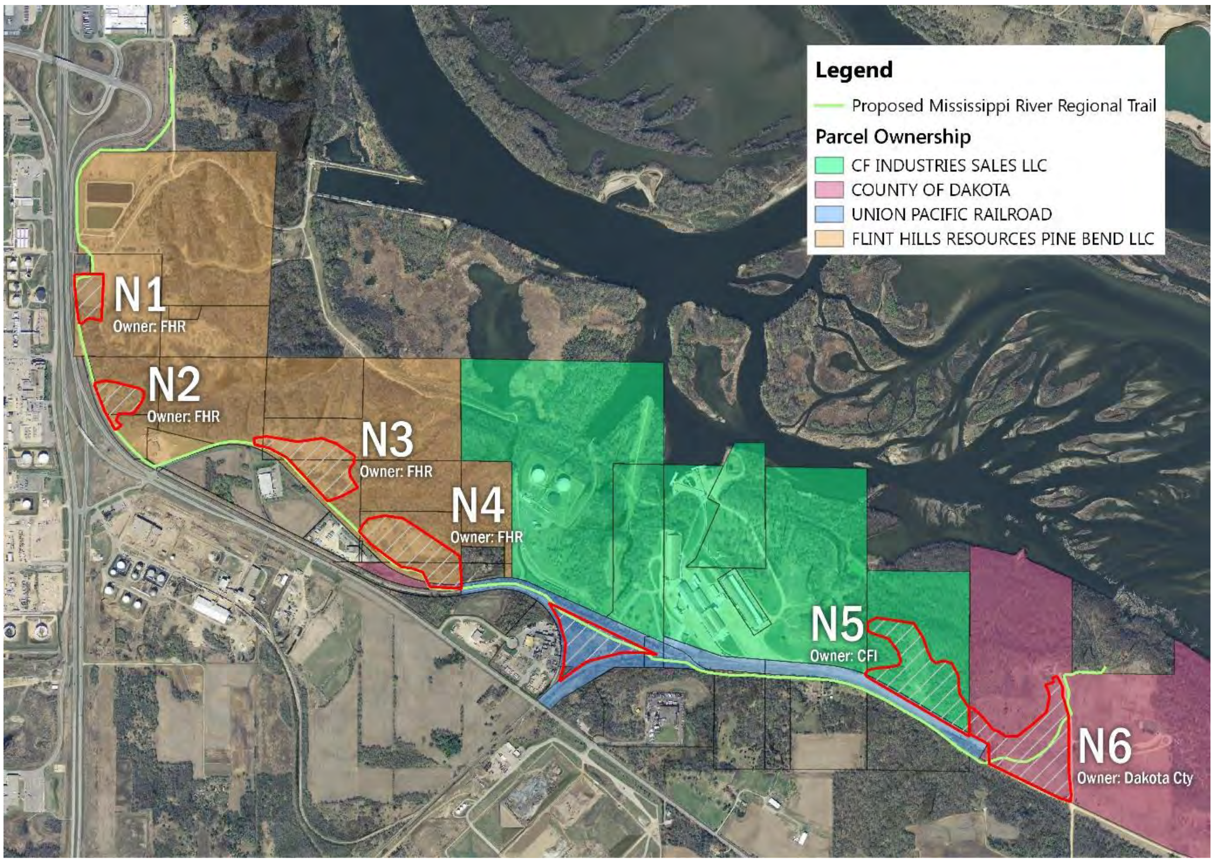
The Rosemount Greenway is a large site of 1278 acres on the west bank of the Mississippi River. This area has a long history of industry, agriculture and recreation. Today, the Flint Hills refinery is on this property. This business, along with CF Industries and Dakota County own various amounts of land on this area. They are partnering up with Friends of the Mississippi River (FMR) and gathering resources and knowledge in order to restore the once natural and diverse ecosystems that were on this property. There are several motives for the restoration of the Rosemount Greenway. First, there are plans for a bike trail to be built through this area. The partners as well as the general public would highly prefer natural scenery from the trail as opposed to a degraded ecosystem. This is not only preferable for the trail-goers but is also important for the public's perspective on the partners' environmental practices. This restoration project could help gain positive public relations with the community. Another major motivation for this project is the fact that the Greenway is a very ecologically important site. The site provides a great buffer between urban development and the water of the Mississippi River. In addition, this corridor provides bird habitat for the Mississippi flyway. This large site provides a bit of an oasis for all kinds of wildlife amidst much development in the surrounding area that is the Twin Cities area.

### 2. Region and Geology

The Rosemount Greenway is an ecologically important area within the Mississippi Watershed and flyway. This is due to both its adjacency to the river as well as the amount of natural area the land occupies by the river. The area is a great natural oasis from the surrounding commercial, residential and agricultural development. This area will benefit the Mississippi River Trail as it will serve as a natural oasis from the highly developed surrounding areas. This site features steep bluffs near the river with flatter, rolling terrain above. According to the United States Department of Agriculture Web Soil Survey, the vast majority of the site contains various types of loamy sands and some sandy loams. Near the riverbank there are various types of muck, silt loams, aquolls and histosols. Much of these soils have been altered for various uses including industrial and agricultural purposes. Loss of topsoil and soil degradation has been a result of these practices.

### 3. Vegetation

Several types of ecosystems are believed to have existed on this site prior to settlement. The two major biomes on this site include prairie and mixed forests. Some of the prairie was likely Oak savanna. Today, mostly deciduous forests remain on the bluffs as well as various areas above. In the early 1900's, much of the prairie areas above the bluffs were converted for agricultural purposes including grazing and crops. These areas have since been abandoned and allowed to grow naturally. As a result, many non-native species including brome grass (*Bromus spp.),* spotted knapweed (*Centaurea maculosa*) and several other plant species have invaded these prairies. The forests on the site have been invaded by European buckthorn (*Rhamnus cathartica),* an exotic invasive that shades out native trees species in the understory. Despite these invasive species, there is still some remnants of native communities. There are still many native prairie plant species as well as large remnant trees including cottonwood, pin oak and American elm. However, due to a large deer population, many native species such as burr oak and white pine have not been allowed to regenerate.




## 4. Conceptual Ecological Model

The three most important human-drivers of ecological change that we identified in the Rosemount corridor include the introduction of invasive species such as European buckthorn, the conversion of land for agricultural use and industrial development, and pollution caused by industry and agricultural runoff both on site and upstream of the corridor. The introduction of invasive species has several negative ecological effects. First, invasive species often out-compete native species for resources. For example European buckthorn grows extremely quickly and is able to shade out competitors while also releasing allopathic chemicals which prevents other species from growing nearby. In this way the introduction of invasive species causes the decline of native species as well as the spread of invasive species. Land conversion for development and industry cause both habitat fragmentation as well as increased erosion and runoff. Pollution caused by industry and agricultural runoff further contributes to the degradation of soil and water resources. These stressors contribute to loss of habitat, the further spread of invasive species, and the loss of native species that require undisturbed habitat and diverse seed banks to maintain healthy populations. Loss of habitat also contributes to decreased resilience of remnant populations of native species, decreased habitat for native fauna, and a loss of genetic diversity in fragmented populations of native species. Together these ecological effects negatively affect the attributes that we are hoping to preserve in the Rosemount corridor such as the presence of healthy oak savanna, prairie, and oak woods ecosystems as well as the existence of viable populations of native species.

(See attached Appendix #1: Greenway Conceptual Ecological Model)

**Part 1.2 Site Assessment**

1. **Introduction**

***Background and Location***

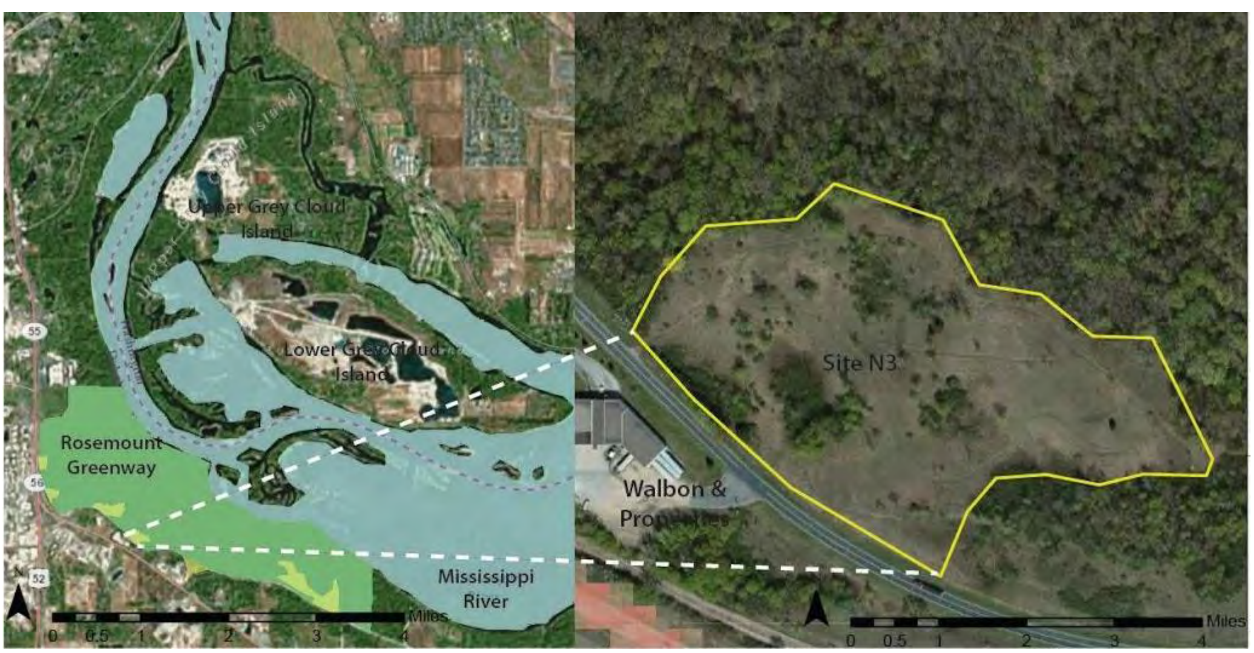
Site N3 is a 9.6 acre site which is generally a small portion of Rosemount Greenway but despite its small size it creates significant impact on this greenway as this site. This site, originally a prairie was converted into an agriculture land and also contained a farmstead on the NW corner which can be seen on the aerial images since 1930's. However, it has been abandoned from human usage and is left in a natural state. After these alterations and interventions this property is presently owned by The Flint Hills Refinery. The refinery currently desires to preserve this site to its original state of forest and prairie.

***Parcel Information***

**Owner:**
Flint Hills Pine Bend LLC

**Property address:**
Invergrove Heights,
Rosemount, MN 55068

**Township, Range, Section:** T18, R115, S18
**Size of site:** 9.6 acres
**Watershed:** Mississippi River
**Watershed District:** Lower Minnesota River Watershed District



***Land use***

This site was generally an open prairie according to historic pre- settlement vegetation map. Aerial images from 1937 to 1970 indicates that this site was largely used as an agricultural field. A small area of this site also contained a farmstead on the north western corner with scattered small farming structures and a street from Pine Bend trail. However, aerial images from 2010 indicates that the site was vacated and was left without any human usage, probably as this site presently lies in the Rosemount Greenway Restoration Zone. There is no direct visible indication of a farmstead or agriculture land but few ornamental plants species like weeping willow and lilac on the NW side does indicate that this site was intervened by humans

## 2. Landscape Context

***Proximity to established greenway***

Dakota County and the City of Rosemount designated a greenway corridor plan adjacent to the Mississippi river to develop restoration plan. Our site is one of the nodes along this corridor which will be Mississippi Regional Trail in near future. The main objective of this corridor system is to create self-generating ecosystems, resembling the past natural system in that area. The proposed greenway will be located on the south western part of our site which will be designed closer to the Pine Bend Trail Street. This greenway will experience the restored ecosystem of native vegetation and introduced bird species but will not intervene directly with the ecosystem as the greenway will be located on the edge of the restoration site.

***Ecological Significance and wildlife value***

This 9.6 acre node has five pollinator attracting perennial vegetation like Whorled Milkweed (*Asclepias verticillata),* Gray Goldenrod (*Solidago nemoralis),* Smooth Sumac (*Rhus glabra),* Heath Aster (*Aster ericoides), and* Raspberry (*Rubus idaeu)* scattered through the site (Mader, Eric et al. ,2010). Especially, the significance of Whorled Milkweed (*Asclepias verticillata)* is rather more as this species is an important source of food and nectar for Monarch butterfly and caterpillars. Monarch are endangered species and milkweed is a targeted species for restoration to provide suitable ecosystem for Monarch species (BBTM). Therefore, the existence of milkweed in our site is ecologically significant.

***Dominant land use within one mile***

Across the Pine Bend Street there is a transport industry Walbon & Properties and also within 0.2 miles there is DPC Industries which is a water treatment site. On the eastern part of the site CF Industries is located which produces nitrogen fertilizers. As a whole we can say that this site is surrounded by industrial areas and industrial programs. However, this node lies in the Mississippi Regional Trail which will have high native flora and fauna diversity overcoming the effects of industrial impact in this area.

3. **Soils and Geology**

***Site geologic history***

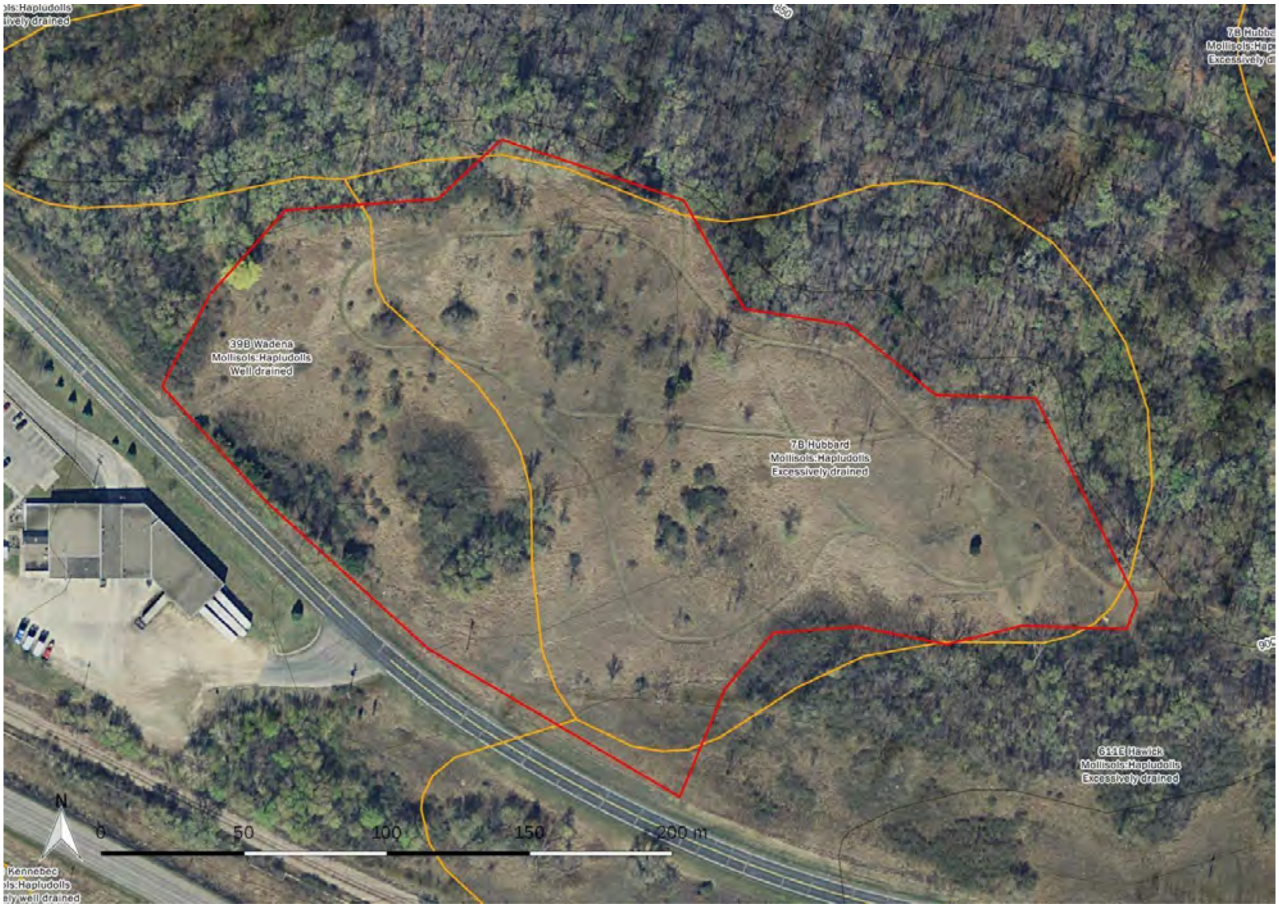
Dakota County's soil was mostly formed by glacial deposits or loess and some soils were also formed in weathered bedrock and recent alluvium. This site in on outwash plains and terraces that is less than 6 percent slope. The soils are well drained.

***Site Soil Survey***

According to Dakota County Soil Survey there are two types of loamy soil present on this site: Hubbard Loamy Sand (7B), Wadena Loam (39B), and Hawick Loamy Sand (611E). Hubbard Loamy Sand (7B) is gently sloping and is an excessively drained soil and is suitable for woodland but because of low availability of water seedling mortality is severe. Wadena Loam (39B) is also gently sloping well drained soil and this site also contains very less amount of Hawick Loamy Sand which is moderately sloping from 18 to 25 percent.

All of these soils are fine- loamy and when a soil sample was taken these soils did not have distinct soil horizons. The change in land usage to a farmland might have resulted in some loss of topsoil (USDA, Dakota County) but most of the soil seemed intact. The topography of this site shows a slow change in grade. There is a gentle slope on the whole site which is not more than 6 percent. This gentle slope is however suddenly changed in near the Mississippi Bluff with fast change in grade, which just outside the site.

| Soil Code | Acres | Soil Name | Slope | Hydric | Water Erodability | Drainage |
|---|---|---|---|---|---|---|
| 7 B | 6.7 Ac | Hubbard Loamy Sand | 1-6 % | N | Low | Excessively drained |
| 39 B | 2.8 Ac | Wadena Loam | 2-6 % | N | Medium (depends on slope) | Well drained |
| 611 E | 0.1 Ac | Hawick Loamy Sand | 18-25 % | N | Medium | Excessively drained |

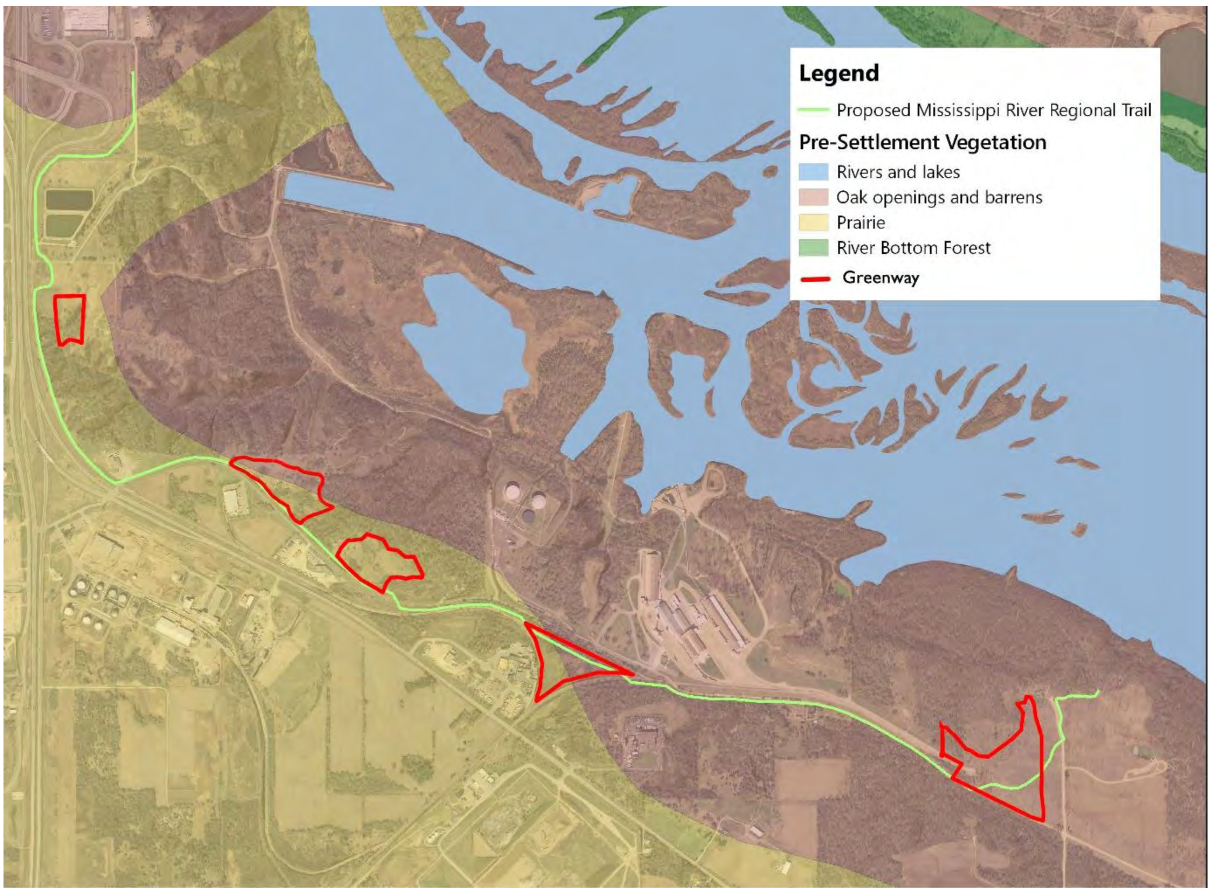



**4. Vegetation**

As the pre-settlement vegetation map in the image below demonstrates the likely pre-settlement conditions at our site were that of a southern dry prairie ecosystem.

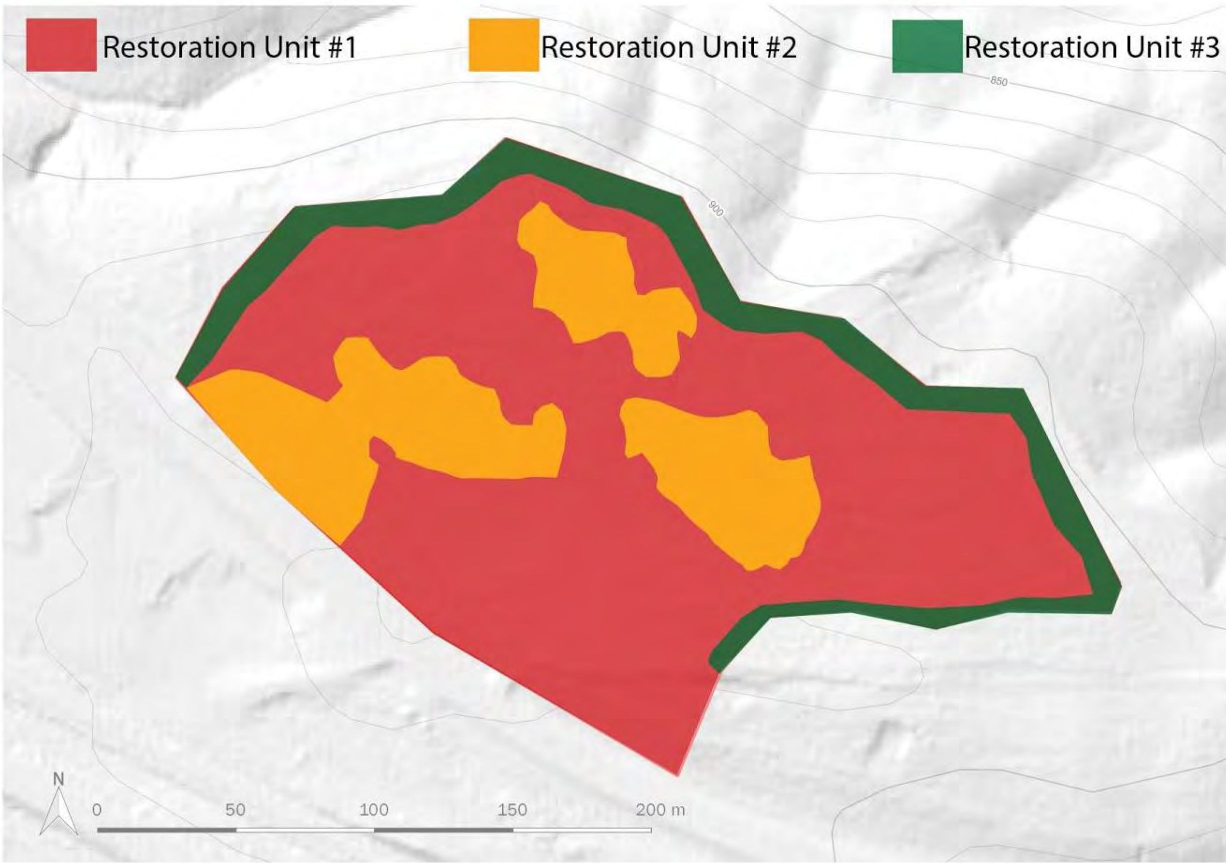
Prairies are dominated by grasses and have less than 25% tree cover or about 1 tree per acre. The most prominent grasses on the southern dry prairie are mid-height and short-grass species as well as some tall-grass species. While species composition on southern dry prairies vary according to local topography and soil types, several common species include little bluestem (*Schizachyrium scoparium)*, side-oats grama (*Bouteloua curtipendula*), prairie drop- seed (*Sporobolus heterolepis)*, porcupine grass (*Stipa spartea*), and plains muhly (*Muhlenbergia cuspidate*). Common forb species include goldenrod (*Solidago nemoralis)*, asters (*Aster ericoides)*, dotted blazing star (*Liatris punctata*), pasquel flower (*Anemone patens*), harebell (*Campanula rotundifolia),* western ragweed (*Ambrosia psilostachya),* and false boneset (*Kuhnia eupatorioides*). Some common prairie shrubs include lead plant (*Amorpha canescens*), prairie rose (*Rosa arkansana*), and smooth sumac (*Rhus glabra*). Trees on southern dry prairie are typically bur oak (*Quercus macrocarpa)* and black oak (*Quercus velutina*) although other tree species often encroach as a result of fire suppression. The surrounding area near our site was also likely to be either dry prairie ecosystem or Southern dry savannah. Southern dry savannah is characterized by a sparse amount of trees (typically oaks) with grass-dominated herbaceous ground-cover.

Today the species composition looks much different. Although some native species still persist on the site, the plant community is composed primarily of several dominant invasive grasses and shrubs and larger trees have encroached on the land perhaps as a result of fire suppression. The species list can be found in the Appendix of this document.



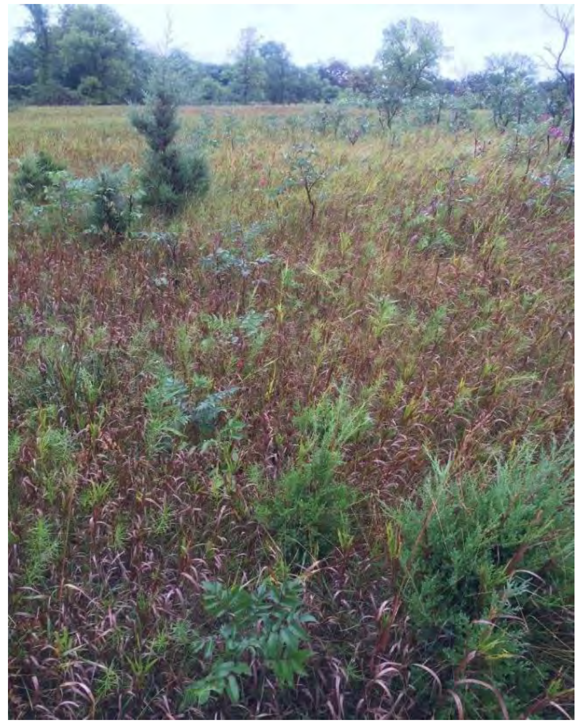
## 5. Restoration Units

The plant composition currently found at our site has been separated into three distinct units each of which have slightly different vegetation. There seem to be three main plant communities found in the site: areas dominated by grasses; areas dominated by shrubby, and mainly invasive, plants; and the area on the edge of our site which is dominated by larger trees.




***Restoration Unit 1: Grass-Dominated Landscape***

The first unit includes the majority of the site and encompasses the areas that are still dominated by grasses. In the grass-dominated areas brome grass (*Bromus Inermus)* and bluegrass (*Poa pratensis*) were the dominant species although there were also large populations of whorled milkweed (*Asclepias verticillata)* and smooth sumac (*Rhus glabra)*.



***Restoration Unit 2: Shrub Land***

The second unit includes several small patches within the site which are dominated by shrubs and low trees. The shrubby areas are heavily populated with invasive species such as honeysuckle (*Lonicera tartarica)*, canada thistle (*Cirsium arvense)* and buckthorn (*Rhamnus cathartica)* as well as other small trees and shrubs.

***Restoration Unit 3: Edge***

The third unit that we identified is located upon the edges of our site. This edge area is primarily populated by large deciduous trees most of which are not native to either the southern dry prairie or oak savanna ecosystems. A list of species identified in the edge area included: black locust (*Robinia pseudoacacia),* cottonwood *(Populus Aigeiros),* box elder (*Acer negundo),* raspberry *(Rubus idaeus),* and blackberry *(Rubus fruticosus).* The edge area also included species such as weeping willows (*Syringa vulgaris)* and lilac bushes (*Salix babylonica)* which provide evidence of past residential land-use on the site. While these edge areas do not make up a large part of our site, they are important to be aware of as they have the potential to encroach upon prairie ecosystems especially in the absence of controlled burns.

## 6. Conceptual Ecological Model

The three largest drivers of ecological change on this site are the introduction of exotic invasive species such as european buckthorn (*Rhamnus cathartica)*, spotted knapweed (*Centaurea maculosa)*, honeysuckle (*Lonicera tartarica)* and brome grass (*Bromus Inermus)*; land conversion primarily for agricultural fields, development for residential or recreational use; and an uncontrollably expanding deer population as the result of lack of predators in the area. The introduced invasive species out-compete native plants for resources which causes the decreased resilience of native ecosystems as well as the loss of native prairie flora and fauna biodiversity. Land conversion contributes to increased erosion and the loss of beneficial soil microbes as well as habitat fragmentation. As a result of these stressors soil fertility is greatly decreased, the resilience of native plants suffers and the habitat for native flora and fauna becomes increasingly fragmented. The very high deer population also contributes to the reduced resilience of native fauna and flora which causes their eventual loss from the site.

Unfortunately, the negative stressors caused by these three main drivers act to reinforce and augment one another’s effect on the site. For example: as deer populations increase only the most resilient species are able to withstand the effects of increased grazing and land conversion favors species that are able to adapt quickly to altered conditions. In addition, as land conversion decreases deer habitat and wild populations become more and more concentrated which focuses the negative impact of deer grazing on native habitats even more. Unfortunately invasive species are often the most resilient species on the site and are best able to survive both increased deer grazing and the encroachment of development making it more difficult for populations of native species to withstand stressors and remain on the site. The attributes affected by these drivers are the native oak savannah and prairie ecosystems as well as the overall biodiversity of the site

(See attached Appendix Site Specific Conceptual Ecological Model)

**Part 1.3 Greenway (Landscape) Goal Setting**

**Goal #1**: A reduction in the cover of invasive plants per invasive species on the site so that there is no more than a 1% cover of any individual invasive species within 5 years.

**Rationale:** As the conceptual model for the site indicates, both species introduction and land conversion has contributed to the spread of invasive species which are out competing native vegetation and causing the native prairie ecosystems to be dominated by perennial weeds. Because the abundance of invasive species contributes to the loss of native ecosystems and habitat, it is an important problem to address. We believe that an aggressive management strategy involving the removal of invasive species within four years is a feasible goal. We chose an aggressive goal of a reduction to a no more than 1% cover of any invasive species on site because we recognize that if we leave to many invasive species on and they will be able to repopulate and out compete native plants very quickly. Therefore, an aggressive invasive elimination strategy is necessary from the very beginning.

**Goal #2:** A 50% increase in the species richness of native prairie or oak savanna plants on the site within five years

**Rationale:** We believe that if the spread of invasive species (addressed in Goal 1) can be curtailed, then it is feasible to repopulate native prairie species on the site. Once invasive species are removed from the site it is very important to repopulate the area with native flora quickly to prevent the accumulation of other opportunistic weeds. Once land conversion and invasive species introduction have been curtailed, we expect that native species will be able to reestablish themselves on the site either from local seed-banks or through manual seeding of native plants.

**Goal #3** At least 90% cover of native prairie or oak savanna species on the site within 5 years.

**Rationale:** As explained in goal 2, we believe that if the spread of invasive species (addressed in Goal 1) can be curtailed and endemic species are allowed to repopulate the area, then it is feasible to see a significant increase in the abundance of native prairie species on the site. Once native plants have been reestablished on the site, they will be able to increase in abundance as long as the spread of invasive species is prevented.

**Goal #4:** An additional 10 bird species endemic to prairie or oaks savanna identified on the site within ten years.

**Rationale:** While it is probable that the return of endemic bird species will take longer than the re-population of native flora, we believe that once habitat destruction is curtailed and the bird's native habitat is re-established then it is a feasible goal to see more native birds either nesting on, or migrating through, the site in 10 years.

**Goal #5:** Increase the abundance and diversity of pollinating bees and butterflies found on the site by 150% within five years.

**Rationale:** Because loss of native species and the spread of invasive species is contributing to the loss of important pollinator nectar sources, we believe that we will see an increase in both the diversity and abundance of pollinating insects on the site as we work towards curtailing the spread of invasive species and increasing the variety and abundance of native flora on the site. The increase in native flora will provide more pollinator habitat and nectar sources and we expect that the pollinator population will increase rapidly and dramatically

**Part 1.4 Site Goal Setting**

**Goal #1:** A reduction in the abundance of honeysuckle (*Lonicera tartarica)*, buckthorn (*Rhamnus cathartica)*, spotted knapweed (*Centaurea maculosa)*, canada thistle (*Cirsium arvense)*, and brome grass (*Bromus Inermus*) on the site so that there is no more than a 1% over of any one of these individual species on the site within four years.

**Rationale:** The site is currently dominated by invasive exotic species. These species are able to outcompete native species for resources and space. As a result the native prairie ecosystem that was once found on this site has been converted to perennial weeds. An aggressive management strategy involving the removal of these invasive species is necessary as there continued presence will severely negatively affect any efforts to reintroduce native plant species to the site. With a focused management strategy over 4 years we believe that our goal is feasible and necessary step to ensuring the overall success of restoration of the site.

**Goal #2:** The successful re-establishment of populations of the following 13 native species to the site within a span of five years: little bluestem (*Schizachyrium scoparium)*, big bluestem (*Andropogon gerardii),* side-oats grama (*Bouteloua curtipendula*), purple prairie clover *(Dalea purpurea),* nodding wild rye (Elymus canadensis), silky aster *(Aster sericeus),* lead plant (*Amorpha canescens*), prairie rose (*Rosa arkansana*), prairie drop-seed (*Sporobolus heterolepis)*, dotted blazing star (*Liatris punctata*), pasquel flower (*Anemone patens*), narrow-leaved purple coneflower *(Echinacea pallida),* and harebell (*Campanula rotundifolia).*

**Rationale:** These species are recognized as being commonly found on dry prairie ecosystems. If the spread of the invasive species discussed in goal 1 can be curtailed, we believe that it will be possible to repopulate native prairie species onto the site. Once invasive species are removed from the site it is very important to repopulate the area with native flora quickly to prevent the accumulation of other opportunistic weeds. We have identified the above 13 species as targets to repopulate because they are known to be found very frequently on the type of ecosystem that we are attempting to restore.

**Goal # 3:** A 150% increase in the native prairie species currently found in the site like heath aster *(Aster ericoides),* gray goldenrod *(Solidago nemoralis)*, whorled milkweed (*Asclepias verticillata)* and bur oak *(Quercus macrocarpa)* within 3 years.

**Rationale:** These four species are the only non-aggressive native prairie flora currently found in our site. These plants are still withstanding the effects of exotic invasive species naturally, indicating their resiliency. We can conclude that these species can help to create better condition for native prairie restoration. By facilitating the expansion of the current populations of these plants we hope to increase the overall coverage of native plants on as well as to increase the resiliency of native flora populations on the site.

**Goal # 4:** Increase the abundance of pollinating bee and butterfly species found in the site by 150% within five years

**Rationale:** As we increase the amount of native flora species in the site there will be abundance of pollinating insect species in the site as they are provided with habitat and nectar sources. The increase in insect species will help and strengthen the ecosystem of the restoration site as the mutualistic relationship between these pollinating insect species and the native prairie vegetation is remarkable. This goal will also be helpful for studies of the relationship between the ecosystems services of these species as well as the production of valuable ecosystem services related to the preservation of pollinator habitat.

# Part 2: Monitoring and Soil/ Landform Modification

## Part 2.1: Soil and Landform Modification

### 1. Trail Construction Considerations

The bike trail connecting site N3 to the other restoration sites as well as other interesting parts of Rosemount Greenway such as Spring Lake Park Reserve will pass through site N3. According to Dakota County's future plan the bike trail is currently planned to run along the southern edge of site N3 running alongside the Pine Bend Trail Street (see image below). The location of the bike trail outlined in this plan coincides with Dakota County's plan. After analyzing environmental and topographical conditions on the site (discussed below), we concluded that this pre-determined location is the best option for the bike trail due to the low risk that the bike trail will pose to the restored habitat during both construction and maintenance of the site. The currently planned location of the bike trial on the edge of the site will minimize the risk of habitat fragmentation and disturbance to the site. In contrast, constructing an active bike path deep inside the restored area might improve the biking experience for visitors who do not want to bike along the road but a path through the middle of the site would divide the site in two different patches which will fragment the site, increase the risk of invasive species seeds being spread throughout the site via bikers, and impede the production of ecosystem services at the restored site.

In addition, due to the topography of the area which is relatively stable soil erosion due to the bike trail is not a big concern. As the image below shows, site N3 has very moderate variation in slope (i.e. about 1 to 6 percent). The southern portion of the site where the location of the bike trail is currently planned is especially topographically stable as you can see in the map below. Therefore, this is the best area for construction of trail.

*Trail Construction and Restoration Timeline*

There are currently two major options for trail construction within the restoration timeline. One option is to complete the construction of trail before starting restoration process. The second option is to construct the trail after the restoration process is finished. Both of these options of the timeline of restoration and trail construction have both positive and negative impacts which are detailed in the table below.

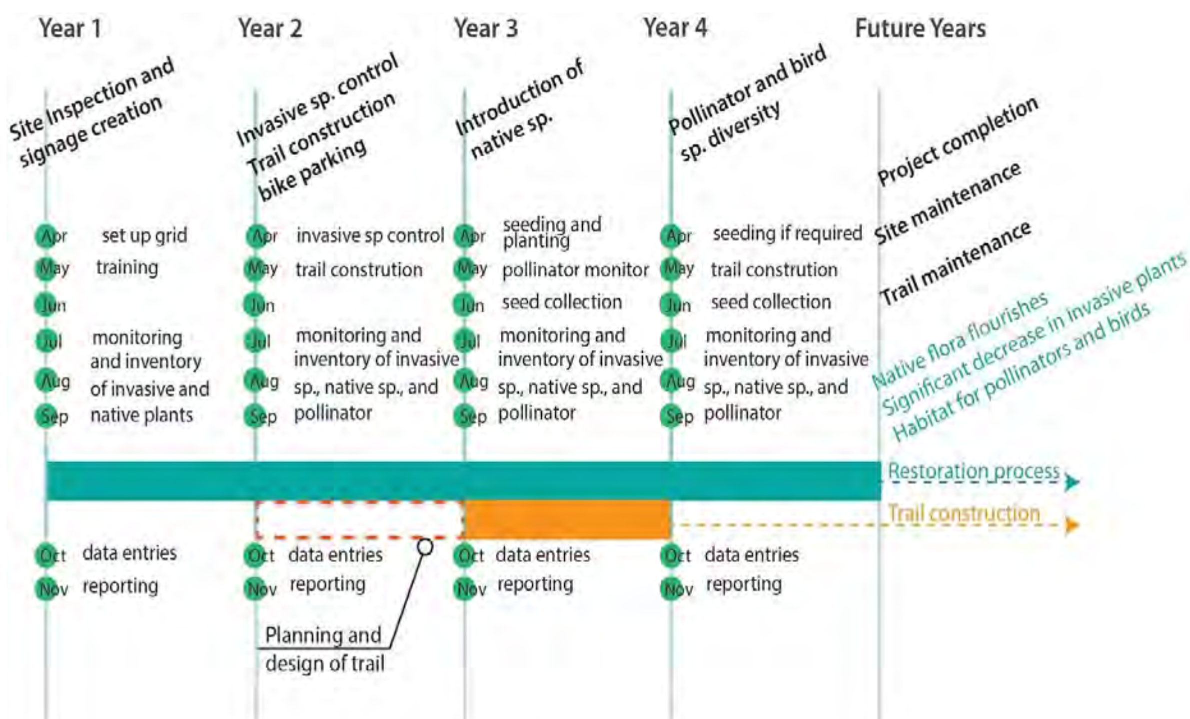
| | **Trail construction before the restoration process begins.** | **Trail construction after the restoration process is completed.** |
|---|---|---|
| 1. | Disturbances occurring in the restored area due to trail construction will be minimized. | There is more probability of disturbances occurring in the restored area due to trail construction. |
| 2. | Bicyclists passing through the site can passively act as a mode of transportation of invasive species which are more likely to cause problems during restoration. However, the ground cover can safeguard the site from invasive species. | Once the restoration work is finished bikes are less likely to transport invasive species and invasive species transported by bikes are less likely to establish on the site. |
| 3. | People might not be attracted to the greenway if the trail is constructed prior to habitat restoration because it currently includes mainly industrial land and abandoned fields. | People will be attracted to the greenway as they can experience a variety of ecological attributes like native forest, prairie vegetation, bird watching and pollinating insects such as butterflies. |

*Recommendations*

In order to minimize adverse impacts of trail construction while maximizing the public benefits provided by the trail, we recommend that the construction of the bike trail occur on the site after invasive species population management has begun but before native reseeding efforts. The goals of this habitat restoration are the reduction of invasive species cover on the site and the simultaneous increase the abundance and diversity of native floras on the site. The removal of invasive flora and the reestablishment of native flora will restore ecosystem function to the site and attract pollinators as well as other native fauna such as and birds.

There are several benefits that would come from waiting to construct the bike trail until after the process of restoration has been carried out. First, the site is currently accessible by Pine Bend Street and there are no access-related problems for the researchers and restoration team that would be mitigated by the construction of a trail prior to restoration. In addition, trail construction before the re-vegetation of the restoration project begins will give the plants more chance to flourish in a natural state without any external human disturbance. We are familiar that a restoration project is a very slow process and takes a long time to entirely be completed. Therefore, it is a better choice to complete the bike trail before the restoration is completed.

According to the restoration goals of site N3 the first goal is a reduction of invasive species and the second goal is reintroduction of native species which will occur within the first five years of restoration project. We recommend that the greenway construction to be started at the third year after the restoration project is ongoing. However, the planning and design of the trail will start on year 2, which will include all construction details about the trail, this will definitely help to carry out the construction very properly on year 3 and also to provide enough time for the restoration team to control invasive species in the site. In addition, construction of the trail before starting the seeding process will create an environment that is less susceptible to disturbance for the native seeds that are just starting to regenerate and establish. This process will also provide visitors and bikers an opportunity to experience different restoration phases of the site. Bikers will be able to relate to the site in a more personal way by experiencing the progression of the site from a neglected area to a well-functioning ecosystem as they pass through the site over the duration of the project.




Construction and Restoration timeline
(sp. = Species)

***Minimizing Adverse Impacts***

In order to minimize adverse impacts of trail construction on the habitat restoration there are several preventative steps that must be taken. The use of signage is a very useful and easy method of creating awareness and making people conscious about their surrounding environment. Signs alerting visitors to the fragile restoration project in process at the site could function to raise interest in the restoration project while also preventing unwanted social trails. In addition a temporary fence can be constructed to block the possible entry of visitors, construction workers and construction vehicles into the site to prevent the site to be compacted due to heavy machineries and vehicles. Therefore, efforts must be taken to mitigate soil compaction on the site during restoration and construction. Any heavy machinery on site will be restricted to a single path and also a proper planning must be done beforehand such that there is less trips that these heavy vehicles will have to make to the site.

Before and during construction a proper grading plan should be designed for the trail in order to ensure that that storm water runoff from the trail is either directed towards the curb or design solutions like bioswales, rain gardens, detention ponds can be created to collect and infiltrate the water.

2. **Soil Erosion**

Soil erosion is not an extreme threat for this site by any means at the current time. The vast majority of the site is currently covered with thick tall grass, small and large shrubs and various sizes of deciduous tree species which keep the soil well in its place. There is very low to moderate variation in slope on the site that ranges from 1 to 6 percent. The only area that may currently be at risk is at the eastern edge of the site where a small agricultural food plot for luring white-tailed deer has been observed. The plot was ocularly estimated to be about a half-acre in size. When observed, the only vegetation on the plot was scattered blades of short grass but the vast majority was exposed soil. It is not known what type of crop that the deer hunter has chosen to plant or what type of agricultural practices that he or she is choosing to implement. The hunter has been allowed by the property owners to lure deer to the area on the condition that this activity stops once restoration activities begin. However, this plot will not be very harmful to the site and it will not cause any erosion because the site is very flat.

Along the northeastern border of the site is a dense, primarily deciduous forest. According to the topographic maps, steeper bluffs are located near this forest edge. The aerial photographs suggest this forest continues along and down the bluffs so there is likely very little erosion taking place, however, it is a definite possibility. This should not, however, significantly impact the ecosystem on site N3. No major erosion control measures are necessary, however, erosion prevention measures will be taken during restoration and bike trail construction to keep the soil intact. Silt fences and hay bale rows will be utilized to prevent soil transport and straw mulch, wood chips and erosion control blankets will be used to prevent periods of exposed soil. These methods may also create a better environment for germination of planted species.

### *Soil Condition and Amendments*

It is difficult to determine the extent to which the soil on this site has been altered. Evidence of a former home site was found on the site. Upon observing the site, the primary indicator of past residential use was the presence of several plants that are not native to the site that typically don't reproduce in the area including a large lilac bush (*Syringa vulgaris*) and a mature weeping willow (*Salix babylonica*). This finding is also supported by the historical photos. The residence on the site was built sometime between 1940 and 1964 and the last known aerial photograph of it that could be found was taken in 1970. Ever since the first aerial photo was taken in 1937, almost the entire site has been farmed for various crops. This likely resulted in some loss of topsoil, however the soil currently seems to be fairly intact and not prone to further erosion. Soil core sampling done on this site in early October of 2014 confirmed the Web Soil Survey prediction of Hubbard loamy sand and Wadena loam type soils. Sometime after 1970, the land was abandoned and allowed to grow naturally. Major soil amendments are not necessary during the restoration due to the relatively intact and fertile condition of these soils. The map on the following page details the soil types and topography that can be found on the site.

## Map Unit Legend

| Dakota County, Minnesota (MN037) | | | |
|---|---|---|---|
| **Map Unit Symbol** | **Map Unit Name** | **Acres in AOI** | **Percent of AOI** |
| 7B | Hubbard loamy sand, 1 to 6 percent slopes | 6.7 | 69.5% |
| 39B | Wadena loam, 2 to 6 percent slopes | 2.8 | 29.3% |
| 611E | Hawick loamy sand, 18 to 25 percent slopes | 0.1 | 1.2% |
| **Totals for Area of Interest** | | **9.6** | **100.0%** |

**Part 2.2: Site Monitoring and Evaluation Plan**

1. **Parameters for each Restoration Goal**

The following section contains a detailed discussion of the parameters that will be utilized to help restoration teams measure the progress they are making towards achieving restoration goals.

**Goal # 1:** A reduction in the abundance of honeysuckle (*Lonicera tartarica)*, buckthorn (*Rhamnus cathartica)*, spotted knapweed (*Centaurea maculosa)*, canada thistle (*Cirsium arvense)*, and brome grass (*Bromus inermus*) on the site so that there is no more than a 1% over of any one of these individual species on the site within four years.

**Parameter #1:** The cover class of each of the invasive species located on the site including: honeysuckle (*Lonicera tartarica)*, buckthorn (*Rhamnus cathartica)*, spotted knapweed (*Centaurea maculosa)*, canada thistle (*Cirsium arvense)*, and brome grass (*Bromus inermus*).

This parameter has several strengths. First, it is biologically relevant (important to maintaining a balanced ecological community) due to the fact that invasive species out compete endemic species for resources and their presence on site will significantly hinder the restoration process. In addition, this parameter is anticipatory because invasive species thrive in disturbed systems and a continued abundance of invasive species will indicate additional problems that must be addressed in order to restore the site (such as continued disturbances or other aspects of the site that are not allowing endemic plant species to thrive). Therefore, the cover class of these invasive species is an excellent indicator of factors affecting the success of the restoration process. This parameter is also cost effective in that estimating cover-class across a site takes relatively little man-time compared to more in-depth surveys. In addition, estimating cover is nondestructive in that it causes minimal damage to the ecosystem. The only potential damage in this case would be caused by surveyors walking across the area to estimate cover class. Estimating cover class is not very sensitive it does not provide a very specific estimation of the amount of any individual species on the site but rather an estimation of the total amount of the site that the particular species takes up. This means that this parameter will not be able to detect small increases or decreases in the populations of invasive species on the site.

**Goal #2:** The successful re-establishment of populations of the following 13 native species to the site within a span of five years: little bluestem (*Schizachyrium scoparium)*, big bluestem (*Andropogon gerardii),* side-oats grama (*Bouteloua curtipendula*), prairie drop-seed (*Sporobolus heterolepis)*, porcupine grass (*Stipa spartea*), and plains muhly (*Muhlenbergia cuspidate*), dotted blazing star (*Liatris punctata*), pasquel flower (*Anemone patens*), harebell (*Campanula rotundifolia),* western ragweed (*Ambrosia psilostachya),* false boneset (*Kuhnia eupatorioides*), lead plant (*Amorpha canescens*), and prairie rose (*Rosa arkansana*).

**Parameter #2:** The cover class of the following 13 native plants on the site: little bluestem (*Schizachyrium scoparium)*, big bluestem (*Andropogon gerardii),* side-oats grama (*Bouteloua curtipendula*), purple prairie clover *(Dalea purpurea),* nodding wild rye (Elymus canadensis) silky aster *(Aster sericeus),* lead plant (*Amorpha canescens*), prairie rose (*Rosa arkansana*), prairie drop-seed (*Sporobolus heterolepis)*, dotted blazing star (*Liatris punctata*), pasquel flower (*Anemone patens*), narrow-leaved purple coneflower *(Echinacea pallida), and* harebell (*Campanula rotundifolia).*

The strengths of this parameter are that it is biologically relevant, sensitive and anticipatory. The species chosen to monitor are recognized as being commonly found on the ecosystem that we are trying to restore. In addition these plants were chosen due to the fact that they represent a variety of plants that provide different services within the ecosystem including: grasses, forbs, shrubs, pollinator habitat and food, and successional stage. The ability of these common species to re-establish on the site will allow restorationists to monitor the success of the restoration. In addition, if these species are unable to re-establish it will help provide early indication of additional drivers that need to be addressed in order to restore the site. However, as was mentioned above, measuring cover class is not a sensitive technique. A benefit to identifying only 13 native plants to monitor is that this technique will take less time compared to conducting a full inventory of the site but will also provide relevant information about the ability of native prairie plants to re-establish on the site.

**Goal # 3:** A 150% increase in the native prairie species currently found in the site such as heath aster *(Aster ericoides),* gray goldenrod *(Solidago nemoralis)*, whorled milkweed (*Asclepias verticillata)* and bur oak *(Quercus macrocarpa)* within 3 years.

**Parameter #3:** The cover of the following four species on the site: heath aster *(Aster ericoides)*, gray goldenrod *(Solidago nemoralis)*, whorled milkweed (*Asclepias verticillata)* and bur oak *(Quercus macrocarpa).*

The strengths of this parameter are that it is biologically relevant and anticipatory. The species chosen to monitor are the only non-aggressive native flora that are currently found on the site. These plants are withstanding the effects of drivers such as invasive species naturally, indicating their resiliency. An increase in an abundance of these plants during the restoration process would indicate the success of restoration and the spread of genes that have proven to be biologically resilient. In addition, if these species experience a decline in population during restoration it could indicate that restoration techniques are having a negative effect on the site and a change in approach is needed. Unfortunately this parameter is also not sensitive as it pertains to cover class and not individual species. A benefit to identifying only 4 native plants to monitor is that this technique will take less time compared to conducting a full inventory of the site but will also provide relevant information about the ability of native prairie plant populations to increase on the site. While this parameter might seem redundant as it aligns closely with parameter #2, the difference between the two parameters is that parameter 2 measures the ability of native plant populations that do not currently exist on site to reestablish while parameter #3 measures the ability of native plants that are currently on the site to increase their population. However, because of the similarities in measurements between the two parameters it will be possible to measure both in with the same protocol (this will be discussed further in the following section).

**Goal # 4:** Increase the abundance and diversity of pollinating bee butterfly species found in the site by 150% within five years

**Parameter #4:** The number of pollinating bee and butterflies found on the site as well as the diversity of pollinating bee and butterfly species represented on the site.

This is a biologically relevant, non-redundant parameter which is also not destructive. The parameter is biologically relevant because as we increase the amount of native flora species on the site it will create habitat for pollinating insect species such as bees and butterflies. Studies have shown that 1/3 of crops production across the globe are dependent upon pollinators and 75% of earth's flowering plants rely on pollinators to reproduce (Ullmann, 2014). Native ecosystems are being increasingly recognized for their ability to provide important pollinator habitat. The increase in these mutualistic insects which help promote the pollination of native plants will help strengthen the ecosystem and improve restoration on the site. Information on the abundance and diversity of pollinators on site will be useful to assess progress towards achieving the goal of increasing the number and types of pollinators on the site via enhancing native habitat which is used by pollinators for both food and nesting. As this is the only parameter that focuses upon fauna on the site it is not redundant compared to the other parameters. However, because the existence of these native pollinators is dependent upon the re-establishment of native plants this parameter is not very anticipatory.

Together these four parameters are measurable, interpretable provide unique and valuable information. Given the relatively small size of the site these parameters also are an appropriate and feasible scale which would provide valuable information but not take up an excessive amount of valuable resources to perform.

## 2. Monitoring Protocol for Each Parameter

This section contains a brief description of the monitoring protocol that has been developed for each parameter. Please referrer to the appendices for full descriptions of each protocol.

***Protocol #1: Invasive species cover.***

In this case data on invasive species cover will be collected yearly beginning the fall (August or September) prior to beginning the restoration activities. Data on invasive species cover will be collected beginning prior to the beginning of restoration efforts in order to establish baseline data on invasive species cover and data collection will continue yearly throughout the duration of the restoration effort. If resources allow, monitoring of invasive species cover can continue after the restoration work has been completed as part of general site maintenance. After restoration activities a cover class of over 1% for any of the invasive species on the site would be indication that maintenance and removal of invasive plants is required.

The techniques used to measure invasive species cover on the site will involve both invasive species mapping and strategic species sampling (see detailed protocol in appendix). In the case of invasive species, this protocol focuses upon collecting data on species cover instead of specific numbers within any of the invasive species populations. This allows researchers to collect data for this protocol in a timely and cost-effective manner while still collecting important data on invasive species populations. Data on species cover class will be presented on a line graph which indicates the % cover class of invasive species over time (see detailed protocol in appendix #4).

***Protocol #2: Native species abundance.***

This protocol is designed to measure the abundance of native prairie species addressed in two parameters. First, the protocol will measure cover of four species that are currently located on the site: heath aster *(Aster ericoides),* gray goldenrod *(Solidago nemoralis)*, whorled milkweed (*Asclepias verticillata)* and bur oak *(Quercus macrocarpa).* In addition the protocol will also measure the cover of 13 native species that are not currently on the site but will be reintroduced over the duration of the restoration project: little bluestem (*Schizachyrium scoparium)*, big bluestem (*Andropogon gerardii),* side-oats grama (*Bouteloua curtipendula*), purple prairie clover *(Dalea purpurea),* nodding wild rye (Elymus canadensis), silky aster *(Aster sericeus),* lead plant (*Amorpha canescens*), prairie rose (*Rosa arkansana*), prairie drop-seed (*Sporobolus heterolepis)*, dotted blazing star (*Liatris punctata*), pasquel flower (*Anemone patens*), narrow-leaved purple coneflower *(Echinacea pallida), and* harebell (*Campanula rotundifolia).*Because both parameters #2 and #3 address the abundance of native species, it is appropriate to utilize the same protocol to fulfill the monitoring requirements of each parameter. In total this monitoring protocol measures the cover of 17 pre-identified native species.

As with invasive species monitoring, native species monitoring will begin the fall prior to the beginning of restoration activities in order to establish a baseline. As 13 of the species to be monitored do not currently exist on the site and are expected to be reintroduced to the site over time, it is expected that only four species will be identified during the preliminary baseline monitoring. Data collection on native species abundance will occur once per year over the duration of the restoration project. The data collected about the abundance of native species will be presented with a series of graphs which list the cover of each species over time (see detailed protocol in appendix).

***Protocol #3: Pollinators***

This protocol aims at monitoring the number and diversity of pollinating bee and butterfly species found on the site. Like the protocols for flora monitoring, the monitoring of pollinators will begin the year before restoration work is initiated on the site. Unlike protocols for flora, monitoring for bee and butterfly species will need to occur three times each year to account for different bloom times for different flora species that attract different species of pollinators. In addition pollinator monitoring must occur during the afternoon hours where the pollinators are most active. Data collected from monitoring will be presented with a graph which indicates overall number of pollinators identified as well as how many species were identified and when (see appendix).

### 3. Data Interpretation

Data on invasive species cover will be an excellent indicator of the potential success of the restoration and the need for invasive species management. If it is shown that invasive species cover increases over time then this will indicate that increased effort must be taken to manage invasive species and reduce disturbance on the site. Similarly if the restoration is successful we expect the monitoring of native species to show an increase in both species diversity and species abundance over time. If this expected increase does not occur this indicates that there is a driver affecting the ability of native plants to re-establish which needs to be addressed.

In addition, the existence of pollinators on the site should increase as the amount of native flora increases. If native flora increases and a decline or no change in native pollinators on site is observed then the site managers may decide to introduce more native plant species known to be mutualistic with pollinators in order to encourage their re-establishment. Some of these species could include: smooth sumac (*Rhus glabra),* raspberry (*Rubus idaeus),* heath aster (*Aster ericoides*), gray goldenrod (*Solidago nemoralis),* whorled milkweed (*Asclepias verticillata),* and kentucky bluegrass (*Poa pratensis).*

## 4. Logistics

As shown by the table below, monitoring activities will begin in April and continue throughout November. We suggest that the firm should commit the time of 2 employees working 20 hours per week from April to November in order to conduct restoration monitoring. The first step in monitoring is to properly train the two technicians that will be involved in the restoration monitoring and to set up the grid systems for both the pollinator monitoring and the plant monitoring (please see data collection maps which found in the protocol for each parameter in the appendix of this document). Pollinator monitoring will occur three times during the season while native and invasive plant monitoring will occur once. Monitoring for both native and invasive plants can occur at the same time and will use the same grid plots. Examples of data recording sheets are located in the protocols found in the appendix of this document. Data entry should occur after each monitoring activity and final reporting should occur at the end of the season in October or November.

| *Monitoring Activity Timeline* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Activity** | **April** | **May** | **June** | **July** | **Aug** | **Sept** | **Oct** | **Nov** |
| Set up Grid System | X | | | | | | | |
| Train Technicians | X | | | | | | | |
| Pollinator Monitoring | | X | | X | | X | | |
| Invasive Species Monitoring | | | | X | X | | | |
| Native Species Monitoring | | | | X | X | | | |
| Train Technicians for Flora Species Monitoring | | | | X | | | | |
| Data Entry | | X | X | X | X | X | X | |
| Reporting | | | | | | | X | X |

The following table details the expected budget of yearly monitoring activities on the site. The greatest monitoring expense is the manpower involved. We expect that the amount of labor that will be required for monitoring will be the equivalent for the work of 2 people working 20 hours per week at $13.00 per hour for seven months or about 1200 hours total for the season. In addition, if the same employees conduct monitoring each year then the company can save on training costs ($400 per year). In addition, the "One-time costs" box identifies costs that will be incurred only once during the restoration as the tools, once purchased, will be utilized each year.

| *Restoration Monitoring Budget* | | | | | |
|---|---|---|---|---|---|
| Item | 1 Time costs | Unit | Quantity | Cost per Unit | Total |
| GPS and Software | X | GPS | 1 | $600.00 | $600.00 |
| Wooden Stakes | | Bundle | 4 | $20.00 | $100.00 |
| Flagging Tape | | Roll | 2 | $20.00 | $40.00 |
| Topographic Map | X | Map | 1 | $20.00 | $20.00 |
| Anemometer | X | Anemometer | 1 | $40.00 | $40.00 |
| Employee Time | | Hour | 1200 | $13.00 | $15,600 |
| Clipboards | X | Board | 2 | $5 | $10.00 |
| Prints of Datasheets | | Sheets | 40 | $.05 | $2.00 |
| Floral and Invertebrate Identification Guides | X | Guide | 2 | $15.00 | $30.00 |
| Camera | X | Camera | 1 | $100.00 | $100.00 |
| Transportation | | Miles | 200 | .50 | $100.00 |
| Technician Training | | Training | 1 | $400 | $400 |
| Binders for Data Sheets | | Binder | 6 | $1.00 | $6.00 |
| | | | | | |
| | | | | **Total Cost Year 1** | **$17,048** |
| | | | | **Total Cost Years 2+** | **$16,248** |

## 5. Data Management

Data management is a crucial part of any restoration project. Small misinterpretation of data can cause a big impact on the restoration process. Incorrect identification of site/plants, loss of data, technical failure, and data interpretation errors are few of the factors that can go wrong in any project. In order to ensure a quality data set measures must be taken both in the field and afterwards in the office.

### *Data Management in the Field*

Data collectors must have knowledge about their assigned work. Training workshops should be carried out before the data collection process begins. These workshops must include training related to species identification, taking measurements, using species guides, interpreting weather data, and using simple machines. This will help data collectors to work efficiently in the field. Data collectors should also be provided with folders to keep the documents safe from any possible hazards like water, fire, wind or food.

### *Data Management in the Office*

After collecting monitoring data in the field, the information must be transferred as soon as possible in digital format by the same person who collected the field data in order to minimize errors caused by misreading data. Data should be entered as soon as possible when data collection memory is highest as well as in order to minimize the risk of losing the valuable data sheets. Also, our data mostly deal with plant identification and whenever there are taxonomic changes in a particular species, this changes should be noted and data should be altered and saved.

Multiple copies and backups must be created for both field data sheets and the electronic data. The electronic data must be regularly managed so that that changes in the use of software does not affect original data as software are updated very frequently. Also, while creating backups, data should always be saved in an updated format. For example: before data were saved in a diskette which later converted into disks again it changed into using external drives and now the easiest way to keep data in a safe place is in cloud storage. Cloud is very easily accessible but this storage is tricky because anyone can make changes. Therefore data storage must be done in multiple formats like paper, hard drives and also cloud storage. In addition, all hard copies of data sheets from the field should be clearly marked with the date and stored in a safe place for reference as needed.

### *Ensuring the Safety of Data Collectors*

The monitoring activity and data collection process is likely to be carried out in different weather conditions ranging from hot July summer day to cold November days as you can see in the Monitoring Activity Timeline. Precautions should be taken to ensure all data collectors have access to sun screen, insect repellent, and sufficient water. In addition rules should be created in order to ensure that the researchers are not allowed to stay outside during harsh weather conditions for more than an hour without resting in a provided shelter or in a well-equipped vehicle with heating and cooling system. This measure is necessary to ensure the protection of data collectors and also to avoid the occurrence of human error caused by haphazard data collection due to inclement weather conditions.

# Part 3: Revegetation/Vegetation Management Plan

## Part 3.1: Revegetation

### 1. Overall Revegetation Strategy

Site N3 of the Rosemount Greenway restoration plan is delineated into three distinct revegetation areas as shown on the map below. The area with the greatest acreage is the tallgrass prairie ecosystem type which occupies approximately the eastern three quarters of our site or slightly under 6.7 acres. The oak savanna restoration will occupy the western quarter of the site with an area of just under 2.8 acres.The bike trail will run nearly parallel to the road ranging from 30 to 40 yards from the road. Active revegetation will be utilized via broadcast seeding as well as some direct planting of oak saplings in the oak savanna restoration area. Passive revegetation is not a good option for this site since there are many invasive species such as brome grass and spotted knapweed that would quickly colonize the site without intervention through active invasive species management. In addition, the small populations of native species on the site would not be diverse or large enough to recolonize the site without re-seeding of other native plants.

A 50 foot buffer seed mix will be used to create a more aesthetically pleasing view from the trail. In this seed mix, the variety of plants will be very similar to the adjacent oak savanna and dry tallgrass prairie, however, a greater percentage of forbs and other flowering plants including *Agastache foeniculum* and *Rudbeckia hirta* will be selected for this zone. In addition to aesthetically pleasing plants, a few other native plants will be added to discourage foot or bicycle travel through the restoration zone such as thorny plants, tall/thick plants and species with burs or seeds that tend to stick to clothing.

The oak savanna zone was delineated based upon analysis of existing vegetation and soil types on the site. First, the loamy soil in this area is slightly richer than that of the eastern three quarters of the site which is indicative of an oak savanna site. When on site, we also noticed that this site contained a greater number of various tree species including burr oak, elm and heavy sumac thickets. These trees also appeared to be healthier than the trees to the east of this area. Approximately fifty balled and burlapped bur oak (*Quercus Macrocarpa*) trees will be planted within this area. The highest density of these trees will be planted closer to the forest on the western edge of the site with gradually decreasing density eastward. This will create a smooth transition from a hardwood forest to an oak savanna to a tallgrass prairie. The species selected in this mix have much overlap to the seed mix in the tallgrass prairie, however species such as *Andropogon gerardii, Antennaria neglecta* and *Aster laevis* which are native to oak savannas and more tolerant of partial shade were chosen to have greater percentages in this mix.

The dry tallgrass prairie ecosystem was delineated because its soils of loamy sand better match that of a dry tallgrass prairie. The trees on this site were found to be growing very poorly so we believe that shorter prairie plants will do best here. There are several trees of various ages growing on this site, however, they have poor growth form and many appear to have dead tops. Because of this, all trees on this site will be taken down and removed. Most of the prairie species that will be planted on this site require full sun, therefore large trees must not be present in this zone.

Each of these strategies link to our goals of having three separate but gradually transitional vegetation zones. When choosing seed mixes, we chose plants that are native to the ecosystem and fit into the local hardiness zone. One of the goals of this restoration is to maximize pollinator value on the site. For this reason, we selected species that have high pollinator value with bloom times that occur during different times throughout the growing season. This will maximize pollinator value for every type of pollinator including birds, moths, butterflies and bees.


| **Action Area** | **Color** | **Acreage** |
|---|---|---|
| Oak Savanna | Green | 2.8 |
| Dry Tallgrass Prairie | Orange | 6.7 |
| Bike Path Buffer Area | Light Green | .5 |
| Bike Path | Blue | .1 |

**2. Extant Vegetation Conditions**

The current vegetation conditions on the site are grouped into three regions which are spread out uniformly throughout all three identified action areas (Oak Savanna, Prairie, Bike Trail) on the site. These conditions include areas which are dominated by invasive grasses such as brome grass and Kentucky bluegrass as well as other areas which are dominated by shrubby and woody species (primarily invasive). The third identified region is along the edge of the site which has primarily large trees and woody plants which will pose a threat to the establishment of native vegetation if they are allowed to spread onto the site during the restoration.

The current vegetation conditions are not desirable for the ecosystems that we believe belong here for several reasons. For a full list of species present on the site please refer to the species list in the appendix. In addition, refer to species on seed mix lists for desired vegetation. Current vegetative and soil conditions gave us some clues about what ecosystem types belong on the sites. First, the line between oak savanna and tallgrass prairie was drawn directly with the line between loam and loamy sand soil types according to the web soil survey. The existing vegetation in the area of the site with loamy soil tend to be larger with more trees than that of the loamy sand area. We estimated that there is at least 60-80 mature trees on this site that must be taken down due to their status as non-native invasive plants or due to the fact that these mature woody trees will negatively affect the regrowth of prairie plants which require full sunlight.

Invasive species including brome grass and European buckthorn are highly prevalent on each action area on the site. Because of their ability to sprout vigorously after disturbance, extra measures must be taken to ensure that these species do not proliferate or sprout after removal and site preparation. First, European buckthorn will be cut and removed from the site to prevent from dropping seed on the site. The stumps of these trees will be sprayed with herbicide to ensure re-sprouting does not occur. Monitoring shortly into the growing season will take place in order to assess whether these species continue to grow. In this case, a second herbicide application while the vegetation is green to make certain that these species are eradicated. This could set back site preparation for the seeding and planting of selected native species for restoration.

**3. Site Preparation**

The site preparation strategy for site N3 aims at achieving three main steps prior to re-seeding the site with native vegetation. These steps aim to address: preserving the genetic material of the native plants currently located on the sites by collecting seed heads, to remove woody species found in the “Shrubby” regions identified during site assessment which are located in each action area of the site, and to use a broad spectrum herbicide to remove the significant populations of invasive grasses such as brome grass and Kentucky bluegrass which are currently found throughout the site. The goal of the site preparation strategy is to manage/decrease invasive weed populations and other threats on the site in a way that will allow native vegetation to flourish. Typically this is achieved through removing thatch, improving seed-to soil contact, and reducing weeds (Williams, 2010). Because each action area currently has the same amount of grassy and woody species, the site preparation in each action area will be the same.

**Site Preparation Step 1: Seed Collection**

First, it will be necessary to collect the seed heads of native plants that currently exist upon the site. The site is currently overrun by primarily aggressive invasive species. However, there are several native plants that are currently found on the site such as heath aster *(Aster ericoides),* gray goldenrod *(Solidago nemoralis)*, and whorled milkweed (*Asclepias verticillata)*. These three native species are found throughout the site and are the only non-aggressive native prairie flora currently found in our site and are still withstanding the effects of exotic invasive species naturally, indicating their resiliency. Unfortunately, the use of broad-spectrum herbicides on the site to treat invasive species such as brome grass and Kentucky blue grass will likely also kill the small populations of native plants currently on the site. In order to preserve the genetic resiliency of the plants currently found on the site it is recommended that the seed heads of the four native species currently on site be cut and preserved to use during the re-seeding process. By cutting and storing the seed-heads of plants currently on the site, the restoration project will be able to preserve the genetically resilient native plant populations on site.

Because of the low density of these native species on site relative to invasive species, seed collection will be done by hand in order to prevent the collection of unwanted seed and assure the collection of seed from the three desired species. Hand collection of seed typically is more labor-intensive compared to other methods of seed collection as it involves walking through prairie sites and stripping seeds or seed heads from individual plants (Lochner, 1997). There are currently three native species of interest on the site and the table below details the approximate time of year when these species seeds can be harvesting. The dates were obtained from the pleasant valley conservancy website.

| **Species** | **Timing of Harvesting** | **Harvesting Method** |
|---|---|---|
| Heath aster *(Aster ericoides)* | Late October | Cut seed heads by hand |
| Gray goldenrod *(Solidago nemoralis)* | Mid October to early November | Cut seed heads by hand |
| Whorled milkweed (*Asclepias verticillata)* | Mid to late September | Cut seed heads by hand |

Seed collection must occur prior to the application of herbicides on the site to treat invasive grasses as this herbicide application will likely destroy the remnant populations of native plants along with the invasive grasses. However, timing of seed collection will depend upon when the seeds of desired species are ripe and ready to harvest. Individual plants within a species typically do not all ripen at the exact same time but rather over a period of days or weeks and collecting all of the seed at one point in time may result in a loss of genetic diversity by selecting for specific traits related to time of seed maturity. In order to ensure the genetic diversity of the remnant prairie species is retained, it is important to collect seed more than once from the site (Lochner, 1997). In this case seed collection will occur several times between mid-September (see timeline below) and early November in order to assure a large amount of diversity in the seed collected. Because the seed collection occurs at the end of the growing season, seeds should be collected the year prior to the planned prairie restoration and appropriately labeled and stored to be utilized the following spring during re-seeding.

**Site Preparation Step 2: Cutting and removing woody plants**

Second it will be necessary to address the presence of woody species on site. Areas with concentrated populations of trees and shrubs are located on all the action areas in the site and were identified and mapped during site assessment. The full species list of plants located in these areas can be found in the appendix. We estimated that there are at least 60-80 mature trees on this site that must be taken down, therefore this removal must be done prior to herbicide application of smaller, primarily herbaceous vegetation. The shade from trees and shrubs in these areas can create cooler, damper conditions which will favor shade-tolerant species over native prairie species. In addition, these patches of shrubby areas on the site also have very high concentrations of invasive shrubs such as buckthorn and honeysuckle which will spread very aggressively and outcompete native prairie and oak savanna flora. Native trees and shrubs such as box elder, red cedar, smooth sumac, and dogwood can also aggressively spread on a planted prairie and should also be removed.

Trees and shrubs greater than a half an inch in diameter should be manually cut at the stump and then then chemically treated with herbicide to prevent re-sprouting. It is essential to chemically treat all cut plants or else they will regrow and the manual labor that was put into cutting them in the first place will have been wasted. Chemical treatment of stumps must be done by an individual with the appropriate herbicide applicator license and should occur as soon as possible after the trees and bushes were cut. A recommended herbicide to use on the species that occur on the site is triclopyr or glyphosate which can be applied anytime in the season except with snow or running water (Williams, 2010). Glyphosate is a broad-spectrum herbicide which will kill all actively growing vegetation that it comes into contact with while triclopyr is broadleaf specific and will not harm grasses when applied properly. Species that should be treated this way include: smooth sumac, honeysuckle, eastern red cedar, European buckthorn, raspberry, blackberry, and choke cherry. The cut trees and bushes can be piled and burned on site but invasive species should not be mulched. There also several large non-invasive trees located along the edge of the site. These trees will not spread aggressively and can be girdled and left on site as habitat for fauna.

According to the Minnesota DNR, the best time to cut and chemically treat the stumps of species such as buckthorn is late summer throughout the fall. Woody species should not be cut and treated early in May or June because this is when many invasive woody species are putting out leaves and herbicide will be less effective at this time. In the case of this restoration woody species management can occur during the same time that prairie seed collection is occurring prior to seeding the site. Because cutting and manual application of herbicide is labor-intensive, it will be most appropriate to conduct woody species removal when there is a large availability of manual labor.

**Site Preparation Step 3: Broad spectrum herbicide**

Due to the fact that the site is highly covered by invasive exotic grasses such as Kentucky bluegrass and brome grass, in order to re-establish native species on the site there will be no other option than to spray the entire site with a broad-spectrum herbicide such as glyphosate in order to kill the existing invasive species cover prior to "starting over" by planting native flora. It is likely that the site will need to be sprayed with glyphosate several times prior to seeding native plants. First, the site should be burned to reduce dead standing material. Burning helps reduce debris on the site and helps improve seed-to-soil contact which will be essential to the success of the native plant seeding. A month after burning (once there is about 4-6 inches of new growth) the site should be treated with a broad spectrum herbicide. Fourteen days after the initial herbicide treatment the site should be re-sprayed in areas where green plants or re-growth is identified. Once the site has been treated twice with herbicide seeding can occur soon afterwards. In areas with particularly resilient weed populations, the ground can be covered in black plastic prior to seeding. This helps kill established vegetation and sterilizes weed seed in the soil. This process should occur in the late spring/early summer (Williams, 2010).

**Site Preparation Timeline**

For this restoration project, site preparation will begin the spring prior to seeding with seed collection and woody species removal. The following bring, a combination of burning and broad spectrum herbicide across the site will help remove invasive grasses and leave the site in appropriate conditions for reseeding with native plants. The Site preparation timeline below details the timing of each of these activities.

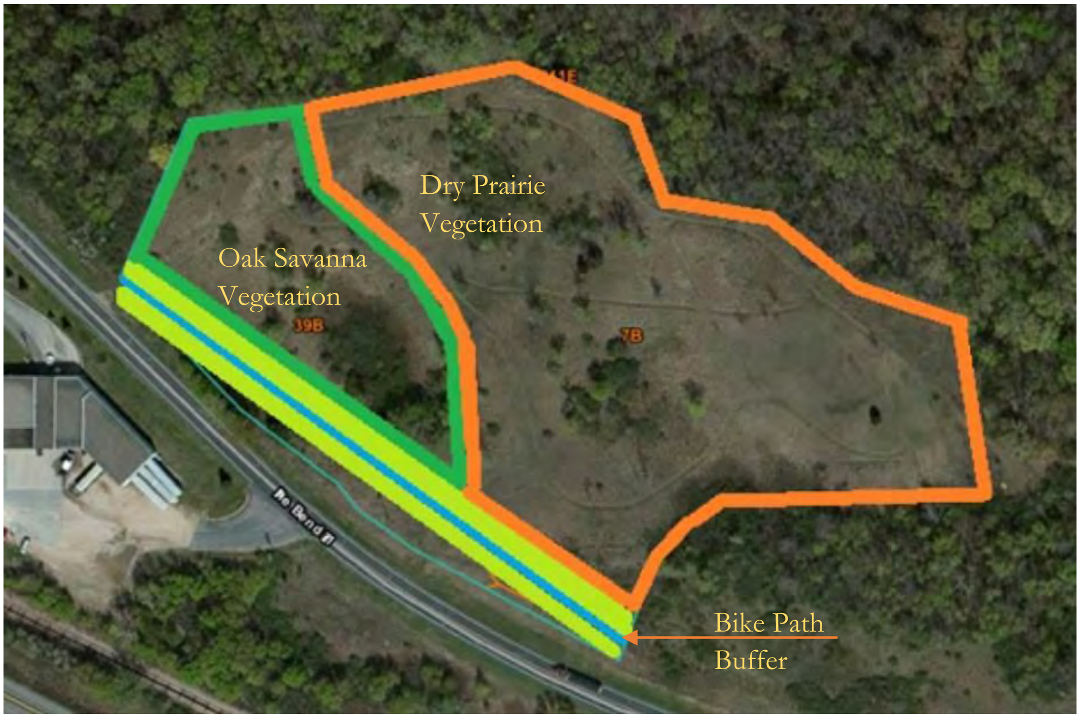
| Site Preparation Timeline | | | | | |
|---|---|---|---|---|---|
| | April through November, Year 1 | April Year 2 | May Year 2 | April Year 2 | April Year 3 |
| Seed Collection | X | | | | |
| Woody Species Removal | X | | | | |
| Burning | | X | | | |
| Herbicide of entire site | | | X | | |
| Spot Herbicide as needed | | | X | X | X |
| Native Plant Seeding | | | | X | X |

Seed collection should occur the year prior to site preparation and seeding. The table below details when visits the prairie for seed collection of native species should occur in order to get the best possible sample of native seeds.

| Prairie Seed Collection Timeline | | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | 3rd Week September | 4th Week September | 1at Week October | 2nd Week October | 3rd Week October | 4th Week October | 1st Week November |
| Heath aster *(Aster ericoides)* | | | | | X | X | |
| Gray goldenrod *(Solidago nemoralis)* | | | | X | X | X | X |
| Whorled milkweed (*Asclepias verticillata)* | X | X | | | | | |

**4. Revegetation Actions**

The following section discusses the revegetation actions that have been established for each of the three action areas on site N3: The dry prairie, the oak savannah, and the bike-path buffer area. Each section details the reasoning behind the seed mix design as well as any other planting plans that will occur for each action area. Detailed descriptions of the seed mixes for each action area can be found in the appendix.




**Dry Prairie Revegetation Design:**

The dry prairie was delineated in this site because larger part of the site (6.7 acres) has the presence of Hubbard loamy sand. This dry soil condition is good for dry prairie. This whole site for dry tallgrass prairie will be seeded by custom seed mixed which were selected from seed glossary provided by MNDot. While selecting the seeds plants native plants that have high pollinator value were selected. One of the restoration goals is to increase pollinator value in this site therefore plants that provided habitat and nectar sources for pollinators were selected.

Ten of the selected species have very high pollinator value and nine of the species have high pollinator value. *Aster sericeus, Liatris punctata, Solidago rigida, Asclepias tuberosa, Asclepias verticillata, Chamaecrista fasciculata, and Sporobolus heterolepis* are some of the selected plants which have very high pollinator value or provides nesting areas for the pollinators. The overall selected species have a wide range of bloom time starting from April to October. This range ensures that the pollinators will receive nectar sources through most part of the year which will ensure that these pollinators are likely to increase in future as this site provides favorable condition. This action area will be restored entirely utilizing a seed mix which is detailed in the dry prairie appendix. Using seed mix will be less expensive than planting plants. It will be easier to manage because plants need immediate aftercare but seeds needs less after care when compared to planting plants.

**Oak Savanna Revegetation Design:**

Oak Savanna site was delineated based on the soil and existing observed vegetation, which was discussed above in "Overall Re-vegetation Strategy". This site has more loamy soil than the dry prairie and thus larger, healthier vegetation was found on this site. The seed mix is very similar to that of the dry prairie, however, greater frequencies of mildly shade tolerant plant species have been selected for this site. The plants that were selected also grow better on loamier, less sandy soils than those that are more common on a dry prairie. This is because approximately fifty balled and burlapped bur oak (*Quercus macrocarpa*) trees will be planted on this site. These large trees will be planted as opposed to seedlings so that there is no chance of browse from white-tailed deer or other mammals. These trees will be planted in decreasing density eastward and away from the forest. However, individual tree will be provided with a mesh housing to safeguard from herbivores which is further discussed in Establishing Management Strategy below. Highest densities of these oaks will be planted adjacent to the forest on the western border of the site to ensure a smooth ecotone from forest to oak savanna to dry prairie. The ground layer seed mix will be applied in the early spring and allowed to germinate and begin to establish. The trees will then be planted in the late spring/early summer so that planting disturbance is minimized to the germinating seed mix species.

Species like harebell (*Campanula rotundifolia*), hoary vervain (*Verbena stricta*), wild bergamot (*Monarda fistulosa)* and other shade tolerant plants were selected for oak savanna planting which is different from other planting zones were selected

**Bike Trail Buffer Revegetation Design:**

This action area runs through the entirety of the site and is meant to act as a buffer between the bike trail and the rest of the restoration project. While the plants chosen for this area's seed mix greatly mirror the seed mixes in the oak savanna and prairie action areas, the main difference is that the seed mix for this strip of land has larger proportion of native bushes and forbs relative to grasses. Larger shrubby species like big bluestem (*Andropogon gerardii),* little bluestem *(Schizachyrium scoparium )*as well as species known for their flowers like sunflowers, coneflower and aster species were selected for this part of the restoration project hoping that these plants will encourage visitors to remain on the bike trail and not stray into, and disturb the rest of the site. In addition, the variety of flowering plants in this area is meant to be aesthetically pleasing to visitors. This action area will be restored entirely utilizing a seed mix which is detailed in the appendix.

**Planting/Seeding Schedule:**

| Seeding and Planting Timeline | | | | |
|---|---|---|---|---|
| Activities | Previous Fall | April | May | April |
| Site Preparation (see timeline in previous section) | X | X | X | |
| Apply Dry Prairie Seed Mix | | | | X |
| Apply Oak Savanna Seed Mix | | | | X |
| Apply Bike Path Seed Mix | | | | X |
| Plant and Fence Oak Trees | | | | X |

**Combined Estimated Budget for Planting/Seeding of Site N3:**

| Seed Mix and Planting Budget | | | | |
|---|---|---|---|---|
| **Item** | **Unit** | **Quantity** | **Cost per Unit** | **Total** |
| Dry Prairie Seed Mix | Acre | 6.7 | $1240.10 | $8309.27 |
| Bike Path Buffer Seed Mix | Acre | 0.5 | $1266.85 | $633.42 |
| Oak Savanna Seed Mix | Acre | 2.8 | $781.98 | $2189.54 |
| Balled and Burlapped Bur Oak Tree | Tree | 50 | $140.00 | $7000.00 |
| Mesh Fencing | Roll | 25 | $34.00 | $850 |
| Labor Cost for a week of work | Worker | 4 | $520 | $2080 |
| | | | | |
| | | | **Total** | $21,062.23 |

## Part 3.2 Vegetation Management

### 1. Establishment Management Strategy

The establishment of a native prairie plant community on a site typically takes around 3 to 5 years and during this time the site will be especially vulnerable to threats. Immediately after plants are put on the site they must be protected from key stressors such as: moisture stress, invasive plant encroachment, and herbivory. At our side we predict that the two largest threats to the establishment of native vegetation after seeding are herbivory from deer and rodents and intrusion from invasive species.

Weed control will be a high priority throughout the site during early restoration management. Fast growing annual weeds can quickly form a canopy over native seedlings stunting their development and crowding them out within a months' time (Williams, 2010). Allowing weeds to grow during the initial establishment of prairie vegetation will reduce native seed germination and growth and severely decrease the survival of perennial prairie plants (Williams, 2010). According to the Minnesota DNR seeds for species such as European buckthorn can remain viable in the soil for up to five years. Therefore, follow up control of all seedlings that emerge after initial treatment efforts is necessary.

Mowing the site can be an effective means of controlling invasive species populations during the first growing season of prairie re-establishment. Whenever vegetation grows to 12-18 inches the site can be mowed down to 4-6 inches. This will help stave off the growth of invasive plants but will not affect native species as most prairie seedlings will grow below the 4-6 inch mow height during the first growing season. Depending upon the growth of vegetation and variance in precipitation, mowing can occur every three weeks from May until early September during the first growing season. This regimen of frequent mowing will serve to reduce weeds and also prevents thatch buildup which can prevent native seeds from germinating. If mowing continues in the second growing season, mow heights should never be below 12 inches in order to prevent damage to native plants. However, mowing is only partially effective at controlling for weeds as it cannot affect invasive plants that rely upon rhizome spread. For this reason, herbicide will also likely be needed to control for any persistent perennial invasive species. It is very important to maintain careful control over invasive species and herbicide when necessary in order to prevent large stands of invasive species from establishing on the site. Spot spraying can be utilized in order to minimize the negative effect of native plants. For example european buckthorn (*Rhamnus cathartica)* found in this site can be re- establishing itself as it is possess a very high resiliency to fire and herbicides as well. Thus, spot spraying these species will be better for other species in the site.

During the second season time between mowing can be monthly or bi-monthly depending upon the prevalence of weedy invasive species on the site. If weedy patches are only found in certain areas of the site, then spot-mowing or hand pulling the weeds will work better to minimize the impact of invasive management on native plants. By the third growing season the majority of the vegetation growth on the site should be native plants and mowing should not be necessary. By the end of the third growing season there should be enough grass on site to begin with prairie burns. Burning the restoration project every two to three years will help cut back the growth of invasive species while favoring native plants.

Protection of plants from herbivory is also an essential part of continued restoration management. Herbivores such as deer and rodents threaten native plants, especially small woody plants, as they likely to feed on them. In this site the oak savannah will be planted with ball and bur lapped trees. After installation these oak saplings will be provided with individual shelters using fencing which must be monitored so that they do not impede on the growth of the trees. This individual mesh shelter will stop herbivores like deer or rabbits from damaging the oak savanna plantings. This mesh shelters should also be monitored for damage so that they can be repaired on time before the plants are destroyed by herbivores. The monitoring of mesh should be done after any type of construction to monitor damages caused by construction process. This mesh can also be monitored after the visit of researchers at the site.

In addition fencing will be utilized to fence off the entire Action Area along the bike trail which will be heavily seeded with native forbs and flowers in order to prevent intrusion to the newly planted area by bikes and other walkers as well as to prevent herbivory of the forb dominant area by deer, rabbits etc. The area should remain fenced for the first few years until plants are established.

The timeline below details the implementation timeline for the management of the seedlings and plantings during the first three years of the restoration project.

| **Initial Planting Maintenance Timeline** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Action | April – July Year 1 | Aug –Nov Year 1 | April- July Year 2 | Aug-Nov Year 2 | April- July Year 3 | Aug- Nov Year 3 | Year 4 |
| Fence off tree saplings | X | X | X | X | X | X | X |
| Fence off area along bike trail | X | X | X | X | | | |
| Mow down to 6 inches every 3 weeks | X | X | | | | | |
| Mow down to 12 inches every month | | | X | X | | | |
| Spot Treatment of Invasive Species with Herbicide | X | X | X | X | X | X | X |
| Monitoring mesh boundary | X | X | X | X | X | X | X |

**2. Long- term vegetation management**

Weeds and invasive species can cause a threat to the sustainability of the site restoration by competing with, and crowding out, desirable species. They rapidly colonize and dominate the exposed areas on the site making it more difficult for desirable native species to spread. Each year the site will be monitored in early summer so that problematic invasive species can be easily identified and treated as they grow rapidly and also early than the native species. Dormant seeds in the seed bank from the invasive plants can cause regrowth and recolonization for many years. Therefore, continued management is required for invasive species.

A very good method of managing invasive species is by mimicking the natural fire regimes in early summer as most of invasive plants are early bloomers whereas desired native species of Minnesota are generally late bloomers. Therefore, using fire after the 3$^{rd}$ year of restoration process is ideal because there will be enough natural fuel on the site. April can be the month for fire regime taken in place every third year which will significantly help control invasive species and prevent woody plants from the edge of the site from encroaching on the prairie. The proper use of prescribed fires can accelerate the growth of native species while deterring cool-season weeds and woody plants from establishing on the site. The spring of the fourth year on the site would be a good time to begin maintaining prairie via burns. However, fire regimes must be carried out sequentially as it is bad for the pollinators and might also effect the oak saplings. Therefore, 3 sets of burning can be done in this site for bike path, prairie and oak- savanna respectively every other week. A proper monitoring must be done for burning the oak savanna part such that fire will not affect the saplings. Also using the burning method in sequence (i.e. weekly) will ensure safety for pollinators and also an easier monitoring for the vulnerable oak saplings. Even after burning, if there are remnant populations of invasive species on the site then the method of spot herbicide can be used to kill unwanted species.

It is also possible that native plants will not successfully re-establish at equal rates throughout the site for a variety of reasons including the presence of stressors such as herbivory and invasive, etc. It may be necessary to re-seed sections of the site as needed in order to facilitate the establishment of native populations and prevent encroachment of woody or invasive species on the site. The seeds of native species can be hand collected such that they can be used to re-vegetate parts of the site that have less dense patches. Seeds will be collected in mid to late summer when most of the seeds are ripe. Hand collection will help leave unripe green seeds behind will naturally spread in the site and germinate. Seeds will only be collected every third year i.e. year 3, year 6, year 9 and so on. These seeds can be broadcasted throughout the site in September such that they will slowly germinate throughout the winter and start growing.

**Vegetation Management after three years**

| | Year 4 | | | Year 5(4+1) | | | Year 6(4+2) | | | Year (4+3) | | | Year (4+n) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | July | Sep | Apr | July | Sep | Apr | July | Sep | Apr | July | Sep | Apr | July | Sep |
| Fire regime | X | | | | | | | | | X | | | | | |
| Spot herbicide (if reqd.) | X | | | X | | | X | | | X | | | X | | |
| Seed collection | | X | | | | | | | | | X | | | | |
| Seeding | | | X | | | X | | | X | | | X | | | X |

Notes,

n = number of year

When, n is a multiple of 3 then seed collection will be done and also fire regime will be carried out

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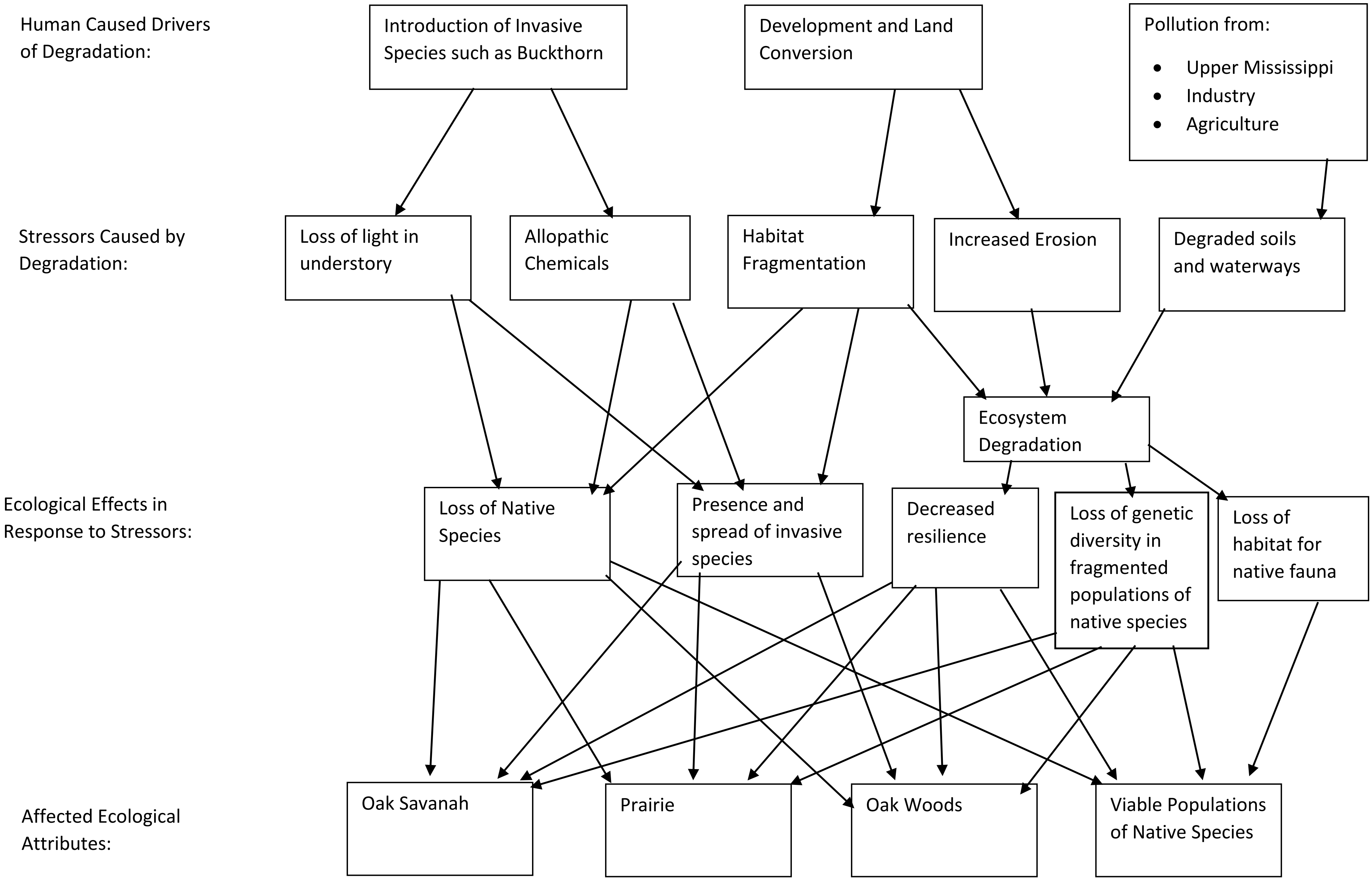
## APPENDICES

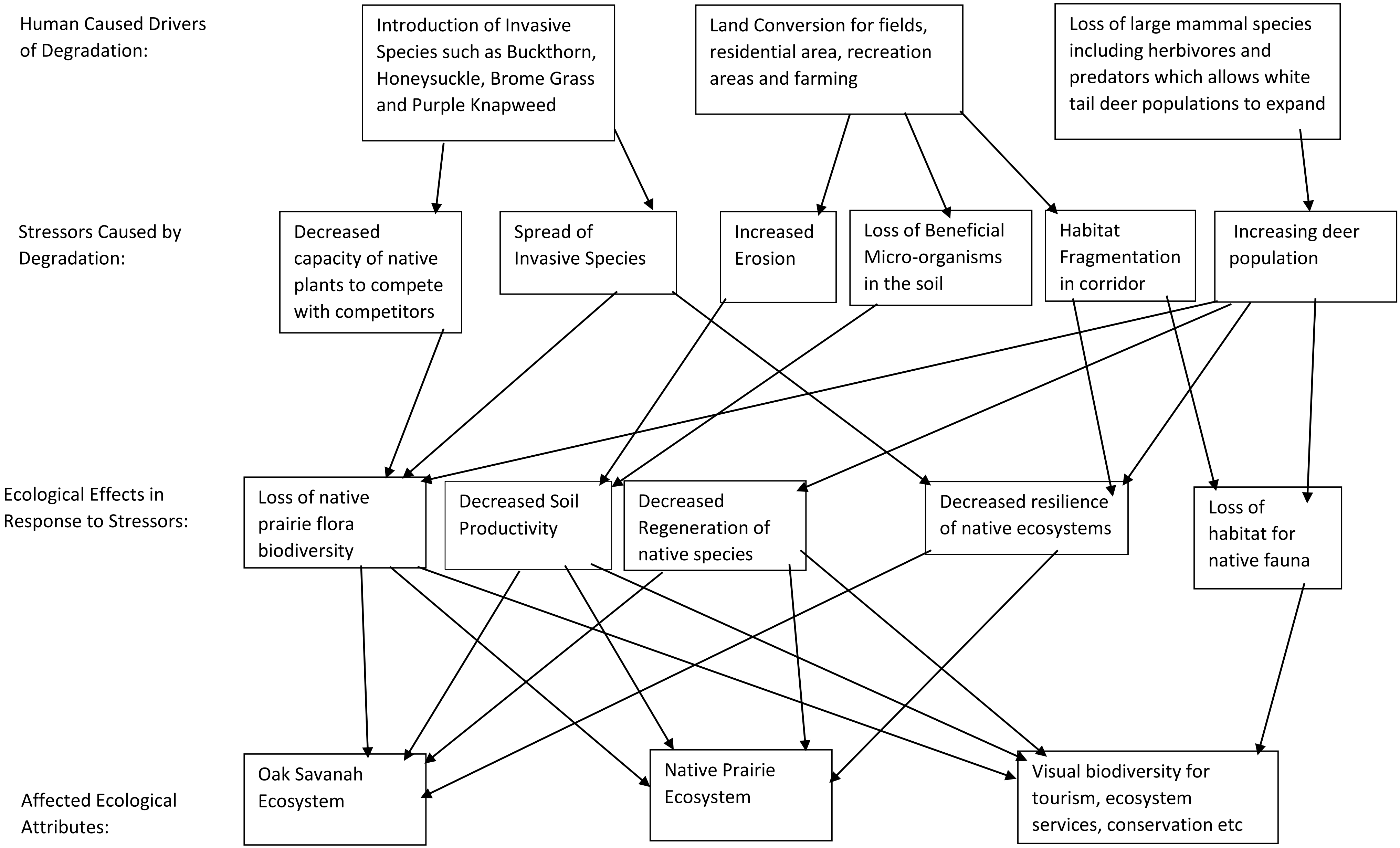
**Contents:**

- ***Greenway Specific Ecological Conceptual Model***
- ***Site Specific Ecological Conceptual Model***
- ***Vegetation Lists***
- ***Monitoring Protocols***
- ***Seed Mixes***

# Conceptual Ecological Model



# Site Specific Conceptual Ecological Model



## SITE N3 SPECIES LIST

| Vegetation Area: Grassland | | | |
|---|---|---|---|
| Species | | Cover Class | Native to Dry Prairie Ecosystem |
| Kentucky Bluegrass | *Poa pratensis* | 6 | No |
| Smooth Brome Grass | *Bromus Inermus* | 5 | No |
| Whorled Milkweed | *Asclepias verticillata* | 3 | Yes |
| Smooth Sumac | *Rhus glabra* | 2 | Yes |
| Green Ash | *Fraxinus pennsylvanica* | 1 | No |
| Eastern Red Cedar | *Juniperus virginiana* | 1 | No |
| Heath Aster | *Aster ericoides* | 1 | Yes |
| Spotted Knapweed | *Centaurea maculosa* | 1 | No |
| Spider Grass (Horsetail) | *Equisetum hymale* | 1 | No |
| Dandelion | *Taraxacum officinale* | 1 | No |
| Clover | *Trifolium* | 1 | No |
| Virginia Creeper | *Parthenocissus quinquefolia* | 1 | No |
| Canada Thistle | *Cirsium arvense* | 1 | No |
| Gray Goldenrod | *Solidago nemoralis* | 1 | Yes |
| American Elm | *Ulmus americana* | 1 | No |

| Vegetation Area: Shrub Land | | | |
|---|---|---|---|
| Species | | Cover Class | Native to Dry Prairie Ecosystem |
| Bluegrass | *Poa pratensis* | 5 | No |
| Brome grass | *Bromus Inermus* | 4 | No |
| Smooth Sumac | *Rhus glabra* | 4 | Yes |
| Honeysuckle | *Lonicera tartarica* | 3 | No |
| American Elm | *Ulmus americana* | 2 | No |
| Green Ash | *Fraxinus pennsylvanica* | 1 | No |
| Eastern Red Cedar | *Juniperus virginiana* | 1 | No |
| Wild Grape | *Vitis labrusca* | 1 | No |
| European Buckthorn | *Rhamnus cathartica* | 1 | No |
| Bur Oak | *Quercus macrocarpa* | 1 | Yes |
| Raspberry | *Rubus idaeus* | 1 | No |
| Blackberry | *Rubus fruticosus* | 1 | No |
| Choke Cherry | *Prunus virginiana* | 1 | No |
| Siberian Elm | *Ulmus pumila* | 1 | No |
| Virginia Creeper | *Parthenocissus quinquefolia* | 1 | No |
| Canada Thistle | *Cirsium arvense* | 1 | No |
| Quaking Aspin | *Populus tremuloides* | 1 | No |

# SITE N3 SPECIES LIST

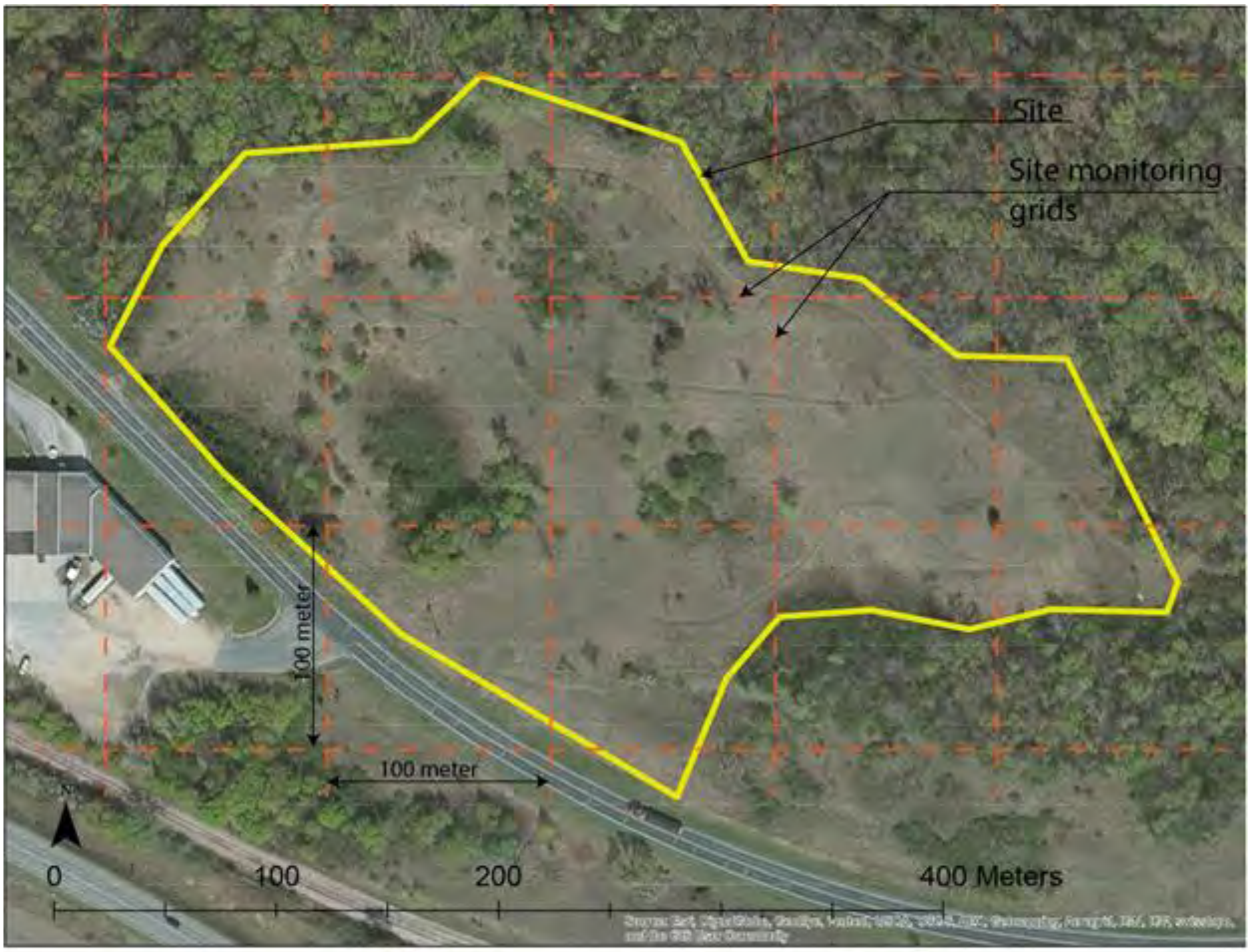
| **Vegetation Area: Edge** | | | |
|---|---|---|---|
| Species | | Cover Class | Native to Dry Prairie Ecosystem |
| Red Oak | *Quercus rubra* | 1 | No |
| Pin Oak | *Quercus palustris* | 1 | Native to Oak Savanah |
| Cottonwood | *Populus Aigeiros* | 1 | No |
| Pin Cherry | *Prunus pensylvanica* | 1 | No |
| Black Locust | *Robinia pseudoacacia* | 1 | No |
| Box Elder | *Acer negundo* | 1 | No |
| Weeping Willow | *Salix babylonica* | 1 | No |
| Lilac | *Syringa vulgaris* | 1 | No |
| Wild Grape | *Vitis labrusca* | 1 | No |
| European Buckthorn | *Rhamnus cathartica* | 1 | No |
| Quacking Aspin | *Populus tremuloides* | 1 | No |
| Bur Oak | *Quercus macrocarpa* | 1 | Yes |
| Raspberry | *Rubus idaeus* | 1 | No |
| Blackberry | *Rubus fruticosus* | 1 | No |

## Monitoring Protocol: Invasive Species on site N3

Invasive species monitoring is vital to assess the effectiveness of our restoration project of site N3 in the Rosemount Greenway since one of our SMART goals for this project is "A reduction in the number of individual invasive plants per invasive species on the site so that there is no more than a 1% cover of any individual invasive species within four years." There are several invasive species on this site, the most pervasive being brome grass (*Bromus spp.*), honeysuckle (*Lonicera tartarica)* followed by spotted knapweed (*Centaurea maculosa*) and scattered European buckthorn (*Rhamnus cathartica*).

**Timing:** Invasive species monitoring can occur once per year in the mid-summer or early fall. Monitoring should occur in the year prior to restoration actions in order to establish a set of baseline data and it should be repeated once per year in order to track change in infestation over time. It is important to take inventory of these species before the restoration takes place in order to monitor how well the restoration plan controls for these species.

**Spatial Considerations:** Because the site is relatively small and because the cover of the site is relatively homogenous a grid can be established on the site via the use of GPS. The grid should be composed of 100 square meter plots. Within each grid a 1 meter plot should be selected to monitor the cover of invasive species. Because the site contains 10.13 acres (40,994 square meters) the grid will contain 410 pots to sample. Estimating that it will take one person about 30 minutes per plot this means that it will take 2 people 13 days to complete sampling on the site. This quantity of plots will provide sufficient data on the overall plant composition of the site. Because monitoring also involves sampling the cover of native plants as well, the same grid and plots can be utilized for both invasive and native species. In addition, invasive and native species sampling can occur at the same time in order to decrease monitoring costs.




**Equipment**: Measuring tape, wooden stakes, GPS, property maps, GIS software, clipboards, pens, paper etc.

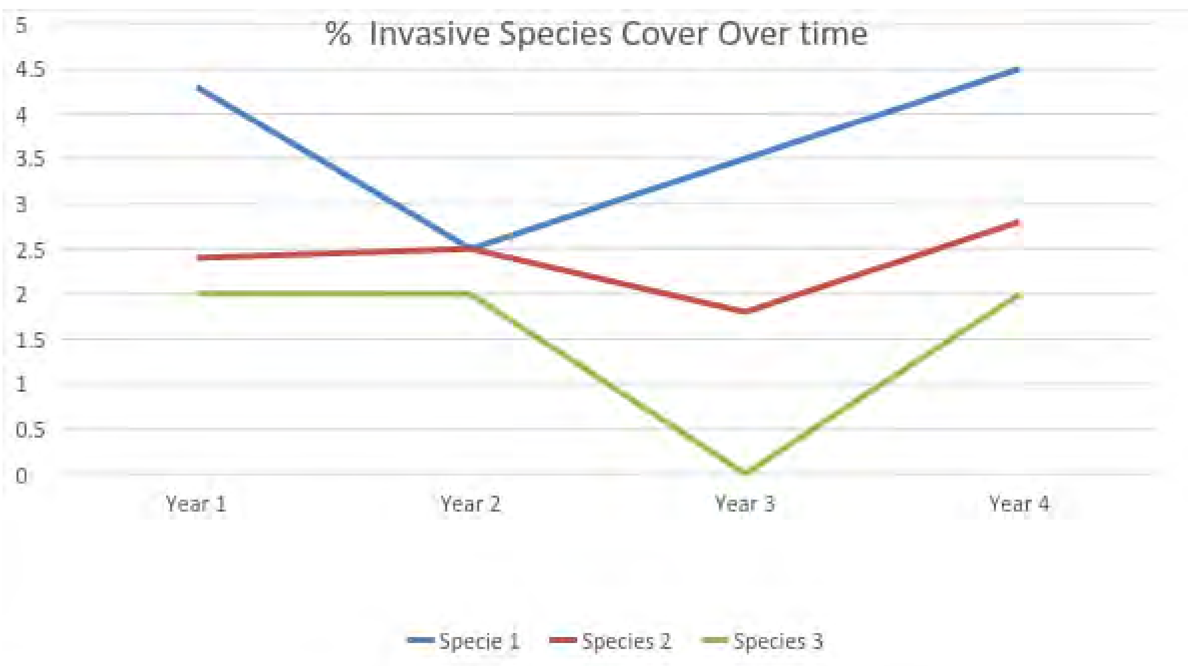
**Invasive Species Sampling:** The first step is in the process is to delineate the grid and 1 meter plots that will be utilized during sampling. This can be done utilizing a GPS and aerial photos of the site. Each square on the grid should represent 100 square meters of land cover on the property. At the center of each square in the grid mark a point with a stake and flagging tape. Each of these points will be the center of each sampling plot. Sampling plots should encompass a 1 square meter area in the center of each grid. Each sampling plot should be assigned a corresponding number in order to avoid double counting and aid in data interpretation.

During sampling data collectors will record the cover class of each invasive species in the plot utilizing the Visual Aid for Assigning Vegetative Cover contained in this protocol. The cover class of of each invasive species contained in the plot should be recorded using the data collection sheets provided at the end of the protocol. This process should be repeated for each of the one meter plots on site.

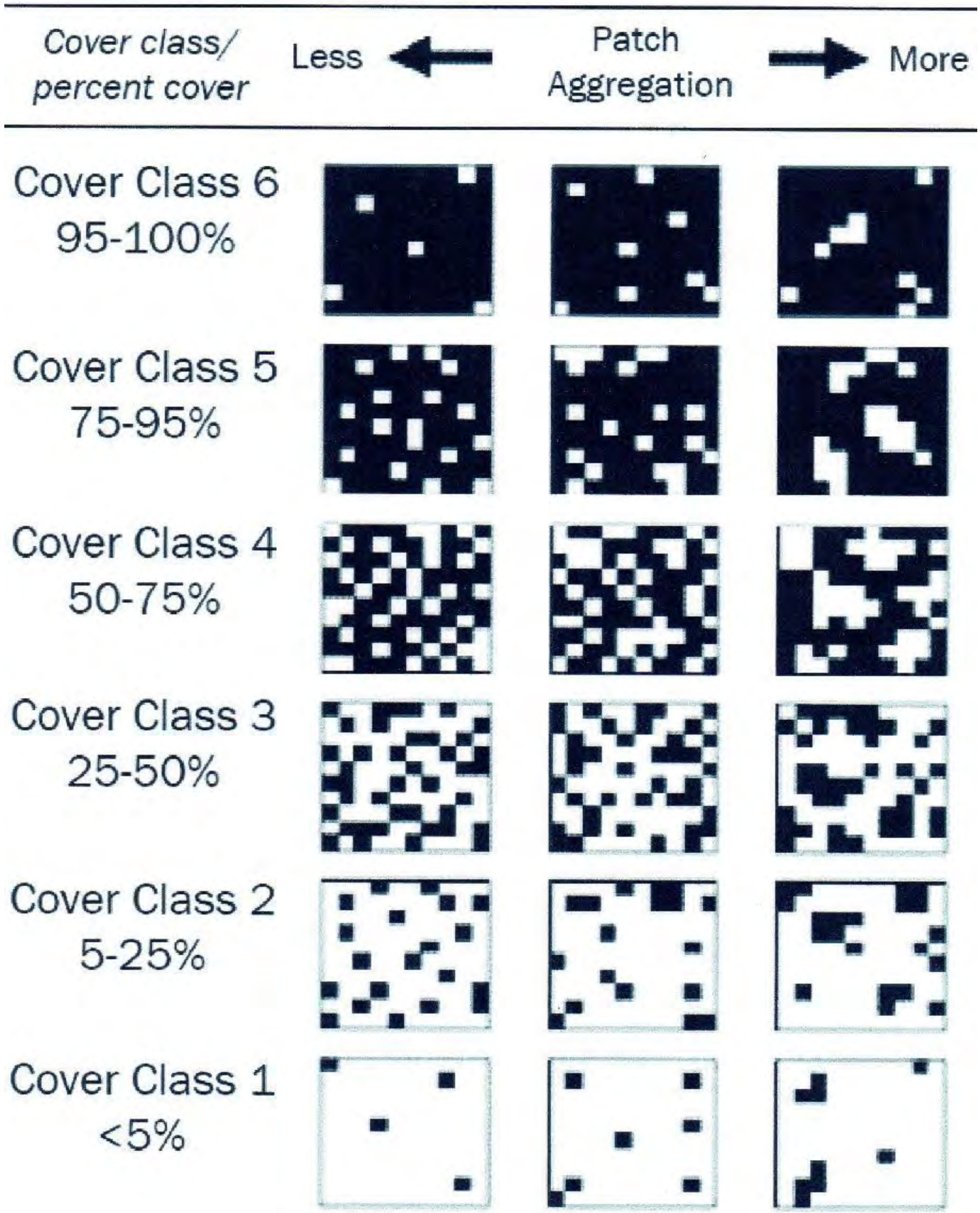
Once data has been collected the cover class of each species will be entered into an excel data sheet and this information will be utilized to calculate the average coverage class across the site for each invasive species being monitored.

**Data Interpretation:**

The cover class of each invasive species should be tracked over time in order to detect changes in infestation over time. Invasive species cover should reduce over time as progress is made towards the restoration goal of having less than 1% cover of any invasive species on the site. If at any time monitoring demonstrates an increase in invasive species cover it will indicate the need for more aggressive invasive species management techniques on site or it will indicate the presence of a different disturbance which is making it difficult for native plants to compete with invasive plants. Because the goal is to reduce invasive species cover to less than 1% on site, any indication of invasive species cover over 1% on site will result in the need for invasive species management and removal. The population of invasive species can be shown with the use of a line graph which tracks the cover of each species over time (see below)



# Visual Aid for Assigning Vegetative Cover



**Invasive Species Data Collection Sheet**

| Plot # | European Buckthorn | Spotted Knapweed | Brome Grass | Honeysuckle | Canada Thistle | Other | Other | Other |
|---|---|---|---|---|---|---|---|---|
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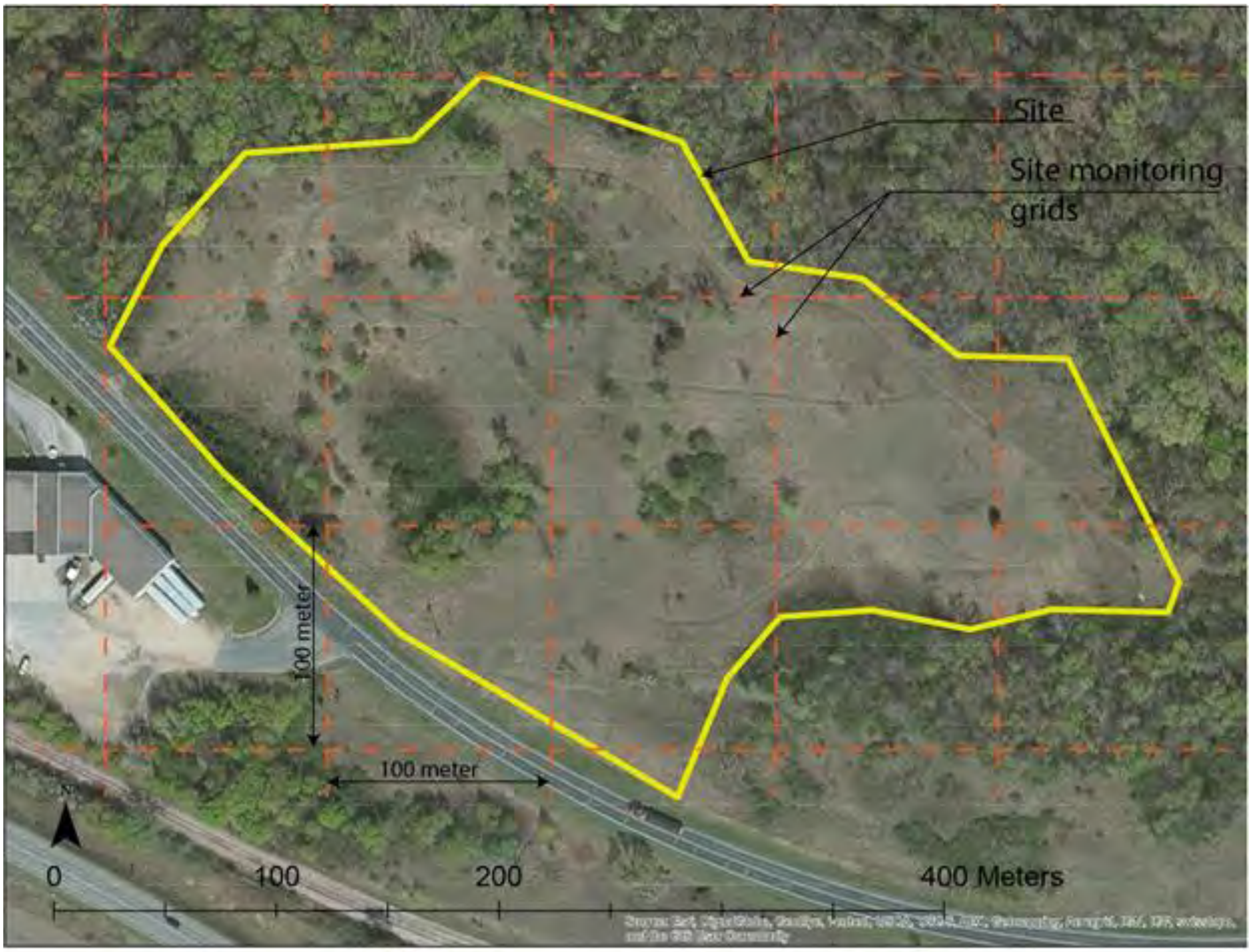
**Monitoring Protocol: Native Species Sampling**

Native species monitoring is vital to assess the effectiveness of our restoration project of site N3. There are two parameters that correspond to this protocol which relate to the cover of four species that are currently located on the site: heath aster *(Aster ericoides),* gray goldenrod *(Solidago nemoralis)*, whorled milkweed (*Asclepias verticillata)* and bur oak *(Quercus macrocarpa)* as well as the cover of 13 native species that are not currently on the site but will be reintroduced over the duration of the restoration project: The cover class of the following 13 native plants on the site: little bluestem (*Schizachyrium scoparium)*, big bluestem (*Andropogon gerardii),* side-oats grama (*Bouteloua curtipendula*), purple prairie clover *(Dalea purpurea),* nodding wild rye (Elymus canadensis), silky aster *(Aster sericeus),* lead plant (*Amorpha canescens*), prairie rose (*Rosa arkansana*), prairie drop-seed (*Sporobolus heterolepis)*, dotted blazing star (*Liatris punctata*), pasquel flower (*Anemone patens*), narrow-leaved purple coneflower *(Echinacea pallida), and* harebell (*Campanula rotundifolia).*This protocol will help monitor the ability of native species to repopulate the site as a result of our restoration efforts.

**Timing:** It is essential to take inventory of the cover of the pre-determined native species before the restoration takes place in order to monitor how well the restoration plan is achieving its goals related to native species. Native species should be monitored once per year late summer/early fall when most of the species are in bloom. Monitoring should occur in the year prior to restoration actions in order to establish a set of baseline data and it should be repeated once per year in order to track change in infestation over time.

**Spatial Considerations:** Because the site is relatively small and because the cover of the site is relatively homogenous a grid can be established on the site via the use of GPS. The grid should be composed of 100 square meter plots. Within each grid a 1 meter plot should be selected to monitor the cover of invasive species. Because the site contains 10.13 acres (40,994 square meters) the grid will contain 410 pots to sample. Estimating that it will take one person about 30 minutes per plot this means that it will take 2 people 13 days to complete sampling on the site. This quantity of plots will provide sufficient data on the overall plant composition of the site. Because monitoring also involves sampling the cover of invasive plants as well, the same grid and plots can be utilized for both invasive and native species. In addition, invasive and native species sampling can occur at the same time in order to decrease monitoring costs.



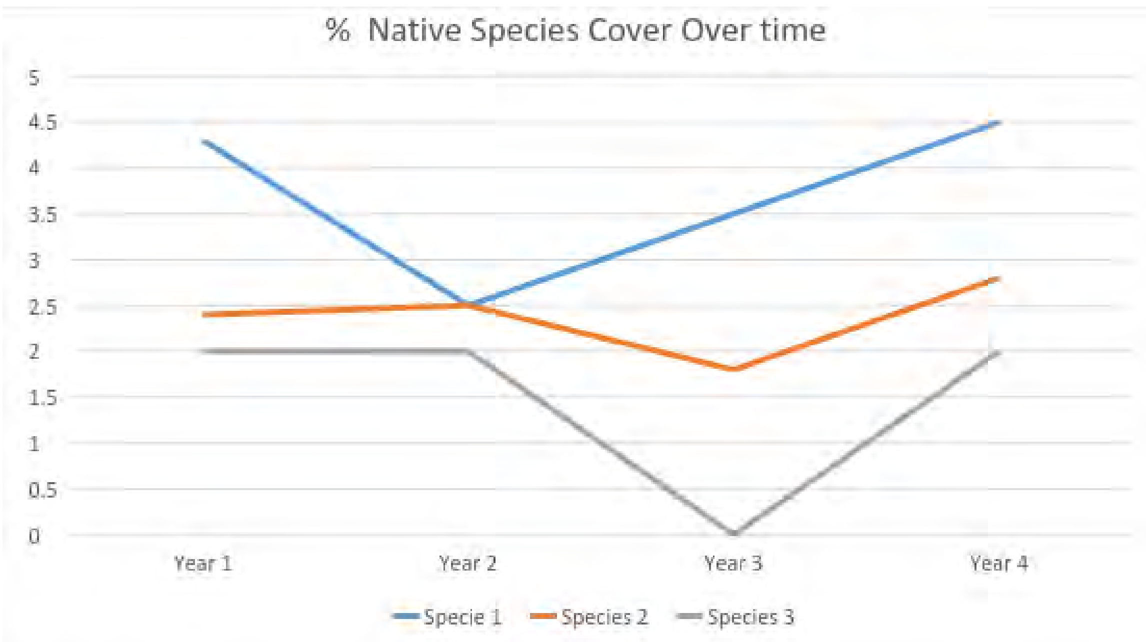

**Equipment**: Measuring tape, wooden stakes, GPS, property maps, GIS software, clipboards, pens, paper etc.

**Native Species Sampling:** The first step is in the process is to delineate the grid and 1 meter plots that will be utilized during sampling. This can be done utilizing a GPS and aerial photos of the site. Each square on the grid should represent 100 square meters of land cover on the property. At the center of each square in the grid mark a point with a stake and flagging tape. Each of these points will be the center of each sampling plot. Sampling plots should encompass a 1 square meter area in the center of each grid. Each sampling plot should be assigned a corresponding number in order to avoid double counting and aid in data interpretation.

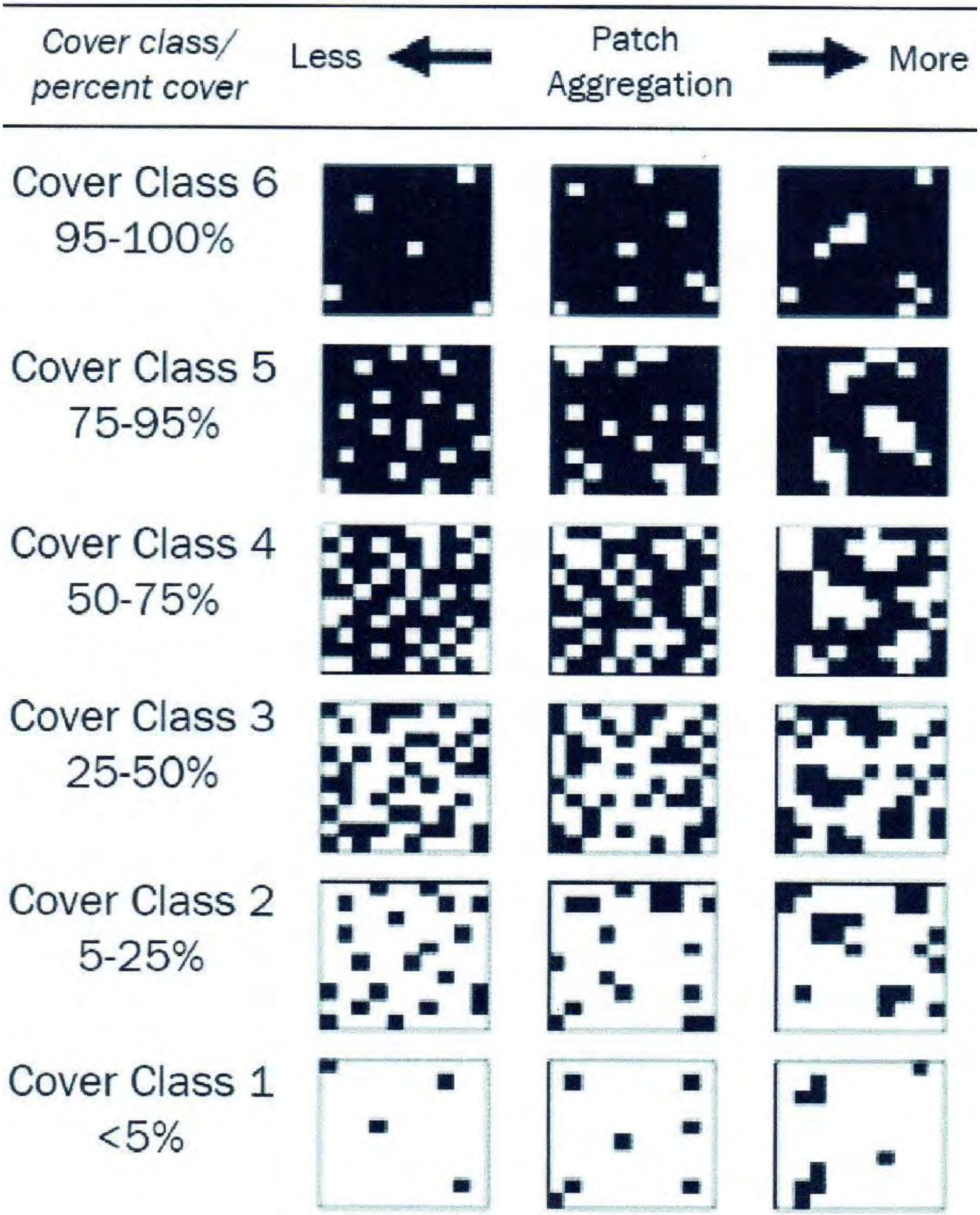
During sampling data collectors will record the cover class of each monitored species in the plot utilizing the Visual Aid for Assigning Vegetative Cover contained in this protocol. The cover class of each species contained in the plot should be recorded using the data collection sheets provided at the end of the protocol. This process should be repeated for each of the one meter plots on site. Once data has been collected the cover class of each species will be entered into an excel data sheet and this information will be utilized to calculate the average coverage class across the site for each species being monitored.

**Data Interpretation:**

The cover class of each native species being monitored should be tracked over time in order to detect changes in populations over time. Native species cover across the site should dramatically increase over time as progress is made towards the restoration goals. If at any time monitoring demonstrates a decrease in native species cover it will indicate the need for an adaptation to restoration strategy if the expected increase does not occur this indicates that there is a driver affecting the ability of native plants to re-establish which needs to be addressed. The population of native species can be shown with the use of a line graph which tracks the cover of each species over time (see below)



# Visual Aid for Assigning Vegetative Cover



Native Plant Monitoring Datasheet

Date: ___________
Name: ___________

| Plot | Species Cover | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | little bluestem *Schizachyrium scoparium* | big bluestem *Andropogon gerardii* | side-oats grama *Bouteloua curtipendula* | purple prairie clover *Dalea purpurea* | nodding wild rye Elymus canadensis | silky aster *Aster sericeus* | lead plant *Amorpha canescens* | prairie rose *Rosa arkansana* | prairie drop-seed *Sporobolus heterolepis* | dotted blazing star *Liatris punctata* | pasquel flower *Anemone patens* | narrow-leaved purple coneflower *Echinacea pallida* | harebell *Campanula rotundifolia).* |
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**Monitoring Protocol: Pollinator Abundance and Diversity**

The primary purpose of this protocol is to provide a standard methods to collect data on pollinator diversity and abundance over the restoration site. There are various parameters of data collection for pollinating bees and butterflies. Native prairie vegetation offers valuable habitat for pollinating bees. There are currently five native perennial species 0n site N3 which wild pollinators are known to be attracted to:

| Name | Bloom time | Attracts |
|---|---|---|
| Smooth Sumac (*Rhus glabra)* | Early summer | Bees |
| Raspberry (*Rubus idaeus)* | Early summer | Bees |
| Heath Aster (*Aster ericoides)* | Late fall | Bees |
| Gray Goldenrod (*Solidago nemoralis* | Fall | Bees and butterflies |
| Whorled Milkweed (*Asclepias verticillata)* | Summer | Bees, butterflies and caterpillars |
| Kentucky Bluegrass (*Poa pratensis)* | n/a | Food for caterpillars |

prairie vegetation must be created such that bees and butterflies are attracted and they are provided with habitat. As the populations of native species on the site increases we expect to see an increase in both the diversity of pollinators on site as well as their abundance. This data will provide valuable information as to the condition of the bee and butterfly habitat on the site as well as the overall success of the restoration. Wild bees do not like to travel much for their food so their habitat and plants requiring pollination must be kept nearby. Therefore, the diversity and abundance of pollinators on a specific site are an excellent indicator of the overall success of the restoration project.

**Timing Considerations**

These invertebrates are heavily affected by harsh temperature, wind, and seasons. Monitoring activities should only occur on warm, clear days between April and September. Monitoring done in winter will be less productive than data collection that occurs between early spring to late fall. Pollinators such as bees are mostly active from early spring to late fall. In addition monitoring assessment must be taken during the warmest part of the day as pollinators are very active at this hour. Some general rules of thumb for deciding whether or not a day will be appropriate for monitoring is: when the temperature is at least 70 degrees fare height, when wind speeds are less than 2.5 meters/second (5.6mph), and when there is enough sunlight for the researchers to see their shadow. In addition, pollinator communities vary greatly based upon the time of year. Therefore, flight season of pollinators must be monitored several times every year in order to account for the diversity of species and hosts on the site. Monitoring should occur at least three times during the year: once during the spring/early summer, once during the mid-summer, and once in the late summer. Finally, consistently in monitoring is crucial. Therefore it is important that data is collected around the same time and under the same conditions each year.

**Spatial Considerations**

The easiest and most efficient means of collecting data on pollinators is through the collection of observational data. Monitoring plots should be located within a relatively uniform habitat types. While the units that have currently been identified on the site are: edge, shrubs, and grassland. However, because the shrub area is currently primarily composed of invasive species, it is expected that these areas will be transformed into grassland areas over the duration of the restoration. Therefore it is expected that the habitat type on the site will be very consistent dry prairie.

The area should be divided into four linear transects that stretch the entire length of the site. The transects should be equally spaced throughout the site. Wooden stakes and flagging tape should be used to mark the beginning, middle and end of the transects. In addition, mapping the study site via GPS and marking its location on topographic maps or aerial photos will assure consistency and that monitoring can occur on the same transects each year.


**Equipment:** GPS, Wooden Stakes, Flagging Stakes, GPS Software, Topographic Map, aerial photos, anemometer, 2 researchers at $13/hour for 3 weeks.

**Pollinator Sampling:**

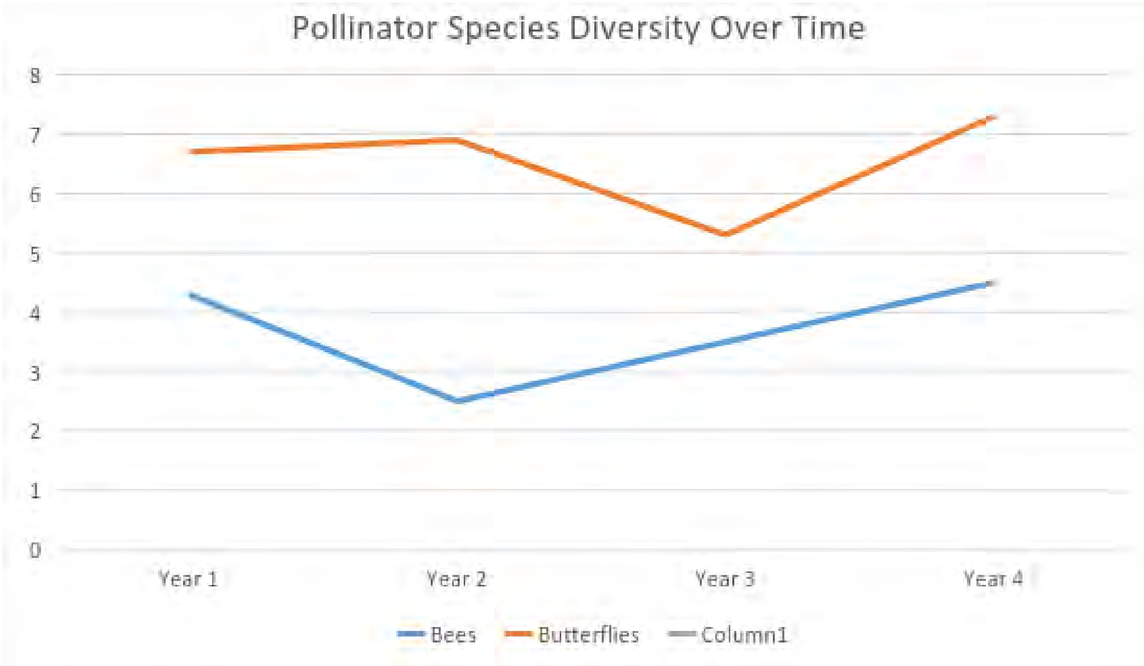
Time, weather, location, date and wind speed should be recorded on the day of monitoring to confirm that conditions were suitable for monitoring on that day. In addition, observers should record the amount of time that it takes to walk a transect. A good rule of thumb is that observers should move along a transect at a rate of 10 feet per minute. Effort should be made to ensure that observers take around the same amount of time each time they walk the same transect to continue to assure consistency. During observation while walking along a transect every time a pollinator is observed it is important to record the observation. Each observation should include data on: the species of pollinator, the number of times the pollinator is observed during the monitoring period, and the species of plant where it was observed.

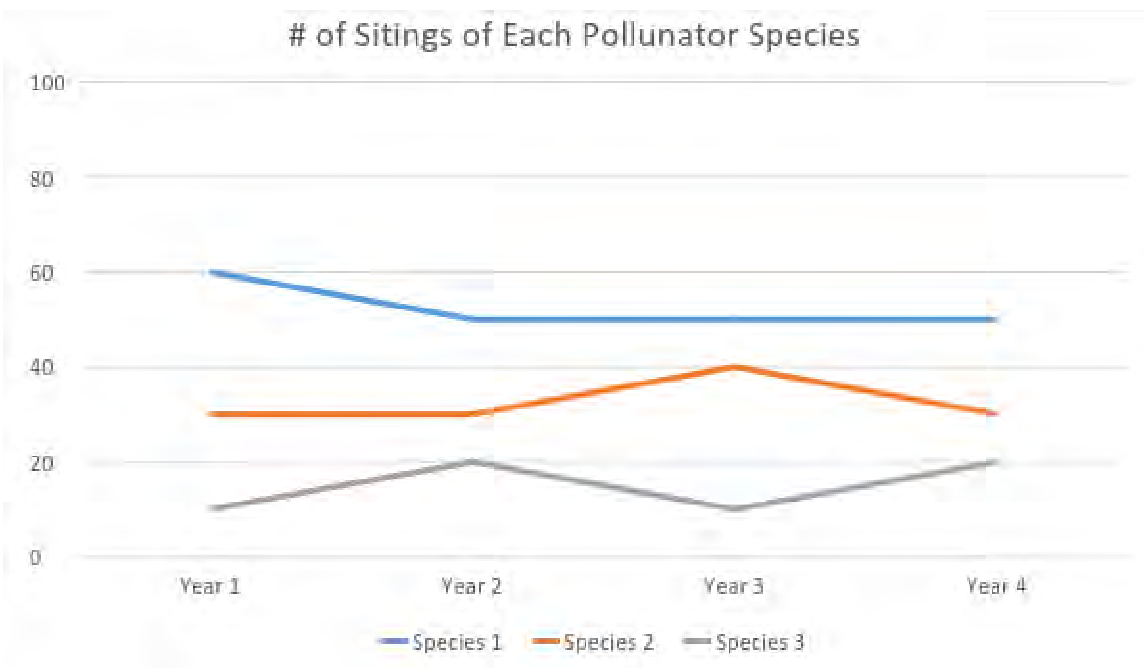
**Interpretation of Monitoring Data**

Data recorded during observation should be averaged for each year and plotted on a graph or table (such as the examples below) to show the change in species diversity and abundance over time. If there is increase in number of bees another patch of native habitat must be created such that these species can advance but challenges like decrease on their number can also occur. In this case, proper equipment and skilled people must be used to analyze the cause to bring about the population in the old condition as soon as possible.

| Number of Pollinators Observed | | | | |
|---|---|---|---|---|
| # Pollinators | Late Spring | Mid-Summer | Late Summer | Averages |
| 2015 | | | | |
| 2016 | | | | |
| 2017 | | | | |
| 2018 | | | | |

| Number of Species Observed | | | | |
|---|---|---|---|---|
| # Species | Late Spring | Mid-Summer | Late Summer | Averages |
| 2015 | | | | |
| 2016 | | | | |
| 2017 | | | | |
| 2018 | | | | |


Pollinator Species Diversity Over Time
8
7
6
5
4
3
2
1
0
Year 1
Year 2
Year 3
Year 4
Bees
Butterflies
Column1


# of Sitings of Each Pollunator Species
100
80
60
40
20
0
Year 1
Year 2
Year 3
Year 4
Species 1
Species 2
Species 3

POLLINATOR MONITORING DATASHEET

Date: ________________ Observer: ___________________________

Observation Start time: ______________________ Weather at Start: Temp (F)_______ Wind (Mph)_________ Sky: clear/cloudy

Observation End time: ________________________ Weather at Start: Temp (F)_______ Wind (Mph)_________ Sky: clear/cloudy

| OBSERVATIONS | | | |
|---|---|---|---|
| | Pollinator Description | Floral Host Description | Quantity |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
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| 20 | | | |
| 21 | | | |
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| 23 | | | |
| 24 | | | |
| 25 | | | |

## Site N3 Seed Mixes

## Dry Prairie Seed Mix

### Dry prairie cover crop mix

| Guild | Scientific Name | Common Name | Pollinator Value | *Bloom Time* | Cost/ lb | Gross % of core list seed count | Net # seeds/ s.f. | Lb/ acre | Cost/ acre |
|---|---|---|---|---|---|---|---|---|---|
| G | *Andropogon gerardii* | big bluestem | Nests | *M* | $16 | 20.0 | 3.90 | 1.06 | $16.99 |
| G | *Bouteloua curtipendula* | side-oats grama | Nests | *7,8,9* | $18 | 30.0 | 9.75 | 4.42 | $79.63 |
| G | *Bouteloua gracilis* | blue grama | Nests | | $45 | 10.0 | 6.50 | 0.44 | $19.91 |
| L | *Dalea purpurea* | purple prairie clover | Very High | *7,8* | $45 | 4.0 | 2.60 | 0.47 | $21.24 |
| G | *Elymus canadensis* | nodding wild rye | None | *7,8* | $15 | 11.0 | 2.86 | 1.50 | $22.46 |
| G | *Schizachyrium scoparium* | little bluestem | None | *8,9* | $26 | 25.0 | 9.10 | 1.65 | $42.94 |
| | **Total** | | | | | **100%** | **34.71** | **9.55** | **$203.17** |

### Dry prairie seed mix

| Guild | Scientific Name | Common Name | Pollinator Value | *Bloom Time* | Cost/ oz | Gross % of total seed count | Net # seeds / s.f. | Oz/ acre | Cost/ acre |
|---|---|---|---|---|---|---|---|---|---|
| A | *Aster laevis* | smooth aster | High | *8,9,10* | $15 | 3.0 | 0.60 | 0.48 | $7.13 |
| A | *Aster ericoides* | heath aster | High | *8,9,10* | $50 | 3.0 | 1.20 | 0.26 | $13.07 |
| A | *Aster sericeus* | silky aster | Very High | *8,9,10* | $14 | 5.0 | 1.00 | 1.68 | $23.46 |
| A | *Liatris aspera* | rough blazing star | High | *7,8,9* | $19 | 3.0 | 0.48 | 1.31 | $24.83 |
| A | *Liatris punctata* | dotted blazing star | Very High | *7,8,9* | $40 | 3.0 | 0.30 | 1.87 | $74.67 |
| A | *Rudbeckia hirta* | black-eyed susan | Very Low | *7,8,9, 10* | $3 | 1.0 | 0.20 | 0.09 | $0.28 |
| A | *Solidago nemoralis* | gray goldenrod | High | *7,8* | $19 | 1.0 | 0.46 | 0.07 | $1.27 |
| A | *Solidago rigida* | stiff goldenrod | Very High | *8,9* | $8 | 1.0 | 0.20 | 0.21 | $1.70 |
| F | *Agastache foeniculum* | blue giant hyssop | Very High | *7,8,9, 10* | $9 | 5.0 | 1.20 | 0.58 | $5.23 |
| F | *Anemone patens* | pasque flower | Low | *4,5* | $47 | 4.0 | 0.64 | 1.55 | $72.79 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| F | *Asclepias tuberosa* | butterfly milkweed | Very High | *6,7,8* | $28 | 6.0 | 0.48 | 4.86 | $136.15 |
| F | *Asclepias verticillata* | whorled milkweed | Very High | *6,7,8, 9* | $28 | 4.0 | 0.56 | 2.22 | $62.09 |
| F | *Monarda fistulosa* | wild bergamot | Very High | *7,8* | $40 | 4.0 | 0.96 | 0.60 | $23.90 |
| F | *Rosa arkansana* | prairie rose | High | *6,7,8* | $25 | 2.0 | 0.04 | 1.94 | $48.40 |
| F | *Rosa blanda* | smooth wild rose | High | *6,7* | $20 | 2.0 | 0.16 | 2.68 | $53.61 |
| F | *Tradescantia bracteata* | bracted spiderwort | High | *5,6,7* | $30 | 3.0 | 0.36 | 1.57 | $47.04 |
| F | *Tradescantia occidentalis* | western spiderwort | High | *5,6,7* | $60 | 2.0 | 0.24 | 1.16 | $69.70 |
| F | *Zizia aptera* | heart-leaved alexanders | Low | *4,5* | $15 | 3.0 | 0.42 | 1.52 | $22.87 |
| G | *Bromus kalmii* | kalm's brome | None | *8,9* | $3 | 8.0 | 0.80 | 4.36 | $13.07 |
| G | *Elytrigia smithii* | western wheatgrass | None | *7* | $10 | 4.0 | 0.40 | 2.45 | $24.49 |
| G | *Sporobolus heterolepis* | prairie dropseed | Nests | *8,9* | $8 | 12.0 | 1.92 | 5.23 | $41.82 |
| G | *Sorghastrum nutans* | Indian grass | Nests | *8,9,* | $2 | 6.0 | 0.84 | 3.05 | $6.10 |
| L | *Amorpha canescens* | lead plant | Very High | *6,7,8* | $14 | 5.0 | 0.70 | 2.50 | $34.97 |
| L | *Astragalus crassicarpus* | ground plum | High | *5,6* | $30 | 3.0 | 0.24 | 2.01 | $60.31 |
| L | *Chamaecrista fasciculata* | partridge pea | Very High | *7,8,9* | $2 | 5.0 | 0.30 | 4.84 | $9.68 |
| L | *Pediomelum esculentum* | prairie turnip | Medium | *5,6,7* | $50 | 2.0 | 0.08 | 3.17 | $158.4 |
| | ***Total*** | | | | | **100%** | **14.8** | **52.24** | **$1037.02** |

## Oak Savanna Seed Mix

### Oak Savanna Cover crop mix

| Guild | Scientific Name | Common Name | Pollinator Value | *Bloom Time* | Cost/ lb | Gross % of core list seed count | Net # seeds / s.f. | Lb/ acre | Cost/ acre |
|---|---|---|---|---|---|---|---|---|---|
| G | *Andropogon gerardii* | big bluestem | Nests | *M* | $16 | 40.0 | 15.60 | 4.25 | $67.95 |
| G | *Bouteloua curtipendula* | side-oats grama | Nests | *7,8,9* | $18 | 12.0 | 3.90 | 1.77 | $31.85 |
| G | *Bouteloua gracilis* | blue grama | Nests | | $45 | 4.0 | 2.60 | 0.18 | $7.96 |
| L | *Dalea purpurea* | purple prairie clover | Very High | *7,8* | $45 | 4.0 | 2.60 | 0.47 | $21.24 |
| G | *Elymus canadensis* | nodding wild rye | None | *7,8* | $15 | 15.0 | 3.90 | 2.04 | $30.63 |
| G | *Schizachyrium scoparium* | little bluestem | None | *8,9* | $26 | 25.0 | 11.38 | 2.06 | $53.68 |
| | **Total** | | | | | **100.0** | **39.975** | **10.77** | **$213.31** |

### Oak Savanna seed mix

| Guild | Scientific Name | Common Name | Pollinator Value | *Bloom Time* | Cost/ oz | Gross % of total seed count | Net # seeds/ s.f. | Oz/ acre | Cost/ acre |
|---|---|---|---|---|---|---|---|---|---|
| A | *Aster laevis* | smooth aster | High | *8,9,10* | $15 | 2.0 | 0.40 | 0.32 | $4.75 |
| A | *Liatris aspera* | rough blazing star | High | *7,8,9* | $19 | 3.0 | 0.48 | 1.31 | $24.83 |
| A | *Rudbeckia hirta* | black-eyed susan | Very Low | *7,8,9,10* | $45 | 2.0 | 0.40 | 0.19 | $8.52 |
| A | *Solidago nemoralis* | gray goldenrod | High | *7,8* | $18 | 4.0 | 1.84 | 0.27 | $4.81 |
| A | *Solidago rigida* | stiff goldenrod | Very High | *8,9* | $8 | 4.0 | 0.80 | 0.85 | $6.80 |
| A | *Aster oolentangiensis* | skyblue aster | Low | *8,9,10* | $20 | 1.0 | 0.28 | 0.15 | $3.05 |
| A | *Antennaria neglecta* | field pussytoes | None | *4,5,6* | $14 | 1.0 | 0.54 | 0.06 | $0.80 |
| A | *Aster ericoides* | heath aster | High | *8,9,10* | $50 | 4.0 | 1.60 | 0.35 | $17.42 |
| A | *Helianthus pauciflorus* | stiff sunflower | High | *7,8* | $40 | 2.0 | 0.12 | 1.31 | $52.27 |
| A | *Ratibida pinnata* | gray-headed coneflower | Medium | *7,8,9* | $15 | 2.0 | 0.40 | 0.58 | $8.71 |
| | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| F | *Agastache foeniculum* | blue giant hyssop | Very High | *7,8,9,10* | $9 | 4.0 | 0.96 | 0.46 | $4.18 |
| F | *Asclepias syriaca* | common milkweed | High | *6,7,8* | $8 | 3.0 | 0.18 | 1.96 | $15.68 |
| F | *Asclepias tuberosa* | butterfly milkweed | Very High | *6,7,8* | $28 | 2.0 | 0.16 | 1.62 | $45.38 |
| F | *Asclepias verticillata* | whorled milkweed | Very High | 6,7,8,9 | $28 | 3.0 | 0.42 | 1.66 | $46.57 |
| F | *Monarda fistulosa* | wild bergamot | Very High | *7,8* | $40 | 4.0 | 0.96 | 0.60 | $23.90 |
| F | *Campanula rotundifolia* | harebell | Medium | *6,7,8,9* | $20 | 2.0 | 1.84 | 0.09 | $1.78 |
| F | *Ceanothus americanus* | American New Jersey tea | Very High | *6,7* | $40 | 4.0 | 0.40 | 2.29 | $91.71 |
| F | *Heuchera richardsonii* | alumroot | Low | *5,6* | $50 | 2.0 | 1.60 | 0.10 | $4.98 |
| F | *Oenothera biennis* | common evening primrose | Medium | *6,7,8,9* | $15 | 2.0 | 0.52 | 0.25 | $3.78 |
| F | *Sisyrinchium campestre* | field blue-eyed grass | Low | *5,6* | $35 | 2.0 | 0.40 | 0.39 | $13.55 |
| F | *Verbena stricta* | hoary vervain | Medium | *7,8,9* | $40 | 2.0 | 0.40 | 0.62 | $24.89 |
| | | | | | | | | | |
| G | *Sorghastrum nutans* | Indian grass | Nests | *8,9,* | $2 | 13.0 | 1.82 | 6.61 | $13.21 |
| G | *Bromus kalmii* | kalm's brome | None | *8,9* | $3 | 7.0 | 0.70 | 3.81 | $11.43 |
| G | *Elymus trachycaulus* | slender wheatgrass | | | $10 | 5.0 | 0.50 | 3.16 | $31.57 |
| G | *Elytrigia smithii* | western wheatgrass | None | *7* | $10 | 5.0 | 0.50 | 3.06 | $30.61 |
| L | *Amorpha canescens* | lead plant | Very High | *6,7,8* | $14 | 7.0 | 0.98 | 3.50 | $48.96 |
| L | *Astragalus canadensis* | Canada milk vetch | Low | *7,8* | $6 | 2.0 | 0.32 | 0.82 | $4.92 |
| L | *Dalea candida* | white prairie clover | Medium | *6,7,8* | $3 | 4.0 | 0.64 | 1.47 | $4.40 |
| L | *Desmodium canadense* | Canada tick trefoil | Low | *7,8* | $12 | 2.0 | 0.16 | 1.27 | $15.21 |
| | **Total** | | | | | **100.0** | **20.32** | **39.11** | **$568.67** |

## Bike Trail seed mix

### Bike trail cover crop mix

| Guild | Scientific Name | Common Name | Pollinator Value | *Bloom Time* | Cost/oz | Gross % of core list seed count | Net # seeds/ s.f. | oz/ acre | Cost/ acre |
|---|---|---|---|---|---|---|---|---|---|
| G | *Andropogon gerardii* | big bluestem | Nests | *M* | $16 | 40.0 | 15.60 | 4.25 | $67.95 |
| G | *Bouteloua curtipendula* | side-oats grama | Nests | *7,8,9* | $18 | 12.0 | 3.90 | 1.77 | $31.85 |
| G | *Bouteloua gracilis* | blue grama | Nests | | $45 | 4.0 | 2.60 | 0.18 | $7.96 |
| L | *Dalea purpurea* | purple prairie clover | Very High | *7,8* | $45 | 4.0 | 2.60 | 0.47 | $21.24 |
| G | *Elymus canadensis* | nodding wild rye | None | *7,8* | $18 | 15.0 | 3.90 | 2.04 | $36.75 |
| G | *Schizachyrium scoparium* | little bluestem | None | *8,9* | $26 | 25.0 | 11.38 | 2.06 | $53.68 |
| | **Total** | | | | | **100.0** | **39.98** | **10.77** | **$219.44** |

### Bike trail seed mix

| Guild | Scientific Name | Common Name | Pollinator Value | *Bloom Time* | Cost/ oz | Gross % of total seed count | Net # seeds/ s.f. | Oz/ acre | Cost/ acre |
|---|---|---|---|---|---|---|---|---|---|
| A | *Aster laevis* | smooth aster | High | *8,9,10* | $15 | 2.0 | 0.40 | 0.32 | $4.75 |
| A | *Liatris aspera* | rough blazing star | High | *7,8,9* | $19 | 3.0 | 0.48 | 1.31 | $24.83 |
| A | *Rudbeckia hirta* | black-eyed susan | Very Low | *7,8,9,10* | $45 | 5.0 | 1.00 | 0.47 | $21.31 |
| A | *Solidago nemoralis* | gray goldenrod | High | *7,8* | $19 | 4.0 | 1.84 | 0.27 | $5.08 |
| A | *Solidago rigida* | stiff goldenrod | Very High | *8,9* | $8 | 4.0 | 0.80 | 0.85 | $6.80 |
| A | *Aster oolentangiensis* | skyblue aster | Low | *8,9,10* | $20 | 1.0 | 0.28 | 0.15 | $3.05 |
| A | *Antennaria neglecta* | field pussytoes | None | *4,5,6* | $14 | 1.0 | 0.54 | 0.06 | $0.80 |
| A | *Aster ericoides* | heath aster | High | *8,9,10* | $50 | 4.0 | 1.60 | 0.35 | $17.42 |
| A | *Helianthus pauciflorus* | stiff sunflower | High | *7,8* | $40 | 2.0 | 0.12 | 1.31 | $52.27 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A | *Ratibida pinnata* | gray-headed coneflower | Medium | *7,8,9* | $15 | 2.0 | 0.40 | 0.58 | $8.71 |
| A | Kuhnia eupatorioides | false boneset | Low | 8,9 | $10 | 2.0 | 1.00 | 1.36 | $13.61 |
| F | *Agastache foeniculum* | blue giant hyssop | Very High | *7,8,9,10* | $9 | 5.0 | 1.20 | 0.58 | $5.23 |
| F | *Asclepias syriaca* | common milkweed | High | *6,7,8* | $8 | 3.0 | 0.18 | 1.96 | $15.68 |
| F | *Asclepias tuberosa* | butterfly milkweed | Very High | *6,7,8* | $28 | 6.0 | 0.48 | 4.86 | $136.15 |
| F | *Asclepias verticillata* | whorled milkweed | Very High | *6,7,8,9* | $28 | 6.0 | 0.84 | 3.33 | $93.14 |
| F | *Monarda fistulosa* | wild bergamot | Very High | *7,8* | $40 | 4.0 | 1.20 | 0.75 | $29.87 |
| F | *Campanula rotundifolia* | harebell | Medium | *6,7,8,9* | $40 | 2.0 | 1.84 | 0.09 | $3.56 |
| F | *Ceanothus americanus* | American New Jersey tea | Very High | *6,7* | $40 | 4.0 | 0.40 | 2.29 | $91.71 |
| F | *Heuchera richardsonii* | alumroot | Low | *5,6* | $50 | 2.0 | 1.60 | 0.10 | $4.98 |
| F | *Oenothera biennis* | common evening primrose | Medium | *6,7,8,9* | $15 | 2.0 | 0.52 | 0.25 | $3.78 |
| F | *Sisyrinchium campestre* | field blue-eyed grass | Low | *5,6* | $35 | 2.0 | 0.40 | 0.39 | $13.55 |
| F | *Verbena stricta* | hoary vervain | Medium | *7,8,9* | $40 | 2.0 | 0.40 | 0.62 | $24.89 |
| F | *Allium stellatum* | Prairie Wild Onion | Medium | *6,7* | $15 | 2.0 | 0.42 | 1.66 | $24.95 |
| F | *Rosa arkansana* | prairie rose | High | *6,7,8* | $25 | 7.0 | 0.14 | 6.78 | $169.40 |
| F | *Anemone patens* | pasque flower | Low | *4,5* | $50 | 1.0 | 0.80 | 1.94 | $96.80 |
| F | *Potentilla arguta* | tall cinquefoil | Medium | *6,7,8,9* | $10 | 2.0 | 2.10 | 0.40 | $3.98 |
| F | *Viola pedatifida* | bearded birdfoot violet | Low | *4,5,6* | $50 | 1.0 | 1.00 | 1.56 | $77.79 |
| G | *Sorghastrum nutans* | Indian grass | Nests | *8,9,* | $2 | 3.0 | 0.42 | 1.52 | $3.05 |
| G | *Bromus kalmii* | kalm's brome | None | *8,9* | $3 | 2.0 | 0.20 | 1.09 | $3.27 |
| G | *Elymus trachycaulus* | slender wheatgrass | | | $10 | 1.0 | 0.10 | 0.63 | $6.31 |
| G | *Elytrigia smithii* | western wheatgrass | None | *7* | $10 | 1.0 | 0.10 | 0.61 | $6.12 |
| L | *Amorpha canescens* | lead plant | Very High | *6,7,8* | $14 | 6.0 | 0.98 | 3.50 | $48.96 |
| L | *Astragalus canadensis* | Canada milk vetch | Low | *7,8* | $6 | 2.0 | 0.32 | 0.82 | $4.92 |
| L | *Dalea candida* | white prairie clover | Medium | *6,7,8* | $3 | 4.0 | 0.80 | 1.83 | $5.50 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | *Desmodium canadense* | Canada tick trefoil | Low | *7,8* | $12 | 2.0 | 0.16 | 1.27 | $15.21 |
| | **Total** | | | | | **100.0** | **25.06** | **45.84** | **$1,047.41** |