# Consultant Vegetation Management Recommendations

## Stormwater Utility Vegetation Plan

October 2024

City of Madison Engineering Division

## Background

As part of plan development, the City of Madison sought consultant recommendations for vegetation management strategies to address feedback from the public engagement process. Heartland Ecological Group, Quercus Land Stewardship Services and Inter-Fluve River Restoration and Water Resources each provided recommendations.

- Recommendations were specific to an example property reflective of typical stormwater utility land.
- Recommendations received reflect the range of perspectives on how to approach vegetation management as well as the complexity of addressing public concerns and our changing climate.
- They do not incorporate specific operating information related to city resources, equipment, and available staff which is an important component of a system-wide vegetation management plan.

## Implementation Barriers

There are a few implementation barriers to applying many of these strategies uniformly at a citywide scale, demonstrating the complexity and uniqueness of SWU lands. These implementation barriers include:

- Engaging residents in long-term management of sites and increasing volunteer efforts. This is a goal of the SWU, however education, outreach and training volunteers requires additional resources the SWU does not currently have.
- Prescribed fire is a current integrated pest management strategy. Prescribed fire use is limited by available funding for trained professionals within the operating budget to conduct prescribed burns, and the fire season.
- Control of reed canary grass and cattails system wide is not feasible within existing resources to implement citywide and these species must be selectively removed where they constrict flow and/or cause significant erosion. Eradication of these species requires long term financial resources and typically multiple annual treatments with herbicide.
- Woody and structural habitat enhancements need to ensure they will not obstruct overflow structures, or back-up stormwater and cause flooding, during storm events.
- More woody management and invasive species management than described in current levels of service. This is particularly important to understand related to management of forested areas. Unlike predominately herbaceous and shrub vegetation, forest dominated areas can not be as easily managed by prescribed fire and mowing. Work to ensure invasive species do not colonize and simplify the vegetation by creating monocultures or proliferating DNR NR 40 species requires many more resources compared to a landscape that can be managed with a combination of mowing and prescribed fire.
- Increasing hydraulic roughness through woody vegetation in narrow channels that are prone to adjacent structure, road and bike path flooding is not desirable, where decreasing velocity may contribute to localized flooding.

## Scope of Services

Below is the specific request for quotes for vegetation management strategies.

As part of the stormwater utility vegetation management plan, the City of Madison is requesting quotes for consulting service to review top public concerns identified through the public engagement process and identify how these concerns may be addressed as part of the Stormwater Utility (SWU) citywide vegetation management plan. Public concerns that should be addressed shall include, but not be limited to improving habitat for wildlife, including birds and pollinators; addressing climate change impacts; improving biodiversity, and preserving tree canopy, etc.

**Task One:** Review public feedback identified in the public engagement report.

**Task Two:** From the example sites, identify one site to provide recommendations to address public concerns. Describe why this site was selected as a priority to implement strategies.

**Site One: Sister Oak Ponds PD 1452-033**
**Site Two: North Penito Creek Greenway GR 7052-005**
**Site Three: Hanson Road Wetland PD 6417-002**

**Task Three:** Develop a prioritized list of recommendations for the specific site to address vegetation management that reflects public concerns. These recommendations shall incorporate research, data, and relevant academic, governmental, or other professional documents to support recommendations. A site visit to the selected site is required. Staff may or may not be able to attend the site visit with you, but you are free to visit the site and traverse the public property. While the sites vary, the general approach and recommendations to address concerns should be similar in scope.

**Additional information:**

Recommendations for each specific site will not be specifically implemented at the example sites. Rather, these recommendations will be evaluated and considered respective to how they could be prioritized and implemented citywide on SWU lands. The site selected is intended to portray common examples of types of vegetation and concerns within the stormwater utility system.

The primary function of these systems is for stormwater management. Below are stormwater management considerations that are required on each site.

- Greenways: channel conveyance during storm events, ensuring that channels, inlets, are not blocked or overgrown, maintain bank stabilization during high velocity conditions, withstand urban hydrological conditions of both periods of drought and flooding and significant fluctuating water depths of several feet during storm events.
- Permanent Wet Ponds: bank stabilization along pond edge, vegetation that does not block storm inlets, culverts, equalizer pipes, and other storm structures. Vegetation that withstands fluctuating water elevations. Permanent ponds elevations are designed to be

constant, but during periods of drought or rainfall the elevations may decrease or increase by several inches to feet for prolonged periods.

The city has limited resources for vegetation management. The purpose of this exercise is to incorporate recommendations within existing resources. For this exercise, assume the following activities can be performed by staff: prescribed burning, brush mowing, spot mowing, herbicide application, manual removal of shrubs and/or herbaceous materials, native seeding, small scaled native plug planting (200-300 plants), planting of small 1' tall whips. For this exercise, assume that there is annual funding for 8-20 hours of staff time available and $3,000 available for contracted work which would include any tree removals greater than 4" DBH.

**Deliverables:**

- A minimum 3-page report on how to implement public concerns related to vegetation management at each site. Develop a list of prioritized recommendations that incorporates research, data, and relevant academic, governmental, or other professional expertise to manage areas for top public concerns including but not limited to concerns related to wildlife habitat, pollinators, heat islands, etc.
- A map of each site where these vegetation management goals should occur.
- Deliverables should be submitted by October 1, 2024.

Heartland Ecological Group

# Vegetation Management for Stormwater Properties Report

## Sister Oak Ponds

City of Madison, Dane County, Wisconsin

September 30, 2024

Project Number: 20241341

506 Springdale Street | Mount Horeb, WI 53572 | www.heartlandecological.com

# Sister Oak Ponds

City of Madison, Dane County, Wisconsin

September 30, 2024

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Solutions for people, projects, and ecological resources.

# Table of Contents

# 1.0 Introduction and Project Background

The City of Madison Engineering Division (the "City") contracted Heartland Ecological Group, Inc. ("Heartland") to review top public concerns identified through a public engagement process and identify how these concerns may be addressed as part of the Stormwater Utility (SWU) citywide vegetation management plan. Heartland's scope of work was to review the collected public feedback, select one of the three example SWU lands provided by the City to provide recommendations, complete a site visit, and develop a prioritized list of recommendations for the specific site to address vegetation management that reflects public concerns. The recommendations given will not necessarily be implemented at the selected site but will be considered by the City respective to how they could be implemented citywide on SWU lands. Recommendations should be given in the context of the City's limited resources for vegetation management.

The City utilized three public engagement strategies to gain feedback that included scheduled public listening sessions, on-site pop-up engagement sessions, and an online survey. The type of engagement strategy used yielded different results, there is a variety of opinions, and some of the environmental values and concerns identified were conflicting with each other. Overall takeaways included the following:

1. Top public concerns identified with regards to SWU land development included impacts to biodiversity and habitat for pollinators, birds, and other wildlife. There is concern over large-scale tree removal in SWU lands.
2. The public was largely in support of restoring native ecosystems on SWU land and removing invasive plants. The public values native and biodiverse landscapes for aesthetics, resiliency to flooding and erosion, and for benefits to other ecosystem services such as pollinator habitat.
3. The public is interested in volunteering at these properties and would like to learn more about restoration techniques and methods.

# 2.0 Site Selection and Existing Conditions Assessment

Heartland selected the Sister Oak Ponds site (PD 1452-033) to provide recommendations to address public concerns on SWU lands. Sister Oak Ponds (the "Site") is located at 10327

Sister Oak Drive, T7N, R8E, Section 20, in the City of Madison (Figure 1, Appendix A). The Site is approx. 2.76 acres and contains a wet pond and an infiltration basin within a new residential development. The area was prior agricultural land and the Site was constructed around 2019 along with portions of the residential development.

The Site is located in the western portion of the Southeast Glacial Plains Ecological Landscape of Wisconsin (WDNR 2015). The Southeast Glacial Plains historically consisted of a mix of prairie, savanna, and oak forest that experienced consistent low-medium severity surface wildfires, with maple-basswood forests common in areas experiencing less wildfire.

Heartland selected this Site for this report because the SWU land was planted to native vegetation following construction, which is now the expectation for stormwater lands associated with residential developments in the City as well as adjacent municipalities. This SWU land is highly visible to the adjacent residences as it directly abuts the backyards. It is anticipated that more of these types of SWU lands will be developed in the coming years as rural land in Madison is converted into residential developments. The recommendations provided in this report can guide management recommendations for existing wet ponds/infiltration basin systems in the City as well as provide insight for the construction and implementation of these facilities in future developments.

Heartland Senior Ecologist, Sarah Kraszewski, conducted a field visit to the Site on September 19, 2024 to assess existing conditions. The Site was meandered on foot, observations were noted, and representative photographs were taken of the stormwater infrastructure and vegetation. Representative photos are provided in a photo log (Appendix B) and photo point locations are depicted on Figure 2 (Appendix A). The Site was divided into the following three areas for which species lists were created: 1) upland prairie on slopes and berms, 2) wet pond perimeter, and 3) infiltration basin. Vegetation abundance was not assessed on a species level but dominant species within each area were noted. Species lists were input into the Universal FQA Calculator (Freyman et al. 2016) utilizing the nomenclature assigned in the Northcentral and Northeast Region of Wisconsin FQA database. Species lists are provided in Appendix C and contain summary data such as species richness, physiognomy (e.g., grass, forb, tree), and duration (e.g. annual, perennial) below the species list.

## 2.1 Prairie

The upland slopes and berms around the wet pond and infiltration basin were planted to prairie. These areas were overall well-vegetated (>95% cover) and the vegetation appeared to be stabilizing the soils although there were a few areas with sparser vegetation. The deep-rooted prairie vegetation provides a buffer between the adjacent mowed lawns and the ponds, which serves to intercept and filter nutrients from the runoff and stabilize the pond banks. The prairie contains a good diversity of prairie species given its small size and 40 native species were recorded (Table C-1, Appendix C). Although 5 native grasses were recorded, most of the grass cover observed was attributed to Indian grass (*Sorghastrum nutans*). Dominant forbs observed included wild bergamot (*Monarda fistulosa*), saw-tooth sunflower (*Helianthus grosseserratus*), yellow coneflower (*Ratibida pinnata*), Canada goldenrod (*Solidago canadensis*), and Queen Anne's lace (*Daucus carota*).

There is a tree line along the southern perimeter of the Site, between the infiltration basin and an agricultural field. Dominant trees along the perimeter include black cherry (*Prunus serotina*), white mulberry (*Morus alba*), northern hackberry (*Celtis occidentalis*), and box elder (*Acer negundo*) and the understory is dominated by weeds. This wooded edge is casting shade and contributing to the spread of undesirable weeds, shrubs, and trees into the Site along the southern berm of the infiltration basin. A total of 12 woody species were recorded in areas planted to prairie, all of which were observed along the southern berm of the infiltration basin. Species invading the prairie from the tree line included box elder, black cherry, and white mulberry saplings; poison ivy (*Toxicodendron rydbergii*); multiflora rose (*Rosa multiflora*); stinging nettle (*Urtica dioica*); common burdock (*Arctium minus*); invasive bush honeysuckle (*Lonicera* spp.); American red raspberry (*Rubus idaeus* var. *strigosus*), and bittersweet nightshade (*Solanum dulcamara*).

Tree saplings are growing into the riprap at the culvert outfall in the southwestern portion of the infiltration basin as well as within riprap placed along the southern slope (see photos #6-8, Appendix C). It was hard to assess the functionality of the riprap along the southern perimeter of the infiltration basin due to the vegetative cover. A large portion of a black cherry tree has fallen onto the southern berm of the infiltration basin and is covering the ground surface (see photo #9, Appendix C).

Other scattered invasive species observed within the prairie areas included bird's-foot trefoil (*Lotus corniculatus*), Canada thistle (*Cirsium arvense*), white sweet clover (*Melilotus alba*), and bull thistle (*Cirsium vulgare*). The dominant vegetation in the prairie are taller species, which may result in the reduction or loss of some of the shorter stature species overtime.

## 2.2 Wet Pond

The perimeter of the wet pond is vegetated by wetland plants characteristic of wet meadow and shallow marsh communities (Table C-2, Appendix C). Invasive hybrid cattail (*Typha* x *glauca*) was one of the dominant species observed and is present in scattered patches along the water's edge. The open water portion of the pond was primarily clear except for some scattered duckweed (*Lemna minor*) and unidentified floating-leaf pondweeds (*Potamogeton* sp.) with some algae at the eastern end. Willows (*Salix* spp.) had recently been removed around the wet pond, evidenced by cut stumps and woody debris piles. A minor amount of sediment build-up was observed at the culvert outfalls into the pond. Scattered trash, primarily plastic water bottles, was observed.

## 2.3 Infiltration Basin

The infiltration basin bottom had approximately 80% vegetative cover, with sparser cover in the western portion were there appeared to have been prior inundation. The basin was dry during the assessment, which occurred during a late summer dry period. Native plant diversity within the infiltration basin bottom was observed to be low (Table C-3, Appendix C). Frost aster (*Symphyotrichum pilosum*) was the dominant species observed with approximately 70% cover and partridge pea (*Chamaecrista fasciculata*) was the secondary dominant. Eastern cottonwood (*Populus deltoides*) saplings were scattered across the basin bottom. The intended plant community was not apparent and may not have been established with seeding or planting. It is possible that the basin bottom will not be fully restored until more of the surrounding land has been developed. The basin does not currently appear to be online and is bisected by a pipe that is diverting flow from the wet pond.

## 2.4 Wildlife Habitat

The Site is currently providing habitat for reptiles and amphibians, insects, birds, and mammals. A formal wildlife survey was not conducted; however, wildlife habitat and observations were recorded during the meander survey. Numerous frogs were observed along the wet pond margin. The native forb diversity offers a variety of nectar and pollen resources for pollinators throughout the growing season. The native plantings also provide nesting materials and habitat, cover, and a variety of food for birds including plant seeds as well as insects and larvae hosted on the native plants. Deer tracks and raccoon scat were observed.

# 3.0 Recommendations

Recommendations specific to this Site and that can be applied to SWU lands with permanent wet ponds are provided below that specifically address the overall takeaways from the public engagement process.

1. **Top public concerns identified with regards to SWU land development included impacts to biodiversity and habitat for pollinators, birds, and other wildlife. There is concern over large-scale tree removal in SWU lands.**

   This Site was constructed within a prior agricultural field that had limited biodiversity and habitat and did not require tree removals. The construction of this Site has resulted in the restoration of native prairie, wetland, and open water communities. Native plant diversity and wildlife habitat has been enhanced. Due to the size of the Site and the type of stormwater facilities, there are not opportunities to restore shrub or forested communities.

   A) <u>Site Assessments Before Construction</u>

   It is understood that the City assesses existing site conditions prior to constructing new SWU land to identify if there are natural plant communities, rare species habitat, or desirable trees that should be protected. It is recommended that this practice continues. Consideration should be given to providing native plant corridors when constructing new developments so that the various ponds and greenways are connected by natural land for wildlife use as well as provide opportunities for passive recreation for the residents.

B) <u>Habitat Enhancements</u>

Turtle and frog habitat could be enhanced in the wet pond by adding some basking logs or platforms in the water or extending from the water's edge. Woody material or structures in the water would also provide spots for insects to lay eggs and provide food for other animals. Cattail should be removed from the water's edge as it displaces desirable emergent vegetation and may encourage muskrat use in the ponds. Muskrats can cause structural damage to stormwater ponds by burrowing into berms as well as create areas that Canada geese use as nests.

Recommendations for invasive species management and enhancing native plant diversity are discussed in #2 below.

2. **The public was largely in support of restoring native ecosystems on SWU land and removing invasive plants. The public values native and biodiverse landscapes for aesthetics, resiliency to flooding and erosion, and for benefits to other ecosystem services such as pollinator habitat.**

The Site overall appears to be providing an aesthetically pleasing landscape for the homeowners with backyards abutting the Site. Research has shown that stormwater ponds can increase property values (EPA 2009). The establishment of native, perennial vegetation along the slopes and berms of the ponds is providing resiliency to flooding and erosion. The diverse array of native plants in the prairie areas is providing beneficial habitat for pollinators. There are opportunities to reduce invasive species and enhance native biodiversity at the Site, as discussed below. Vegetation management work should be conducted with sensitivity to the adjacent homeowners.

A) <u>Invasive Species Control</u>

Invasive plant species pose a significant threat to plant biodiversity, which then impacts habitat diversity and the animals and microbes that inhabit those areas. Native plants provide better pollinator benefits than non-native plants, which in turn supports functioning food webs (NIACS). Healthy and diverse habitats can better absorb the stresses of rapidly changing climate (WICCI). The following section describes recommendations for invasive plant control.

### Cattail

It is recommended that cattail is controlled within the wet pond. Cattail is currently creating dense clusters around the perimeter of the pond and will likely continue to spread around the pond margin if left unchecked. Cattail stands can take over shallow marsh wetlands, drainage swales, and pond perimeters; thereby outcompeting other useful native emergent plants that are important to diverse wetland communities (EPA 2009). Diverse plant communities support diverse and balanced aquatic communities that host beneficial species such as mosquito predators (EPA 2009).

Efforts to mechanically cut the cattail stands and then remove the cut biomass or reduce the biomass with prescribed burning should be conducted first. During the following growing season, cattail should be treated with herbicide to kill the plants. Herbicide application with a wick, such as a wand attachment to a backpack sprayer, is recommended to reduce herbicide damage to desirable species.

### Woody Removals

Recent willow removal had been conducted by the City around the perimeter of the wet pond. Woody tree saplings, shrubs, vines, and brambles were observed along the southern berm, exterior slope, riprap, and culvert outfall of the infiltration basin. This woody encroachment will shade out desired herbaceous vegetation, reduce native species diversity, and may destabilize the constructed basins. Trees and brush with extensive woody root systems can destabilize dams, embankments, and side slopes by creating seepage routes (EPA 2029) and can cause blockages within conveyance structures.

It is recommended that encroaching woody vegetation be cut and removed from the Site or placed in small piles along the tree line. Herbicide should be applied to the cut stems to minimize resprouting. As feasible, invasive shrubs and weeds within the southern tree line should be controlled to reduce spread into the native plant communities. The downed black cherry tree that has fallen onto the basin berm should be cut and removed from Site. Removal of encroaching woody vegetation is recommended to be a continued management task at the Site. Prescribed burning should be used as a management tool along with mechanical and chemical control to reduce encroachment by woody vegetation.

**Other Invasive Herbaceous Species**

The abundance of other invasive species at the Site was relatively low; however, management is recommended to control these invasive populations and prevent the spread. Spot spray herbicide treatments are recommended to control perennial invasive species including Canada thistle, reed canary grass (*Phalaris arundinacea*), and bird's-foot trefoil. Cutting the root below the ground surface with a small shovel or appropriately timed spot mowing with a handheld brush cutter is recommended for burdock, bull thistle, sweet clover, and Queen Anne's lace.

B) <u>Native Species Enhancements</u>

The installation of additional native wetland emergent species is recommended to fill in existing gaps along the pond perimeter and to fill in areas where cattail was controlled. Besides increasing plant diversity, stabilizing the shoreline, and contributing to aesthetics; emergent vegetation may also reduce nuisance algal blooms by competing with the algae for nutrients and reduce waterfowl access (EPA 2009). Recommended wetland species that grow well along the water's edge and/or in shallow water of ponds include common arrowhead (*Sagittaria latifolia*), blue flag iris (*Iris virginica*), pickerel weed (*Pontederia cordata*), sweet flag (*Acorus americanus*), common bur-reed (*Sparganium eurycarpum*), soft rush (*Juncus effusus*), bottlebrush sedge (*Carex comosa*), lake sedge (*Carex lacustris*), and swamp milkweed (*Asclepias incarnata*). Water plantain (*Alisma subcordatum*) and soft-stem bulrush (*Schoenoplectus tabernaemontani*) are other suitable emergent species that are already common at the Site.

It is not clear if the infiltration basin bottom has been seeded with a permanent seed mix and it is possible that restoration will not be finalized until more of the surrounding residential development is constructed. It is recommended that a native seed mix be installed with deep and fibrous rooted species that have a diversity of moisture tolerance to withstand dry periods as well as periods of stormwater runoff to assist with stormwater infiltration. The City should evaluate whether the basin vegetation should be established while the system is offline pending the construction to get the basin online does not cause significant disturbance and the vegetation can withstand the change in hydrologic regime. Supplemental seeding of prairie areas may also be conducted in areas of sparser perennial cover.

Prescribed burning is an important management tool for herbaceous plant communities to stimulate native vegetation, remove thatch, recycle nutrients, reduce encroachment of woody vegetation, and facilitate other vegetation management such as invasive species treatments and supplemental seeding. Prairies are fire-adapted communities and prescribed burning can make these ecosystems more diverse and resilient (WDNR 2015). It is recommended that the Site is burned approximately every three years for aesthetic and vegetation management purposes.

3. **The public is interested in volunteering at these properties and would like to learn more about restoration techniques and methods.**

It is recommended that the City provide outreach events for this Site or nearby SWU lands for the surrounding neighborhoods to educate the residents on these facilities. An outreach event could include a walking tour of the SWU land with a description of how the SWU land functions and mitigates runoff, why native vegetation is important at these facilities, and restoration techniques and methods to support the native vegetation at these communities. Knowing more about the functions of these facilities may create more appreciation for the SWU lands and may enlist some site stewards or volunteers. With some guidance from the City, citizens could help with monitoring and reporting of issues, help with trash clean-up, contribute to citizen science plant and wildlife surveys, assist with mechanical removal of invasive plants, and assist with seeding and planting. These are also opportunities to involve local school groups if there is an interested science teacher looking for field trips related to the water cycle, stormwater engineering, and native plant communities.

It is important to note that herbicide treatments shall be conducted by trained and licensed professionals and prescribed burning shall be conducted by a trained and qualified burn team with appropriate local permits.

# 4.0 Conclusion

Heartland evaluated the Sister Oak Ponds property in the context of the public feedback received by the City regarding SWU lands. Overall, the Site appears to be meeting stormwater capture objectives although it is not fully functioning yet since the infiltration basin is offline, the installed plant communities consist primarily of native vegetation, and the Site is providing wildlife and pollinator habitat. The following is a prioritized list of recommendations for the Site:

1) Control cattail and encroaching woody vegetation.
2) Increase native species diversity by installing additional wetland emergent plants along the wet pond perimeter, adding additional native seed in the infiltration basin bottom (either when the basin is still offline or once surrounding residential construction is completed and the pond is online), and adding supplemental native seed as needed in the prairie areas.
3) Utilize prescribed burning as a management tool.
4) Conduct neighborhood outreach.
5) Control other invasive herbaceous plants.
6) Enhance turtle and frog habitat within the wet pond.
7) Consider habitat corridors and connectivity to other SWU lands and public lands in a natural state during development.

# 5.0 References

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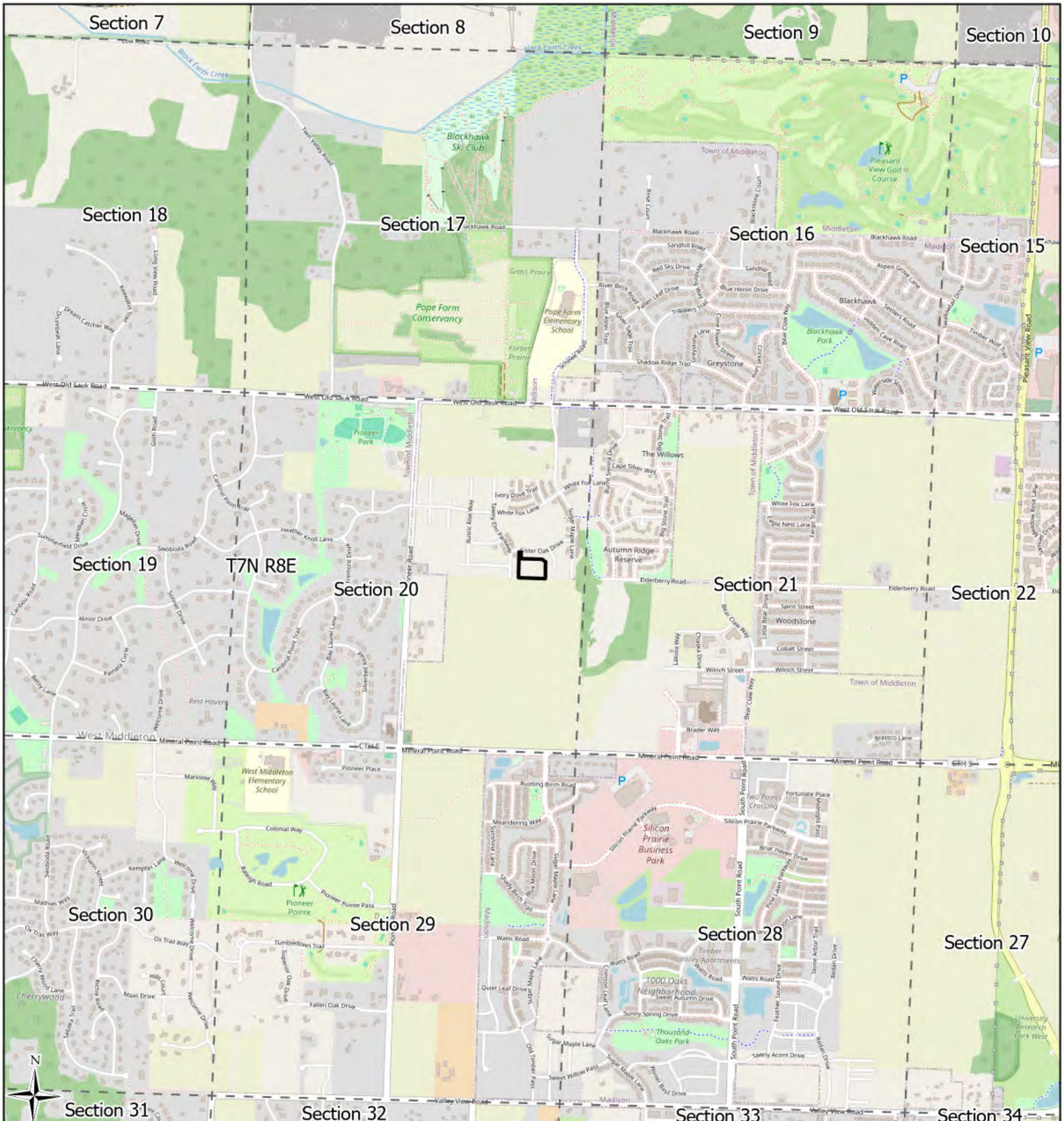
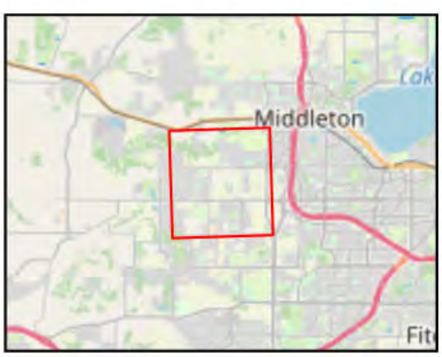
# Appendix A | Figures




Sister Oak Drive Ponds (2.76 ac)

Township

Section

0 1,000 2,000 Ft

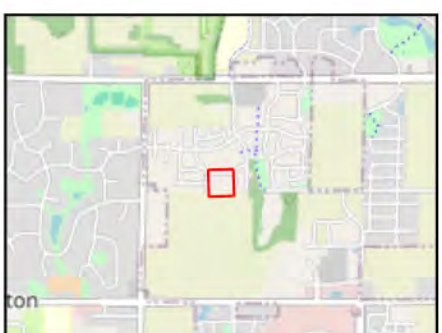
**Heartland**
ECOLOGICAL GROUP INC

Figure 1. Project Location

Sister Oak Ponds
Project #20241341
T7N, R8E, S20
C Madison, Dane Co

OpenStreetMap
ESRI
LRR: NCNE

Figure Created: 9/25/2024

Sister Oak Drive Ponds (2.76 ac)

Photo Points

0 30 60 Ft

Heartland
ECOLOGICAL GROUP INC

Figure 2. Field Map

Sister Oak Ponds
Project #20241341
T7N, R8E, S20
C Madison, Dane Co

OpenStreetMap
ESRI

LRR: NCNE

Figure Created: 9/25/2024

# Appendix B | Photo Log


**Photo #1** Photo point 1, view east toward the wet pond


**Photo #2** Photo point 1, culvert at west side of wet pond


**Photo #3** Photo point 1, view northeast of wetland vegetation, primarily cattail, along wet pond perimeter


**Photo #4** Photo point 1, view southeast along transition from wetland vegetation to upland prairie


**Photo #5** Photo point 2, view east towards the infiltration basin


**Photo #6** Photo point 3, culvert with box elder trees in riprap on the southwest side of the infiltration basin.


**Photo #7** Photo point 3, view north towards tree saplings growing in riprap below infiltration basin culvert


**Photo #8** Photo point 3, view east along the southern perimeter of the infiltration basin with woody encroachment


**Photo #9** Photo point 4, view west along the southern berm of the infiltration basin with a downed tree


**Photo #10** Photo point 5, view west toward the infiltration basin and the berm between the basin and wet pond


**Photo #11** Photo point 6, view west toward the wet pond


**Photo #12** Photo point 6, view north of prairie along the eastern slope of the wet pond.


**Photo #13** Photo point 7, view north facing the culvert outfall in the infiltration basin


**Photo #14** Photo point 8, view northeast toward the west-central portion of the infiltration basin


**Photo #15** Photo point 8, view north-northwest toward the western portion of the infiltration basin


**Photo #16** Photo point 9, view northwest from above the culvert in the southeast portion of the wet pond

# Appendix C | Existing Vegetation Species Lists

**Table C-1. Upland Prairie on Slopes and Berms Species List**

| Scientific Name | Common Name | Native | Physiognomy | Duration |
|---|---|---|---|---|
| *Acer negundo* | box elder | native | tree | perennial |
| *Ambrosia artemisiifolia* | common ragweed | native | forb | annual |
| *Ambrosia trifida* | giant ragweed | native | forb | annual |
| *Andropogon gerardii* | big blue-stem | native | grass | perennial |
| *Arctium minus* | common burdock | non-native | forb | biennial |
| *Asclepias syriaca* | common milkweed | native | forb | perennial |
| *Baptisia alba* | white wild indigo | native | forb | perennial |
| *Bouteloua curtipendula* | side-oats grama | native | grass | perennial |
| *Calystegia sepium* | hedge bindweed | native | vine | perennial |
| *Chamaecrista fasciculata* | golden cassia | native | forb | annual |
| *Cirsium arvense* | Canada thistle | non-native | forb | perennial |
| *Cirsium vulgare* | bull thistle | non-native | forb | biennial |
| *Daucus carota* | Queen Anne's-lace | non-native | forb | biennial |
| *Desmodium canadense* | showy tick-trefoil | native | forb | perennial |
| *Echinacea purpurea* | broad-leaved purple coneflower | non-native | forb | perennial |
| *Elymus canadensis* | Canada wild-rye | native | grass | perennial |
| *Erigeron canadensis* | Canadian horseweed | native | forb | annual |
| *Helenium autumnale* | common sneezeweed | native | forb | perennial |
| *Helianthus grosseserratus* | saw-tooth sunflower | native | forb | perennial |
| *Heliopsis helianthoides* | false sunflower | native | forb | perennial |
| *Juglans nigra* | black walnut | native | tree | perennial |
| *Lonicera x bella* | Bell's invasive honeysuckle | non-native | shrub | perennial |
| *Lotus corniculatus* | bird's-foot trefoil | non-native | forb | perennial |
| *Melilotus albus* | white invasive sweet clover | non-native | forb | annual |
| *Monarda fistulosa* | wild bergamot | native | forb | perennial |
| *Morus alba* | white mulberry | non-native | tree | perennial |
| *Panicum virgatum* | switch grass | native | grass | perennial |
| *Parthenium integrifolium* | wild quinine | native | forb | perennial |
| *Parthenocissus quinquefolia* | Virginia creeper | native | vine | perennial |
| *Poa pratensis* | Kentucky bluegrass | non-native | grass | perennial |
| *Prunus serotina* | wild black cherry | native | tree | perennial |
| *Pycnanthemum virginianum* | common mountain mint | native | forb | perennial |
| *Ratibida pinnata* | globular coneflower | native | forb | perennial |
| *Rosa multiflora* | multiflora invasive rose | non-native | shrub | perennial |
| *Rubus idaeus var. strigosus* | American red raspberry | native | shrub | perennial |
| *Rudbeckia hirta* | black-eyed Susan | native | forb | biennial |
| *Rudbeckia subtomentosa* | sweet black-eyed Susan | native | forb | perennial |
| *Setaria pumila* | yellow foxtail | non-native | grass | annual |
| *Silphium perfoliatum* | cup-plant | native | forb | perennial |
| *Silphium terebinthinaceum* | prairie-dock | native | forb | perennial |
| *Solanum dulcamara* | bittersweet nightshade | non-native | vine | perennial |
| *Solidago canadensis* | Canada goldenrod | native | forb | perennial |
| *Solidago rigida* | stiff-leaved goldenrod | native | forb | perennial |
| *Sonchus arvensis* | field sow-thistle | non-native | forb | perennial |
| *Sorghastrum nutans* | Indian grass | native | grass | perennial |
| *Symphyotrichum lateriflorum* | calico aster | native | forb | perennial |
| *Symphyotrichum novae-angliae* | New England aster | native | forb | perennial |
| *Symphyotrichum pilosum* | frost aster | native | forb | perennial |
| *Toxicodendron rydbergii* | western poison-ivy | native | shrub | perennial |
| *Trifolium hybridum* | alsike clover | non-native | forb | perennial |
| *Trifolium pratense* | red clover | non-native | forb | perennial |
| *Urtica dioica* | stinging nettle | native | forb | perennial |
| *Verbena hastata* | blue vervain | native | forb | biennial |
| *Vernonia fasciculata* | common ironweed | native | forb | perennial |
| *Vitis riparia* | riverbank grape | native | vine | perennial |
| *Zizia aurea* | golden alexanders | native | forb | perennial |

| Vegetation Metrics | Classification | Quantity | Percent of Total |
|---|---|---|---|
| Species Richness | Native | 40 | 71.4% |
| | Non-native | 16 | 28.6% |
| Physiognomy | Tree | 4 | 7.1% |
| | Shrub | 4 | 7.1% |
| | Vine | 4 | 7.1% |
| | Forb | 37 | 66.1% |
| | Grass | 7 | 12.5% |
| | Sedge | 0 | 0.0% |
| Duration | Annual | 6 | 10.7% |
| | Biennial | 5 | 8.9% |
| | Perennial | 45 | 80.4% |

## Table C-2. Wet Pond Perimeter Species List

| Scientific Name | Common Name | Native | Physiognomy | Duration |
|---|---|---|---|---|
| *Alisma subcordatum* | American water-plantain | native | forb | perennial |
| *Asclepias incarnata* | marsh milkweed | native | forb | perennial |
| *Bidens frondosa* | common beggar-ticks | native | forb | annual |
| *Carex vulpinoidea* | brown fox sedge | native | sedge | perennial |
| *Eleocharis acicularis* | needle spike-rush | native | sedge | perennial |
| *Elymus virginicus* | Virginia wild-rye | native | grass | perennial |
| *Epilobium coloratum* | cinnamon willow-herb | native | forb | perennial |
| *Helenium autumnale* | common sneezeweed | native | forb | perennial |
| *Leersia oryzoides* | rice cut grass | native | grass | perennial |
| *Lemna minor* | common duckweed | native | forb | perennial |
| *Lindernia dubia* | yellowseed false pimpernel | native | forb | annual |
| *Penthorum sedoides* | ditch stonecrop | native | forb | perennial |
| *Persicaria lapathifolia* | curly-top smartweed | native | forb | annual |
| *Phalaris arundinacea* | reed canary grass | non-native | grass | perennial |
| *Populus deltoides* | eastern cottonwood | native | tree | perennial |
| *Potamogeton sp.* | unidentified pondweed | native | forb | perennial |
| *Rumex crispus* | curly dock | non-native | forb | perennial |
| *Sagittaria latifolia* | broad-leaved arrowhead | native | forb | perennial |
| *Salix interior* | sandbar willow | native | shrub | perennial |
| *Schoenoplectus tabernaemontani* | soft-stem bulrush | native | sedge | perennial |
| *Scirpus atrovirens* | dark-green bulrush | native | sedge | perennial |
| *Scirpus cyperinus* | wool-grass | native | sedge | perennial |
| *Symphyotrichum lanceolatum* | white panicle aster | native | forb | perennial |
| *Typha x glauca* | hybrid cattail | non-native | forb | perennial |

| Vegetation Metrics | Classification | Quantity | Percent of Total |
|---|---|---|---|
| Species Richness | Native | 20 | 87.0% |
| | Non-native | 3 | 13.0% |
| Physiognomy | Tree | 1 | 4.3% |
| | Shrub | 1 | 4.3% |
| | Vine | 0 | 0.0% |
| | Forb | 13 | 56.5% |
| | Grass | 3 | 13.0% |
| | Sedge | 5 | 21.7% |
| Duration | Annual | 3 | 13.0% |
| | Biennial | 0 | 0.0% |
| | Perennial | 20 | 87.0% |

## Table C-3. Infiltration Basin Species List

| Scientific Name | Common Name | Native | Physiognomy | Duration |
|---|---|---|---|---|
| *Carex vulpinoidea* | brown fox sedge | native | sedge | perennial |
| *Chamaecrista fasciculata* | golden cassia | native | forb | annual |
| *Echinochloa crus-galli* | barnyard grass | non-native | grass | annual |
| *Leersia oryzoides* | rice cut grass | native | grass | perennial |
| *Panicum dichotomiflorum* | fall panic grass | native | grass | annual |
| *Panicum virgatum* | switch grass | native | grass | perennial |
| *Persicaria maculosa* | lady's thumb smartweed | non-native | forb | annual |
| *Phalaris arundinacea* | reed canary grass | non-native | grass | perennial |
| *Populus deltoides* | eastern cottonwood | native | tree | perennial |
| *Schoenoplectus fluviatilis* | river bulrush | native | sedge | perennial |
| *Solidago canadensis* | Canada goldenrod | native | forb | perennial |
| *Sorghastrum nutans* | Indian grass | native | grass | perennial |
| *Symphyotrichum pilosum* | frost aster | native | forb | perennial |
| *Trifolium pratense* | red clover | non-native | forb | perennial |

| Vegetation Metrics | Classification | Quantity | Percent of Total |
|---|---|---|---|
| Species Richness | Native | 10 | 71.4% |
| | Non-native | 4 | 28.6% |
| Physiognomy | Tree | 1 | 7.1% |
| | Shrub | 0 | 0.0% |
| | Vine | 0 | 0.0% |
| | Forb | 5 | 35.7% |
| | Grass | 6 | 42.9% |
| | Sedge | 2 | 14.3% |
| Duration | Annual | 4 | 28.6% |
| | Biennial | 0 | 0.0% |
| | Perennial | 10 | 71.4% |

Quercus Land Stewardship Services

# City of Madison Engineering Stormwater Vegetation Management Recommendations

10/01/2024

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# Introduction

The average daily temperature of Madison Wisconsin is expected to increase 6.8°C (12.2 °F) by 2080 (WICCI 2021). This increase could cause major shifts in the distribution of local flora and fauna, potentially by as much as 145 kilometers (90 miles), as reported by Reidmiller et al. (2018). Conventional vegetation management techniques—including herbaceous and woody vegetation control, interseeding, and prescribed burning—have been demonstrated to enhance the resilience of wooded habitats against heat, drought, and wildfire, while also mitigating air quality impacts associated with climate change, according to the same study. Furthermore, Brewer et al. (2015) have established that grassland habitats subjected to management interventions exhibit increased abundance and species richness of native ground cover. When these ecosystems reach the late successional stage, their capacity for carbon sequestration can increase by up to 200% compared to systems in the early successional stage, as noted by Yang et al. (2019) The City of Madison Stormwater Utility Department (CMSUD), which oversees approximately 1,359 acres of urban green spaces in the Madison area, is positioned to implement these traditional vegetation management strategies and facilitate climate change adaptation through a framework identified as Resistance-Resilience-Transformation, as proposed by St. Laurent et al. (2021).

To achieve this type of management, Quercus recommends using strategies that correspond with the Active Resistance, Resilience, and Directed Transformation categories outlined in Table 1 of St. Laurent et al. (2021) (refer to Figure 1). Active Resistance practices will focus on Tier 1 properties, where vegetation management efforts will prioritize the preservation of intact natural or remnant habitats and the protection of existing species. Resilience practices may be applied to Tier 3 properties adjacent to other Tier 1 and Tier 2 areas, concentrating on the management of woody vegetation and the use of prescribed burning to encourage herbaceous vegetation, thereby supporting associated fauna and connecting these areas to those of superior quality habitat. Directed Transformation practices will target Tier 2 and Tier 3 properties that are primarily grassy, exhibit low biodiversity, and have undergone hydrological alterations, particularly those in proximity to Tier 1 and Tier 2 properties. The emphasis will be on implementing prescribed burning, interseeding native species from the southern limits of their range or from regions anticipated to correspond with Madison's evolving climate, and managing invasive herbaceous species.

The execution of these strategies presents significant challenges related to public perceptions, fiscal limitations, and workforce capacity. To mitigate public concerns, the CMSUD has conducted a thorough review and compiled a report summarizing community feedback regarding vegetation management on CMSUD properties. The specific concerns expressed by the community will be outlined in the Conclusion section of this document. Fiscal limitations and workforce capacity issues are frequently interrelated; however, engaging volunteers can provide a mitigation strategy. It should be noted that volunteer engagement will require staff time for training purposes, presenting an avenue to effectively address community concerns. Additionally, financial and workforce constraints can be alleviated through the strategic implementation of management practices, with a primary emphasis on prescribed fire, which will be further addressed in the discussion section of this document.

This document will outline specific management actions that can be implemented at three example sites provided to Quercus for this purpose. Following this, discussions will present a proposed management regime at the example site selected by Quercus, intended to exemplify the proposed management approach. Finally, we will address key public concerns utilizing recent scientific findings to foster public support for CMSUD's vegetation management program.

## Site Characterizations

### *PD 1452-033*

Site Description

Stormwater area PD 1452-003 is a 2.7 acre retention basin with one wet and one dry pond. The banks and dry pond consist of Dry-Mesic to Mesic Prairie reconstruction. The prairies are relatively diverse with tall warm season grasses dominant and nearly two dozen species of forbs. On the margins of the wet pond emergent marsh exists with water plantain, dark green bulrush and hybrid cattails being the noted dominant species. These habitats are relatively free from invasive herbaceous and woody species. The initial site visit noted canada thistle, hybrid cattails, wild parsnip, and cottonwood. Populations of all herbaceous invasive species were light and confined to sporadic areas. A second site visit noted that CMSUD staff had removed all intruding cottonwood.

Goal

- Stormwater ponds with biologically diverse prairie reconstructions

Objectives

- Keep invasive herbaceous and woody species to less than 5% cover of entire acreage
- Reintroduction of a natural fire regime
- Engage local residents in the long management and care of the site
- Monitoring for the adaptive management of stated objectives

Threats/Limitations

- Invasive herbaceous and woody species

- Refuse dumping by neighboring residents
- Unexpected urban inputs via stormwater flow

Recommendations

A site map and the associated management recommendation areas are presented in Figures 2 through 5.

**Prescribed Fire**

To preserve the existing level of biodiversity, prescribed fire should be reintroduced to the site at a minimum frequency of two out of three years. This approach will enhance the viability of the native seedbank, exert stress on the invasive species seedbank, and regulate the extent of woody encroachment.

**Vegetation Management**

The primary concern identified on-site is the encroachment of cottonwood (*Populus deltoides*). This species exhibits rapid growth and has the potential to establish monoculture-like conditions. Hybrid cattails (*Typha x glauca*) can provide habitat for waterfowl; however, they are also capable of rapidly colonizing areas and overshadowing native aquatic vegetation. It is recommended to implement annual monitoring and management through cut-stump techniques and herbicide application when populations exceed the specified coverage threshold to regulate these two species. Canada thistle (*Cirsium arvense*) can become dominant in newly established plant communities and may necessitate the application of Milestone herbicide if it achieves a coverage of greater than 15%. As the prairie ecosystem matures and native species become established, management strategies such as mowing and prescribed burning appear effective in controlling this invasive species.

Given the current diversity of habitats on-site, additional seeding is not deemed necessary. Introducing additional late-successional legumes, such as Lead plant (*Amorpha canescens*), Milk vetch (*Astragalus spp.*), Goat's rue (*Tephrosia villosa*), and White prairie clover (*Dalea candidans*), will increase nitrogen availability in the soil. C4 grasses are notably efficient at utilizing this nitrogen for root development, thereby enhancing the site's capacity for carbon capture, as reported by Yang et al. (2019)

**Public Engagement**

During our preliminary site assessment, a neighboring resident raised concerns regarding the onsite vegetation. We directed the individual to contact the stormwater utility department after explaining the functional role of the existing vegetation. This interaction suggests a gap in understanding among local residents pertaining to the purpose of vegetation in stormwater management systems. To address this knowledge deficiency, we recommend disseminating informational materials to the community outlining the role of native vegetation and the necessity for periodic management interventions. Additionally, providing details about volunteer workdays would facilitate community involvement in the stewardship of the site. Placing informational signage, such as that depicted in Figure 17, along the property boundary could further enhance public awareness. The overarching objective of these initiatives is to engage local residents in the stewardship of the site, thereby increasing the volunteer workforce and mitigating issues related to unauthorized disposal of waste.

### *PD 6417*

#### Site Description

PD 6417 is a 58-acre natural area which lies within the Starkweather Creek watershed and is in varying stages of ecological restoration. Analysis of satellite imagery reveals extensive drainage features, indicative of the use of drainage tiles. The predominant habitat type is a severely degraded wetland, largely dominated by reed canary grass (*Phalaris arundinacea*) (rcg). A small remnant of sedge meadow exists within this reed canary grass monoculture, as identified in Figure 7 by a black and red star. The site visit also revealed aggressive native forbs such as yellow coneflower (*Ratibida pinnata*) and sawtooth sunflower (*Helianthus grosseserratus*) still prevailing in patchy distribution. The remaining areas of the site comprise dry-mesic and mesic prairie reconstructions, along with both dry-mesic and mesic upland forest ecosystems. The prairie areas are experiencing encroachment by both woody and herbaceous species, including common buckthorn (*Rhamnus cathartica*), cottonwood (*Populus deltoides*), willow (*Salix spp.*), honeysuckle (*Lonicera spp.*), birdsfoot trefoil (*Lotus corniculatus*), wild parsnip (*Pastinaca sativa*), patchy distributions of reed canary grass, and both biennial and perennial thistles. A site visit noted that prairie areas of greater biodiversity recently had encroaching woody species removed. Within the forested regions, the encroachment of woody species has been noted, with observations of honeysuckle, common buckthorn, sumac (*Rhus spp.*), dogwood (*Cornus spp.*), and willow.

#### Goal

- A resilient natural area that delivers stormwater management functions, wildlife habitats, and communal recreational areas.

#### Objectives

- Contain reed canary grass populations to the current extent using prescribed fire and herbicide
- Contain woody encroachment to the current extent using prescribed fire and herbicide

- Expand sedge meadow footprint
- Reintroduction of a fire regime
- Introduce public access infrastructure
- Monitor for the adaptive management of stated objectives

Threats/Limitations
- Herbaceous and Woody invasive species
- Altered hydrology
- Unexpected urban inputs through stormwater

Recommendations

A site map and associated management recommendation areas are presented in figures 7 through 11.

**Prescribed Fire**

Annual burning in the late spring or fall has been found to control and in some cases eliminate reed canary populations as reported by Bates et al. (2021) Given the amount of linear feet of firebreak necessary to install through the rcg and the given budget of $3,000 a year and 8 hours of staff time. Annual burning is not feasible. However if the budget could be saved for one burn out of every three years. It will assist in removing the accumulated thatch which effectively acts as mulch suppressing most native species.

**Vegetation Management**

The primary concerns identified onsite were common buckthorn, honeysuckle, willow, birds foot trefoil, and reed canary grass. All woody species greater than 1 inch dbh can be controlled by a cut stump application of triclopyr, smaller individuals will need to be treated foliarly or through the repeated application of prescribed fire. Given the proposed fire regime above most smaller woody individuals will be able to surpass the 1 inch dbh unless they are smaller than .25 inches wide. Given that most encroaching woody vegetation within the prairie areas of higher biodiversity were removed recently. Effort could be focused going forward on triaging the birds foot trefoil and sporadic rcg populations with a fall herbicide application of triclopyr and milestone or glyphosate respectively, and foliarly spraying any occurrences of woody encroachment. The goal of these treatments would be to push the small satellite populations towards the larger dense patches within the allocated staff hours each year. Treatment in this manner over the course of 5 to 6 years should shift the majority of the on site population to the dense patches limiting the amount of ground that needs to be covered each year and allowing for the gradual containment and reduction of the population. The control of these species is at this time not recommended within the wooded areas or the rcg dominated wetland as budgetary capacity will be depleted with the treatment regime mentioned above.

Prairie habitats within the site are analogous to those present within the PD 1452-033 stormwater ponds, and we propose implementing a comparable interseeding strategy. In contrast, the sedge meadow should undergo frost seeding with rhizomatous sedges and vigorous, hydrologically suitable forbs subsequent to any prescribed burns. The establishment of rhizomatous sedges will generate a root mat capable of competing effectively against rcg, particularly when supplemented by repeated prescribed fire, thereby facilitating the establishment of aggressive forbs. This methodology can be progressively applied as the footprint of the sedge meadow expands. At present, we advise against any seeding activities in the wooded areas until funding—either internally sourced or obtained through grants—is available to support the removal and management of invasive and undesirable woody and herbaceous vegetation present in those areas as well as the subsequent foliar applications to target the expected emergence of invasive brush and weed seedlings following the clearing operations.

**Public Engagement**

At present, there exists a lack of informational resources to communicate the intended use of this property to the public. Implementing informational signage, similar to that illustrated in Figure 17, along the property boundary could significantly improve public awareness. Establishing trails within the property, accompanied by a trailhead sign that delineates the role of wetlands in maintaining water quality and their relevance to the general public, may foster a sense of stewardship. This engagement could lead to increased interest in volunteering to support CMSUD's goals for the site.

*GR 7052-005*

<u>Site Description</u>

A 7.5-acre natural area, which encompasses the North Pennito Creek. Structural interventions, including metal and, in some cases, stone baffles and barriers, were installed along the stream to mitigate erosion. However, these measures have become outdated and have suffered from undercutting due to decades of water flow, often exacerbating channel erosion. Significant undercutting of the creek banks was observed at most bends along the watercourse. The banks are predominantly characterized by mesic to dry mesic upland forest. Currently, they are heavily mesophied, and the understory exhibits ruderal characteristics, with numerous occurrences of ornamental species, particularly daylilies, being present.

<u>Goal</u>

- A natural area that can be used to expand public knowledge of stormwater management

Objectives

- Stabilization of the stream bank
- 75% reduction in the mesic and invasive woody encroachment
- 75% reduction in the undesirable herbaceous vegetation
- Reintroduction of a natural fire regime
- Monitor for the adaptive management of stated objectives

Threats/Limitations

- Influx of ornamental and invasive vegetation from upstream
- Exorbitant cost of channel manipulation

Recommendations

A site map and associated management recommendation areas are presented in Figures 12 through 16.

**Prescribed Fire**

In general the recommended return interval of fire in oak hickory woods is three to five years as long as the woods are not encroached by undesirable and invasive woody or herbaceous species. In which case the interval should be shortened to 1 to 2 in order to reduce or eliminate encroaching species as found by Peterson and Reich. (2008).

**Management Practices**

In order for this site to become a resilient natural area to provide stormwater services and wildlife habitat The process would be similar to this: an assessment of the current erosive conditions within the creek would need to take place. Then the  removal of currently present metal and stone baffles or barriers within the creek. The banks of the creek would then need to be regraded in the areas that are eroding and stone rip rap along with stabilizing vegetation will need to be installed. In the areas that did not undergo grading the focus could be the restoration of the present forest. Given the exorbitant costs involved with each of these actions we do not recommend CMSUD to follow through with this.  Rather this site could be a place to engage local residents in the stewardship of natural resources, and to teach them the importance of setting aside land for water quality and stormwater services.

**Public Engagement**

At present, there exists a lack of informational resources to communicate the intended use of this property to the public. To address this knowledge deficiency, we recommend disseminating informational materials to the community outlining the role of native vegetation and the necessity for periodic management interventions. Additionally, providing details about volunteer workdays would facilitate community involvement in the stewardship of the site. Placing informational signage, such as that depicted in Figure 17, along the property boundary could further enhance public awareness. The overarching objective of these initiatives is to engage local residents in the stewardship of the site, thereby increasing the volunteer workforce and mitigating issues related to unauthorized disposal of yard materials and waste.

# Discussion

*Overview*

CMSUD asked Quercus to choose out of the three described sites one site that could be used to portray common examples of types of vegetation and concerns within the stormwater utility system. The recommendations needed to take into account the limited resources available to the department assuming that vegetation management could be taken care of by the department, with 8 to 20 hours of staff time, and $3,000 available for contractor services annually per site. For this purpose **we have chosen PD 1452-003**; as this site exemplifies the vegetation management activities that must occur throughout all CMSUD properties, provides local proximity to the general public to engage in education, and demonstrates a management regime that will allow for the greatest collective acreage to be effectively stewarded on an annual basis.

*Management Regime*

The primary objective of this management regime is the implementation of prescribed fire in conjunction with other conventional vegetation management techniques. Prescribed fire is integral to this approach, as the ecosystems of the Midwest have historically adapted to fire as utilized by Indigenous peoples for purposes such as protection, hunting, and agriculture, as supported by the findings of Nowacki and Abrams (2008). The native ecosystems, having evolved within a fire-influenced context, now rely on fire for their continued existence; thus, the reintroduction of fire is essential for authentic habitat restoration, as it is the only mechanism capable of stimulating the native seed bank. While fire can aid in managing invasive species, it is often insufficient for eradication; therefore, supplementary actions such as the control of herbaceous and woody plant species through herbicide application and mowing are crucial for making ecological niches available for the reestablishment of native species. In this regime, staff time can be prioritized towards the smaller stormwater ponds such as PD 1452-003, and contractors can aid with the larger sites such as those represented by PD 6417. The rest of this section will describe how to implement each practice under this regime.

Prescribed Fire

Both Decker and Harmon-Threatt (2019) along with Tonietto and Larkin (2017) have recognized that neither growing season nor dormant season fires have negative effects on bee populations when the burned area has unburned natural areas nearby. To that end we propose CMSUD group their small sites similar to 1452-003 together in groups of three to six (3 to 6) always leaving at least one of three ( 1 of 3) so that bee populations can reestablish if at all harmed by the fire. For the larger properties especially if represented by PD 6417 with its challenging firebreak installation, sensitive smoke receptors, and intricate ignition patterns. Contractors may be best suited to implementing these burns, with their access to highly trained personnel, and equipment.

Herbaceous and Woody Vegetation Control

These activities on any site should prioritize the areas that are the most biologically diverse and expand outward as resources allow. This will facilitate the retention of the best habitat across the sites that CMSUD manages, allowing for corridors, which wildlife can utilize to navigate the wildland urban interface of Madison and get to larger natural areas outside the city.

Interseeding

Any introduced native species into remnant habitat should utilize local ecotype seed to preserve native diversity, enhance ecological resilience, and ensure long term sustainability of the ecosystem. Local ecotype seed is more likely to be adapted to the specific conditions on site, helping to improve survival and long term ecological function according to Lesica and Allendorf (1999). Hufford and Mazer (2003) highlighted that locally adapted ecotypes may already possess traits that help them survive local stressors, which contributes to the overall resilience of the ecosystem. Given the budgetary and workforce constraints of CMSUD the use of local ecotype seed in this context could also overtime reduce the need for follow up interventions, as this seed often leads to higher survival rates and faster establishment as pointed out by Gustafson et al. (2005)

In contrast, areas of low biodiversity should have seed sourced from areas in which Madison's climate is predicted to shift towards and can help anticipate and prepare for shifts in local ecosystems. This approach known as assisted gene flow improves the adaptive potential of plant populations by introducing genetic material that is better suited to the future conditions, as demonstrated by Breed et al. (2013) In this case the plants selected should be either plants that are at the northern edge of their geographic range or directly from the region of future predicted climatic conditions.

Public Engagement

Given the wildland urban interface that exists within the city of Madison, CMSUD has a unique opportunity to engage the general public on lands that are in their own backyard allowing for an increased sense of ownership and engagement, which can contribute to the long term success of a vegetation management program. Ryan et al. (2001) has demonstrated that providing the opportunity to help the environment and learn can get the public interested in volunteering, but considering their changing motivations over time can help to ensure longevity. Involving volunteers early in the process of vegetation management, allowing them to give concerns and other input as CMSUD has done through its public engagement process. Allows for possible conflict to be addressed ahead of potentially emotionally induced interactions as noted by Stringer et al. (2006). Finally, volunteers allow for the successful implementation of adaptive management through citizen science especially in programs that have constrained in-house staff. As found by Danielsen et al. (2009)

### *Public Concerns Addressed through Management*

Traditional vegetation management techniques can be designed to decrease the prevalence of undesirable herbaceous and woody species, enhance the diversity of native flora that supports a broad spectrum of wildlife, promote stormwater infiltration into soil substrates, regulate herbicide application levels, and mitigate the effects of climate change. These techniques can be customized to reduce environmental impacts while optimizing ecological benefits. The following outlines specific public concerns identified in the public engagement report, which were consistently raised across various engagement types, exhibited significant levels of concern, and encompassed a wide range of factors. We will examine each identified public concern and delineate how each management practice addresses these issues.

Wildlife habitat and impacts

**Prescribed Fire**

Prescribed burns can facilitate the restoration and maintenance of habitats by promoting the proliferation of fire-adapted plant species, enhancing habitat structure, and generating diverse vegetation strata that are advantageous for wildlife. For instance, regular fire events can mitigate dense underbrush, thereby increasing light penetration to the ground and fostering the growth of herbaceous plants, which in turn support pollinators, small mammals, and ground-nesting birds, as further articulated by Van Lear and Brose (2002).

**Herbaceous and Woody Species Control**

Barnes and Van Lear (1998) observed that the targeted removal of invasive or excessively abundant woody plant species can improve habitat quality by facilitating the proliferation of native herbaceous species, which serve as a food source and shelter for wildlife.

**Interseeding**

The introduction of native plant species via interseeding contributes to the restoration of habitats that have been degraded or are predominantly occupied by invasive species. This practice enhances plant diversity, resulting in a more complex habitat structure that benefits wildlife. Baer et al. (2002) demonstrated that interseeding can enhance habitat quality by increasing species richness and offering a diverse array of resources for wildlife.

<u>Loss of biodiversity and species extinction</u>

**Prescribed Fire**

Fire-adapted ecosystems frequently undergo a reduction in biodiversity as a result of fire suppression. The implementation of prescribed fire can reinstate natural fire regimes, thereby aiding in the preservation of species diversity through the facilitation of native plant growth and the mitigation of the encroachment of fire-sensitive invasive species. Fuhlendorf et al. (2009) illustrated that prescribed fire is instrumental in sustaining plant and animal diversity within prairie and savanna ecosystems by establishing a mosaic of habitats.

**Herbaceous and Woody Species Control**

Through the management of invasive species and the regulation of overabundant woody plant populations, this methodology mitigates the competitive pressure on native species. It contributes to the preservation of biodiversity within a specified ecosystem, thereby lowering the likelihood of local extinction events. Zavaleta et al. (2001) demonstrated that the control of invasive species is effective in preventing biodiversity decline and enhancing the resilience of native species.

**Interseeding**

Interseeding native plant species facilitates the enhancement of biodiversity by reintroducing taxa that may have been lost as a result of habitat degradation. This practice contributes to improved ecosystem resilience and mitigates the risk of species extinctions. Pywell et al. (2003)

demonstrated that interseeding significantly increases plant species diversity and enhances ecosystem functionality in degraded grassland ecosystems.

Invasive plants

**Prescribed Fire**

Fire can decrease the abundance of invasive plant species that frequently lack fire adaptations. In numerous ecosystems, fire acts as a regulatory mechanism for invasive species and facilitates the proliferation of native species that are adapted to fire conditions. Emery and Gross (2005) demonstrated that prescribed burning is an effective strategy for managing invasive species, including tall fescue, in native prairie ecosystems.

**Herbaceous and Woody Species Control**

Mechanical removal, cutting, and selective herbicide application are methodologies employed to manage invasive plant species. These techniques are implemented to mitigate the risk of invasive species outcompeting native flora and to preserve habitat integrity. DiTomaso et al. (2007) emphasized that integrated weed management approaches, which incorporate both mechanical and chemical control measures, demonstrate efficacy in the management of invasive species.

**Interseeding**

The incorporation of native plant species via interseeding can effectively outcompete invasive species, facilitating the restoration of the indigenous plant community. This technique is particularly advantageous in regions where invasive species have been eradicated, yet native species have not reestablished themselves. Blumenthal et al. (2005) demonstrated that interseeding with competitively dominant native species can mitigate the re-establishment of invasive species.

Herbicide on stormwater land

**Prescribed Fire**

Prescribed burning serves as an effective ecological management technique for mitigating the prevalence of invasive species and suppressing the growth of non-desirable plant species, thereby potentially decreasing the dependency on chemical herbicides. This approach is particularly advantageous in regions where there is significant public interest in minimizing the application of synthetic chemicals. DiTomaso et al. (2007) posited that the incorporation of fire as a management tool within vegetation management frameworks can lead to a decreased reliance on herbicides.

**Herbaceous and Woody Species Control**

Selective herbicide application is frequently essential for the management of invasive plant species; however, precision targeting and integrated methods that amalgamate mechanical and chemical control strategies can alleviate the total herbicide consumption. Spot treatments mitigate environmental repercussions by limiting the spatial extent of herbicide application, thereby necessitating diminished volumes of the chemical. Monaco et al. (2012) posited that the concomitant use of herbicides and mechanical control methods can optimize the overall quantity of herbicide required.

**Interseeding**

The process of restoring native plant communities via interseeding diminishes the requirement for herbicide applications over time, due to the enhanced capacity of robust native ecosystems to withstand invasive species. Blumenthal et al. (2005) observed that once native species are established, they possess the ability to inhibit the growth of invasive species, thereby decreasing the necessity for ongoing herbicide use.

<u>Vegetation and heat islands</u>

**Prescribed Fire**

In urban or peri-urban environments, the application of prescribed fire may be limited; however, it is essential for the preservation of open, vegetated spaces. These spaces contribute to the mitigation of the urban heat island effect by sustaining cooler, vegetated landscapes. Taha (1997) articulated that vegetated regions are effective in reducing the urban heat island effect, and their maintenance through methodologies such as prescribed fire is beneficial.

**Herbaceous and Woody Species Control**

In urban ecosystems, the management of overgrown vegetation and the enhancement of tree and shrub proliferation are effective strategies for mitigating the urban heat island effect. The removal of excessive woody biomass facilitates the establishment of grasses and other herbaceous plants, which contribute to thermal regulation via evapotranspiration processes. Research conducted by Bowler et al. (2010) demonstrated that urban green spaces play a significant role in lowering ambient temperatures and alleviating heat island phenomena, underscoring the importance of effective vegetation management practices.

### Interseeding

Interseeding native grasses and plants in urban green spaces can enhance vegetation cover and mitigate temperatures in heat-affected regions. Hough (2004) highlighted that increased plant diversity in urban environments contributes to reductions in surface and ambient air temperatures. Additionally, Yang et al. (2019) observed that carbon sequestration potential in grassland ecosystems may increase by as much as 200% when transitioning from the early successional stage to the late successional stage.

## Flooding, Water Quality and Types of Vegetation

### Prescribed Fire

In flood-prone regions, the application of prescribed fire can mitigate dense vegetation that obstructs water flow, thereby facilitating enhanced drainage and diminishing flood risks. Additionally, fire can stimulate the proliferation of vegetation that enhances soil stabilization, subsequently reducing erosion and surface runoff. Twidwell et al. (2013) proposed that prescribed fire may serve as a management tool for regulating water flow and attenuating flood risks in specific ecosystems by eliminating obstructive vegetation.

### Herbaceous and Woody Species Control

Management of vegetation along riparian zones, including the removal of invasive woody species, can enhance flood resilience. The presence of native riparian vegetation, specifically grasses and shrubs, facilitates improved water infiltration and mitigates the likelihood of flooding. Tabacchi et al. (2000) demonstrated that the management of riparian vegetation contributes to increased water retention and diminished flood risk.

### Interseeding

The integration of deep-rooted native plant species via interseeding has been shown to enhance soil structure and promote water infiltration, thereby diminishing surface runoff and mitigating the likelihood of flooding. Research conducted by Palmer et al. (2005) has evidenced that the restoration of native vegetation contributes to flood mitigation by improving soil permeability and lowering runoff rates.

Sequestering carbon in soils and vegetation

**Prescribed Fire**

Although combustion processes release carbon into the atmosphere, fire-adapted ecosystems are frequently able to sequester greater amounts of carbon over the long term. This is attributed to enhanced primary productivity and elevated soil organic carbon storage in the aftermath of fire events. Fire acts as a mechanism to rejuvenate vegetative growth and augment overall ecosystem productivity, thereby facilitating carbon sequestration. Pausas and Keeley (2009) documented that fire can positively influence carbon sequestration in fire-adapted ecosystems by promoting increased biomass productivity and enhancing soil carbon storage.

**Herbaceous and Woody Species Control**

Management of overabundant woody species can result in a reduction of carbon storage within woody biomass; however, it can concurrently enhance soil carbon sequestration by facilitating the establishment of grasses and other herbaceous plant species with deeper root systems. Post and Kwon (2000) demonstrated that grassland restoration, which frequently necessitates the control of woody plant populations, leads to elevated levels of soil organic carbon.

**Interseeding**

Interseeding of native species, specifically deep-rooted graminoids and forbs, contributes to the augmentation of soil organic matter and facilitates long-term carbon sequestration in soils. Conant et al. (2011) provided evidence that the restoration of native grasslands via interseeding can significantly improve soil carbon storage.

*Conclusion*

The City of Madison Stormwater Utility Department manages numerous properties with differing constraints and objectives. To effectively manage these properties in the face of climate change, CMSUD must be able to consistently identify these constraints and objectives, then apply the appropriate management activities. To aid in this task, we recommend adopting the Resistance-Resilience-Transformation (R-R-T) framework, as proposed by St. Laurent et al. (2021). An R-R-T framework will provide a lens to focus management activities to areas that best meet the public need. Management activities, such as prescribed burning, controlling invasive species, and interseeding native species, are vital in maintaining the health of local natural areas and addressing the public concerns of habitat destruction, biodiversity loss, climate change, carbon sequestration, and flood abatement. The incorporation of R-R-T theory into a comprehensive restoration strategy for CMUSD properties would help align management activities and ecological objectives with the demands of Madison citizens and infrastructure well into the future.

# Appendices

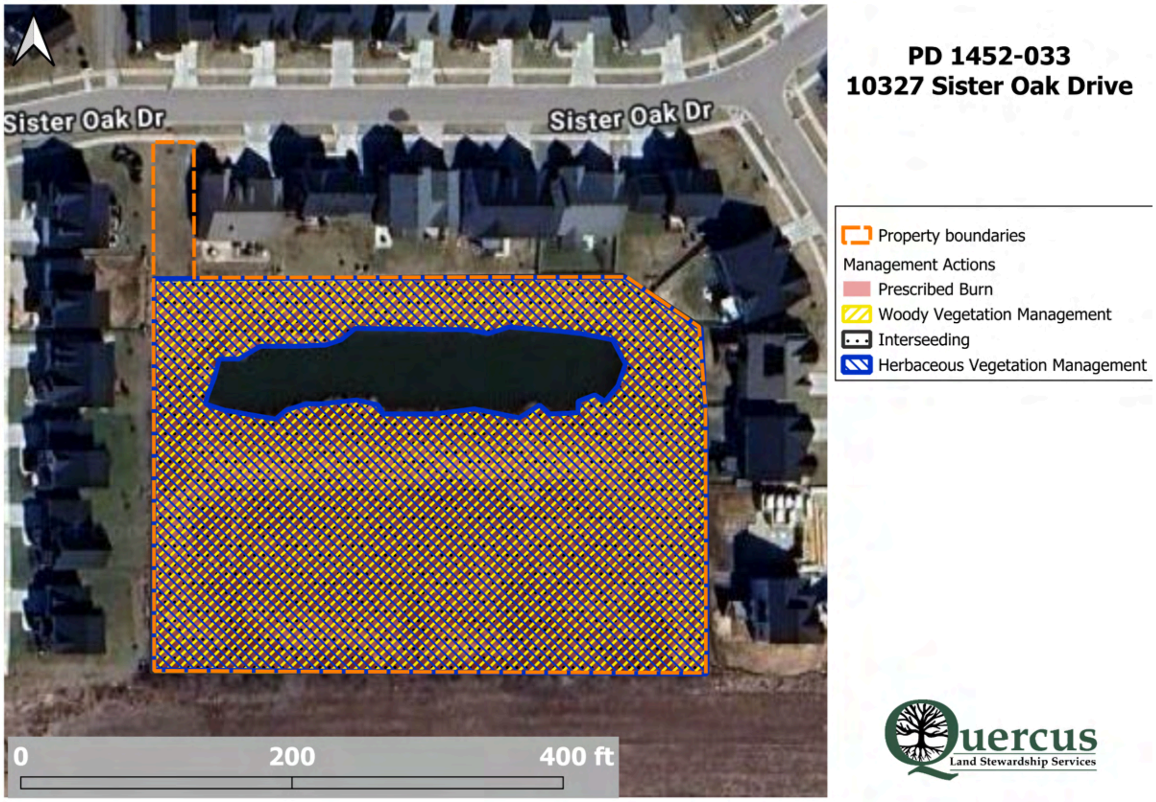
Figure 1

**Table 1 Examples of adaptation actions and their primary objective for the six categories of the "R-R-T scale".**

| Categories | Examples of actions | Primary objective |
|---|---|---|
| 1. Active Resistance | Eradicate non-native species in grassland or forest ecosystems. | Actively prevent changes in species composition. |
| | Install and manage water control structures to maintain historic water levels in a coastal impoundment. | Actively resist rising sea levels. |
| 2. Passive Resistance | Create or expand protected areas in climate refugia. | Passively maintain current ecosystems. |
| | Purchase conservation easements to protect a species that is endangered by climate change. | Passively protect species in their historical habitat. |
| 3. Resilience | Reconnect previously existing corridors to allow the migration of specific species. | Enhance the ability of species to persist as climate changes by removing barriers to movement and dispersal |
| | Restore streams by re-introducing beaver. | Increase resilience of stream functions to natural disturbances such as floods and droughts. |
| 4. Autonomous Transformation | Connect relatively warmer and colder aquatic areas. | Create opportunities for species movements to seek cold water refugia. |
| | Apply forestry techniques designed to increase native species diversity. | Increase chances that some species will thrive as climate changes. |
| 5. Directed Transformation | Use assisted migration by planting with seeds gathered in a warmer part of a species' current range (aka assisted gene flow). | Drive transition towards climate-adapted genetic composition of species or populations. |
| | Use climate-informed forestry to direct future species composition (e.g., post-harvest planting using drought-resistant native species). | Drive transition towards more climate-adapted native species compositions. |
| 6. Accelerated Transformation | Use assisted migration to move a species outside of its current or historic range (aka assisted range expansion). | Accelerate climate-driven species transition. |
| | Restore riparian ecosystems by inoculating soils with non-native inoculant materials that are adapted to warmer and dryer conditions. | Accelerate transition towards more climate-adapted ecosystem functions. |

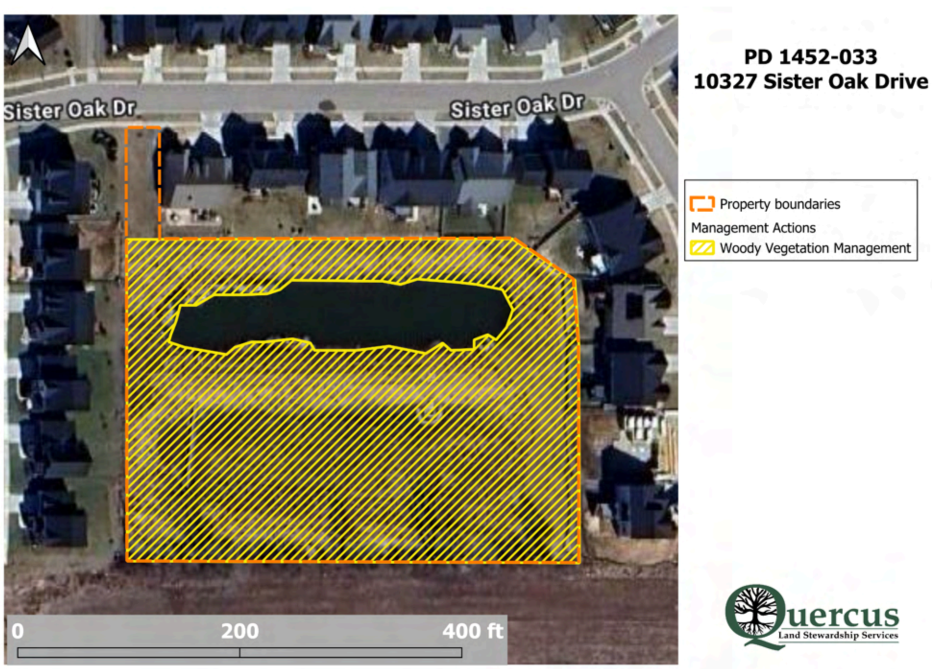
Adapted from"R-R-T (resistance-resilience-transformation) typology reveals differential conservation approaches across ecosystems and time." by St-Laurent, G. P., Oakes, L. E., Cross, M., & Hagerman, S., *Communications Biology*, 4, open source

Figure 2




PD 1452-003 Overall Management Actions. Depicted above are the boundaries of each proposed management action.

Figure 3




PD 1452-003 Woody Vegetation Management Area . Depicted above is the boundary of the proposed woody vegetation management area..

Figure 4


PD 1452-003 Prescribed Burn Area . Depicted above is the boundary of the proposed prescribed burn management area..

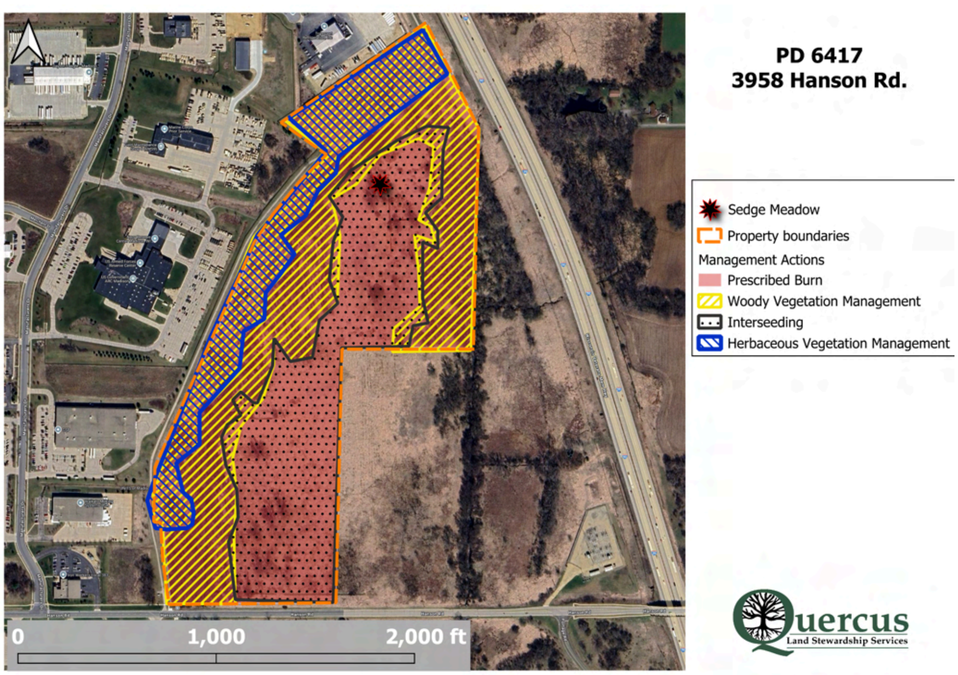
Figure 5


PD 1452-003 Interseeding Management Area . Depicted above is the boundary of the proposed interseeding management area..

Figure 6

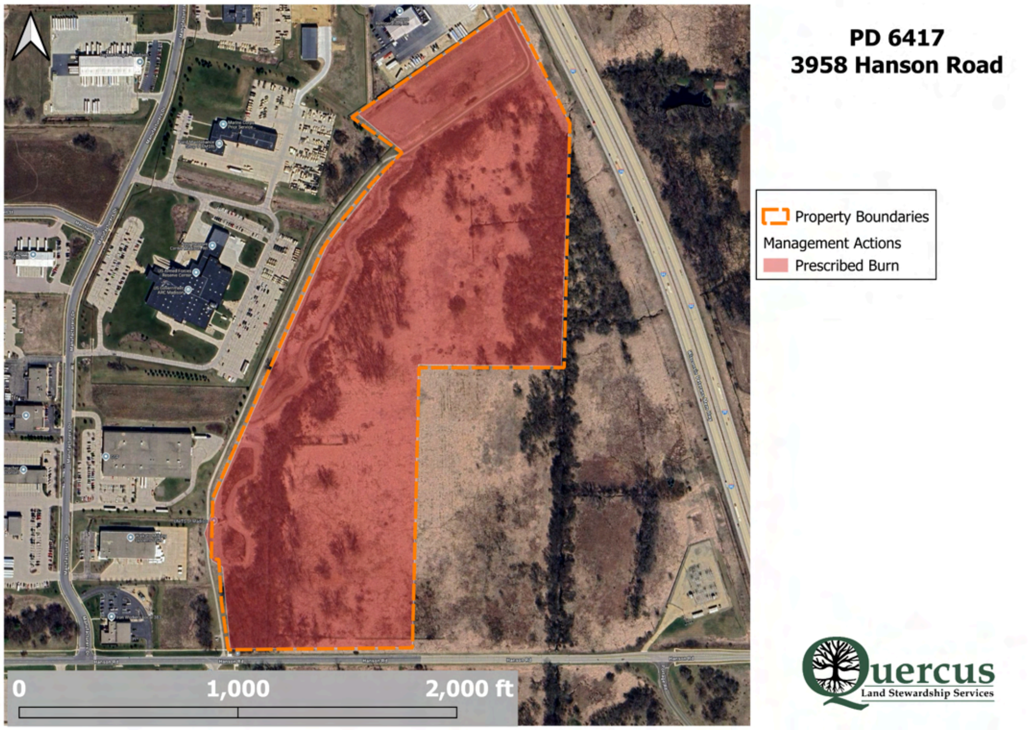

PD 1452-003 Herbaceous Vegetation Management Area . Depicted above is the boundary of the proposedherbaceous  vegetation management area..

Figure 7



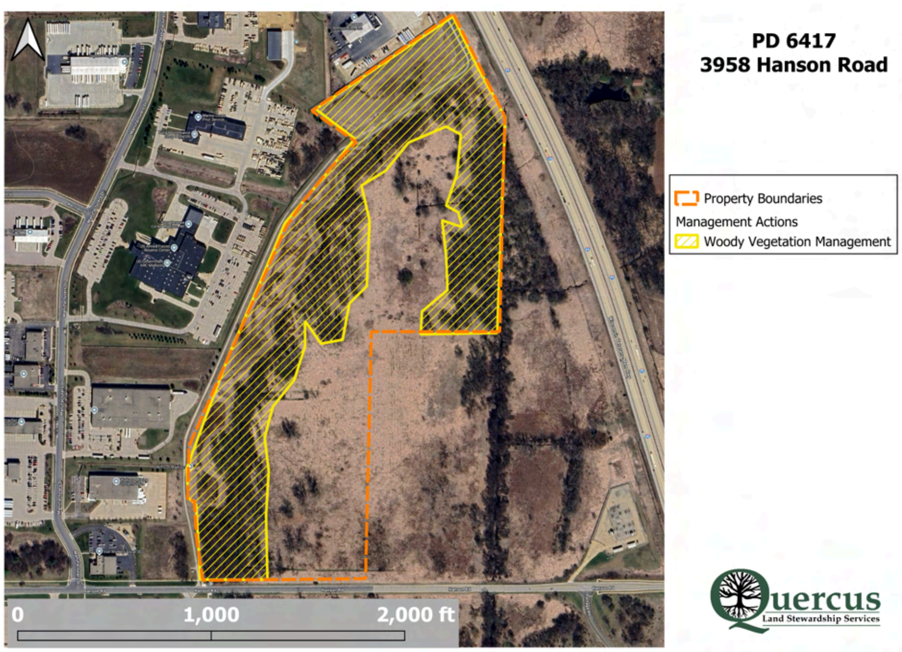

PD 6417 Overall Management Actions. Depicted above are the boundaries of each proposed management action.

Figure 8



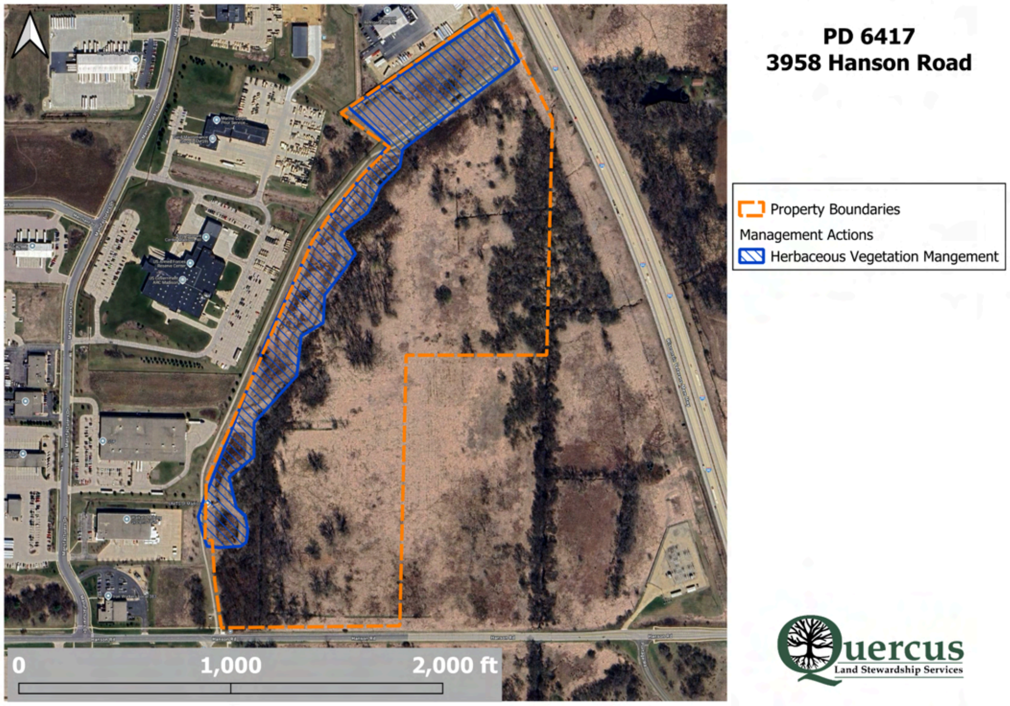

PD 6417 Prescribed Burn Management Area . Depicted above is the boundary of the proposed prescribed burn management area..

Figure 9



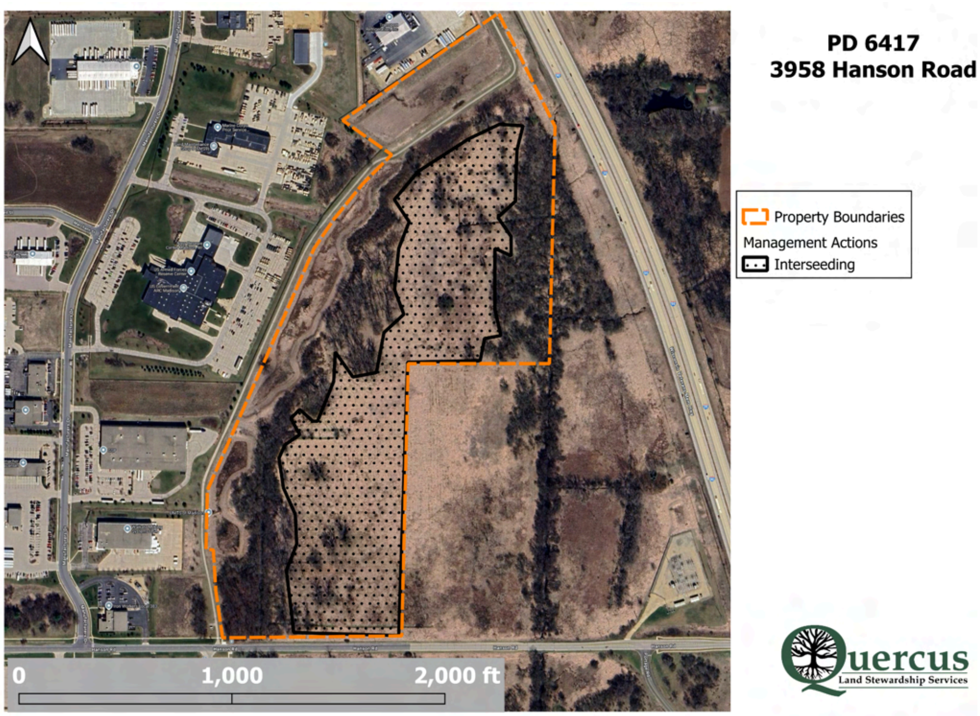

PD 6417 Woody Vegetation Management Area . Depicted above is the boundary of the proposed woody vegetation management area..

Figure 10



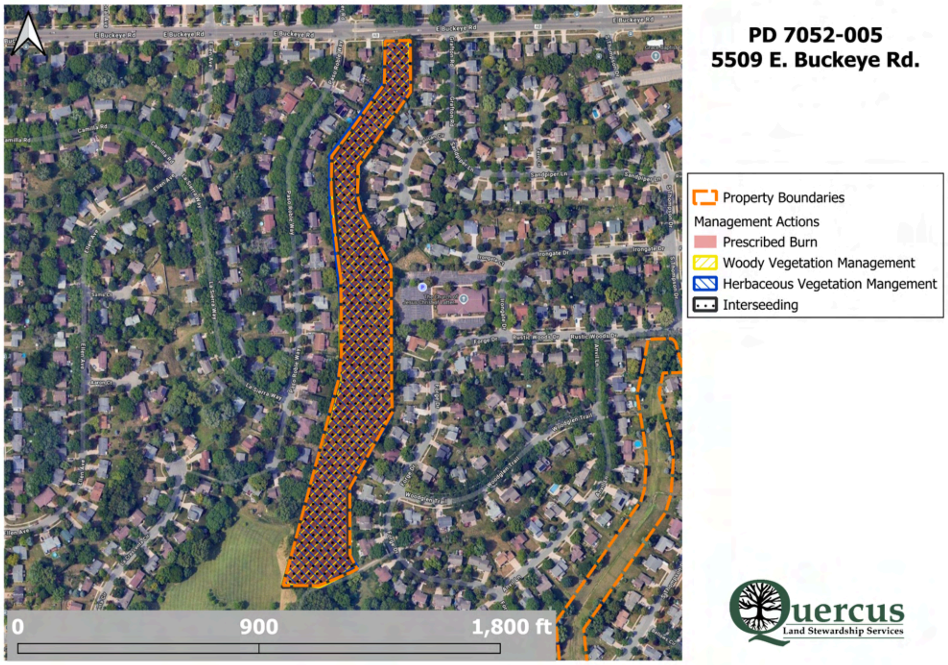

PD 6417 Herbaceous Vegetation Management Area . Depicted above is the boundary of the proposed herbaceous vegetation management area.

Figure 11



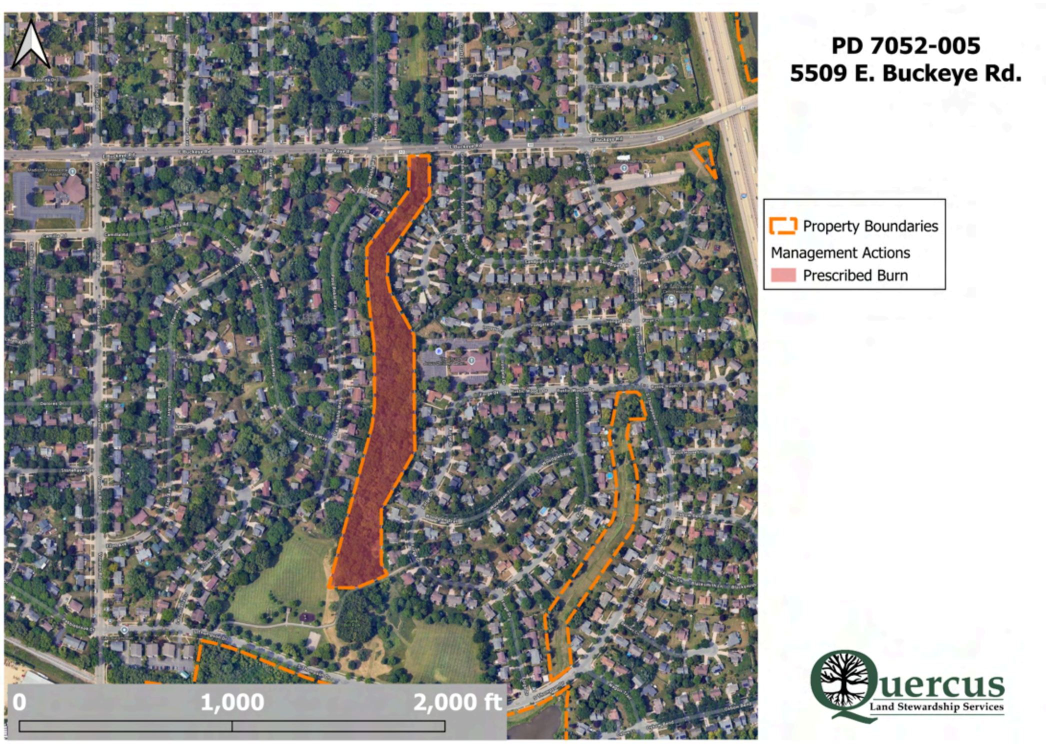

PD 6417 Interseeding Management Area . Depicted above is the boundary of the proposed interseeding management area.

Figure 12



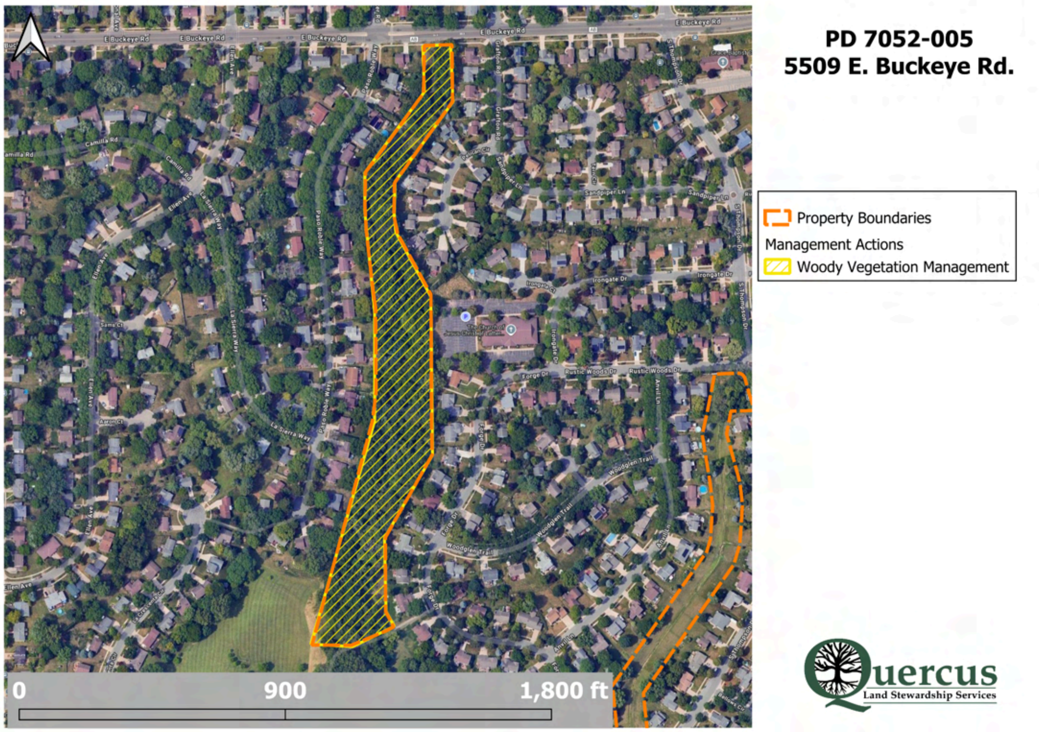

PD 7052-005 Overall Management Actions. Depicted above are the boundaries of each proposed management action. .Due to QGIS constraints the creek has not been delineated.

Figure 13



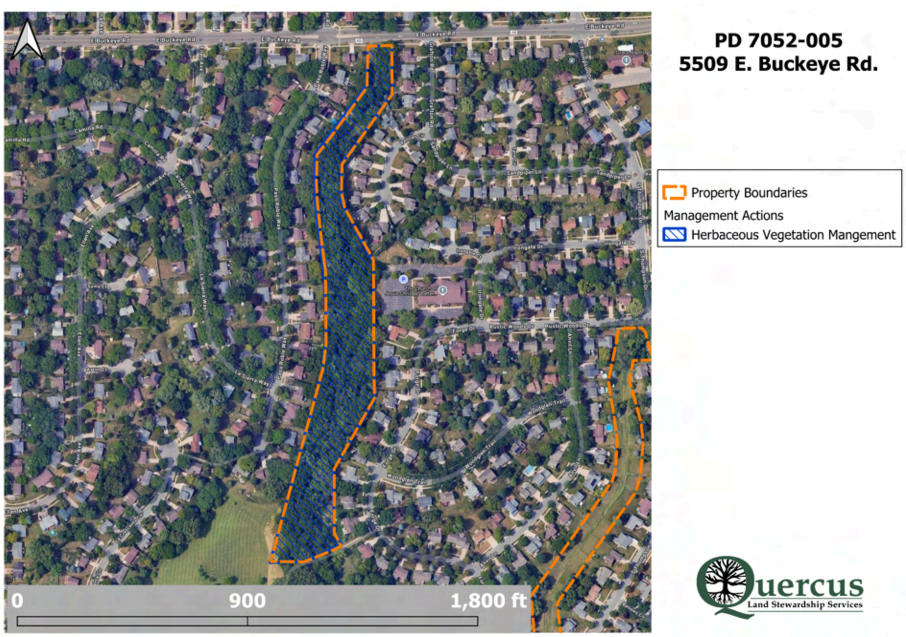

PD 7052 -003 Prescribed Burn Management Area . Depicted above is the boundary of the proposed prescribed burn management area..Due to QGIS constraints the creek has not been delineated out.

## Figure 14



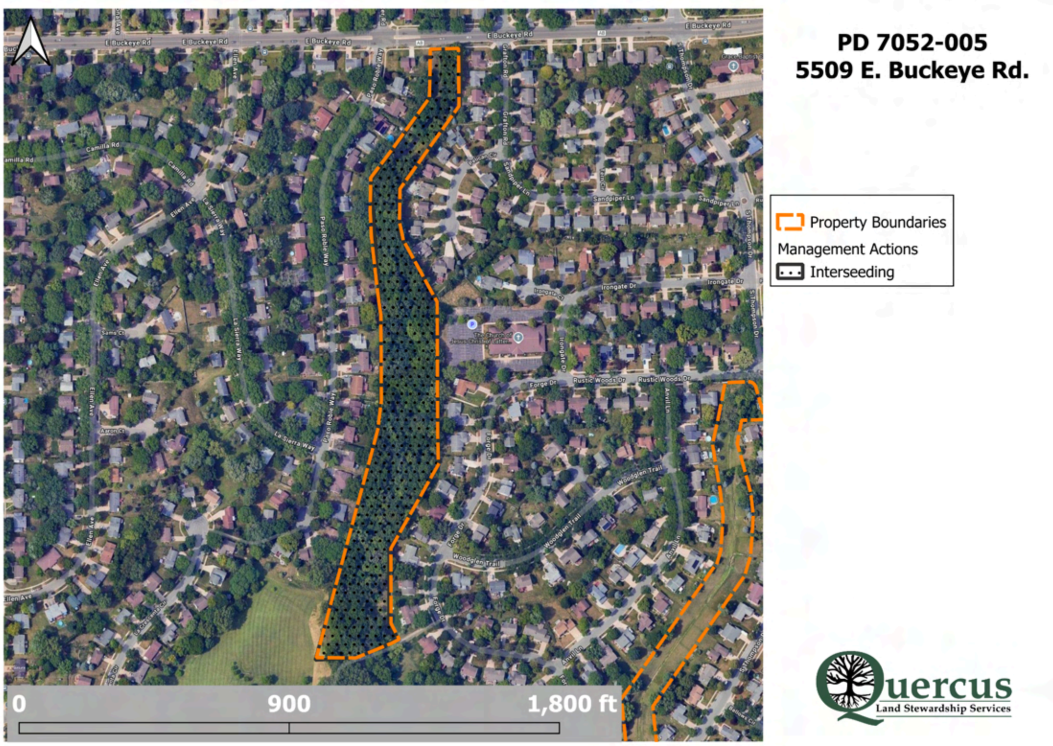

PD 7052-005 Woody Vegetation Management Area.. Depicted above is the boundary of the proposed woody vegetation management area..Due to QGIS constraints the creek has not been delineated out.

## Figure 15




PD 7052-005 Herbaceous Vegetation Management Area.. Depicted above is the boundaries of the proposed herbaceous vegetation management area..Due to QGIS constraints the creek has not been delineated out.

Figure 16




PD 7052-005 Interseeding Areas. Depicted above is the boundary of the proposed interseeding area.Due to QGIS constraints the creek has not been delineated out.

Figure 17


Example Restoration In Progress sign.

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Inter-Fuve River and Restoration Resources

**Inter-Fluve, Inc.**
**Draft Memorandum**

| | |
|---:|---|
| TO: | Sarah Lerner, City of Madison |
| FROM: | Marty Melchior |
| DATE: | October 14th, 2024 |
| REGARDING: | Vegetation Management Review - North Pennito Creek Greenway GR 7052-005 |

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**Introduction**

As part of development of the stormwater utility vegetation management plan, the City of Madison retained Inter-Fluve to review vegetation management for stormwater properties, specifically North Pennito Creek, also known as the Mira Loma Greenway, on the east side of Madison. The goal of this effort is to review public concerns identified in past public engagement, and identify how these concerns can be addressed as part of the citywide stormwater vegetation management plan. This memo summarizes our evaluation of public concerns related to vegetation management, makes recommendations for future vegetation management in Madison greenways, and also develops a prioritized list of recommendations for one specific site, the North Pennito Creek Greenway.

Watersheds have a wide variety of characteristics including land use, impervious surface cover, natural spaces (wetlands, forest, prairie), topography, soils, slope, drainage and vegetation. This assessment highlights the importance of developing watershed restoration and management solutions on a case-by-case basis. Management approaches that are appropriate for one watershed may not be appropriate for an adjacent watershed.

Management approaches must also be prescriptive to the relationship between watershed scale and drainage characteristics of the individual watershed. North Pennito Creek has a small watershed with a relatively large greenway, taking up a significant percentage of its 13-acre drainage. Other watersheds may be larger, yet have less erosive energy because of a higher percentage of natural areas, or perhaps a lower overall channel slope. Conversely, smaller watersheds could have more erosive power due to a higher percentage of impervious cover (e.g. urban or commercial development) and steeper drainage slopes. Watershed management needs to account for the many factors that contribute to runoff, and balance those inputs with best management practices such as infiltration, storage and conveyance of flows. Greenways provide important ecological and aesthetic oasis in urban areas, providing not only critical corridors for wildlife, but also drainage of potentially damaging floodwaters.

*Flooding and Vegetation* – Flooding can be accurately modeled via hydrologic and hydraulic computer modeling, which are beyond the scope of *this* study, but within the purview of the ongoing Pennito Creek Watershed Study (City of Madison) and the WDNR Flood Hazard Mapping study (pending 2025 completion). North Pennito Creek is a very small headwater watershed. The upper ditch appears to be sized to contain the regulatory flood event (100 yr flood), and the lower 1,000 feet of channel is sized to accommodate between the 5- and 10-year event, with the larger valley cross section able to convey larger storm flows. Although modeling was not completed as part of this effort, geomorphic evidence does not suggest any significant impact of riparian vegetation on recent flooding. However, stable forested vegetation is important in preventing widescale valley erosion during a large event. The channel slope, and thus overall valley slope in the lower channel is greater than 1.5%. During a large flood, if the riparian zone and valley walls were not fully forested, the erosive power of the flood could result in major erosion and soil loss. Any restoration plans for the channel bed should minimize disturbance of the riparian forest to the extent practical.

There are a variety of forest ecosystems that can be targeted for restoration, and each has its own floodplain roughness characteristics based on stem density, canopy coverage, forest leaf litter, sunlight, soils and debris on the forest floor. There is no ideal forest type or canopy coverage, as there is a spectrum that varies with management, rates of decay, and tree age. Older forests tend to have more abundant woody debris, but less understory shrub and sapling growth. Younger forests tend to have less debris but a higher stem density of shrubs and saplings.

*Erosion* – Bank erosion in non-armored sections of the upper greenway is very limited. The upper segment of grassed waterway does have a few bed locations that have scoured (Figure 1).

Downstream of Buckeye Road, a few select areas of bluff erosion or localized scour around debris jams are present, but do not represent a risk to infrastructure or a significant source of sediment to downstream reaches (Figure 2). Eroding channel material is depositing just downstream and is essentially locked up within the most immediate downstream cross-sections.

*Improving habitat for wildlife* – Wildlife habitat in the lower North Pennito channel can be improved by removal and long-term management of invasive plants. Removing aggressive invasive shrubs like Japanese knotweed, bush honeysuckle and buckthorn can keep lower canopies more open and usable, and helps native shrubs to compete. Treating aggressive

Figure 2. The grassed waterway looking upstream of Buckeye Road. This segment of channel is relatively stable, but this photo shows channel incision beginning at the downstream end of the reach (photo Inter-Fluve).

Figure 3. Bank and bluff erosion observed in the armored lower segment of Pennito Creek. Note large bar of mobile bedload and exposed underlying geotextile fabric (photo Inter-Fluve).

understory forbs and grasses like reed canarygrass, giant reed grass (*Phragmites* spp) and garlic mustard helps to maintain forest plant diversity, and thus insect and wildlife diversity.

*Biodiversity* – The effects of climate change also impact biodiversity. Invasive and destructive insects that could not survive Wisconsin winters are spreading north with increasing winter temperatures. Insects such as the emerald ash borer, Japanese beetle and wooly adelgid can have a devastating impact on the plants they target. Monoculture plantings are particularly susceptible to wholesale damage from invasive insects, fungus and blight. Maintaining a diverse assemblage of plants in Madison's corridors is one way of minimizing the spread of these insects.

Many urban centers in North America have faced challenges in managing or eradicating invasive plants. Many invasive plants are extremely aggressive and produce either prodigious seeds, rhizomes or both that allow them to reproduce and spread quickly. They almost always grow extremely fast, outpacing any native vegetation. In just the past 30 years, urban areas including Madison have seen the number of invasive plants go from just one or two to dozens. These invasions limit biodiversity, further increasing the susceptibility of the plant community to disease and damage from pests. North Pennito Creek has a fairly diverse assemblage of canopy trees and understory shrubs, as well as native forbs. Monitoring and maintenance strategies should focus on controlling invasive shrubs, forbs and grasses.

*Preserving the tree canopy* – Trees and shrubs provide multiple benefits to urban corridors. Tree canopies provide valuable habitat and cover for migratory birds, mammals and a diverse assemblage of insects. Trees and shrubs also have deep root systems that help to hold soil in place. Trees and shrubs also provide hydraulic roughness, which is defined as variable surfaces, debris and blockages that interrupt the flow of water. Tree roots, trunks and fallen limbs, combined with the stems of shrubs and other plants, help to prevent riling and gullying on valley slopes, and they provide important protection against erosion of floodplains and banks. If riparian canopies are removed, they reduce hydraulic roughness on banks and floodplains, and that can result in increased water velocity and erosive power, particularly in steeper terrain like North Pennito Creek. Roughness elements interrupt flows, pooling water and causing a general decrease in velocity and thus erosive power. This effect is not noticeable most of the time, and may only play a role very infrequently, such as during large storms.

Future management of riparian corridors needs to consider the idea of novel ecosystem management, which states essentially that even though a current or proposed ecosystem may not have been the historic condition, that modern ecosystem can be tailored to succeed and thrive under a variety of anthropogenic influences such as development, modern stormwater and climate change. To understand what is appropriate, however, it is important to understand both the past history and future trajectory. From the last glaciation up to the period of European settlement, southern Wisconsin vegetation communities consisted of tallgrass prairie and bur oak savanna on ridgetops and drier plateaus, cottonwood gallery forests along rivers, maple-basswood and oak forest on wetter or north facing slopes, and wet prairies and marshes along rivers and floodplains. Some watersheds, were more forested than others, and there was generally more prairie and savannah south of what is now I-90. At the time of the first government land surveys in the 1830s, some southern Wisconsin watersheds were approximately 70% forested and 30% prairie, with shrub thicket and forests in narrow divides and higher relief areas (Trewartha 1940; Knox 1977; Leitner et al. 1991). Prairie was restricted primarily to the broader ridge tops or plateaus, which were unfavorable sites for trees due to thin soils and shallow bedrock, rapid drainage, and desiccating winds; all conditions conducive to wildfires. Natural fires likely created a patchwork of various vegetation successional states (Trewartha 1940; Knox 1977; Leitner et al. 1991). In the absence of fire or disturbances such as grazing, succession of riparian vegetation generally follows a grass/forbs to primary colonizing willows and alders to primary growth trees (box elder, etc). Second and old growth trees follow suit, with flood tolerant trees persisting along river corridors, such as silver maple, cottonwood, black willow, swamp white oak, bur oak and others.

Subsequent farming after 1850 included widespread conversion of forest cover to pasture, and conversion of plateau prairies to row crop corn, which in Madison was followed by development (Knox 1977). Research has shown that undisturbed prairie and forest cover yields very little overland flow (runoff) during precipitation events, particularly under drier conditions when soil infiltration capacity is high. Conversely, row crop agriculture, pasture and urban development has been shown to increase runoff, thereby increasing peak flows as much as five times over pre-settlement vegetation conditions (Bates and Zeasman 1930; Sartz 1970; Sartz 1976; Lyons et al. 2000).

In the case of North Pennito Creek, prior to settlement, the stream channel was either simply a swale or a much smaller channel. Although there may have been prairie or oak savannah coverage in the plateau areas, the drainage corridor itself could have been forested. Future management of the corridor could include any number of options, but a forested riparian zone is recommended to preserve roughness on the floodplain and valley walls so that rilling, gullying and erosion are thus minimized. Any other management strategy would increase the risk of erosion and damage to property.

**Existing Conditions Summary**

The segment of North Pennito Creek evaluated for this study originates in Droster Park and runs south along Droster Place and crossing Buckeye Road. The channelized drainage continues south, eventually disappearing underground in Orlando Bell Park, emerging from under South Thompson Drive into a pond north of the railroad and south of South Thompson Drive. The City of Madison is currently developing a watershed study for Pennito Creek, and the Wisconsin DNR is completing a Flood Hazard Mapping study of the watershed. These computer modeling studies will help to identify the causes of existing flooding and examine potential flood reduction. Both are scheduled for completion in 2025.

North Pennito Creek drains a watershed area of approximately 13 acres. The upstream 2,000 feet of channel drops roughly 9 feet for an overall slope of 0.50%. Downstream of Buckeye Road, the creek steepens through a shallow ravine to 2.0%, dropping over 20 feet over the next 1,000 feet before flattening out again in Orlando Bell Park. In-channel hydraulic roughness is low and dominated by the material size of the channel bed, as there is only sparse woody or other vegetation growing within the stream channel, with occasional woody stems growing below the top of bank.

The narrow floodplain and terrace elevations have high hydraulic roughness from primary forest canopy growth of boxelder, mulberry and black walnut among others, with infrequent second growth trees greater than 12” dbh, including red oak, silver maple, elm, cottonwood and hackberry. Understory shrubs are common, including elderberry, serviceberry, and buckthorn. The forest floor is a mix of native and non-native grasses and forbs.

**Pennito Creek Recommendations**

*Bank stabilization and vegetation* – Bank erosion is influenced by bank height, soil pore water pressure, hydraulics and other factors. Bank erosion is a normal geomorphic process that helps to build floodplains and create habitat, but at above normal rates often seen in urban areas, can lead to imbalances in sediment load, loss of property and damage to infrastructure. Conversely, bank stabilization is the arresting or slowing of bank erosion. Because of the close proximity to infrastructure (houses) along North Pennito Creek, in this report, we refer to channel stability as an immobile boundary, or fixed boundary channel. Bank stability can be imparted in many ways, including by hard armoring with stone, concrete or sheet pile, or by a combination of immobile toe material and robust bioengineering of the upper banks. Bioengineering stability can be imparted by stabilizing vegetation, cohesion of bank sediments and the soil moisture effects of vegetation such as interception, transpiration, evaporation, and storage. It is extremely important to consider that all vegetation has an upper limit with regard to the amount of stabilization that can be imparted. Beyond those thresholds, additional countermeasures such as stone toes or large wood need to be employed to prevent erosion. The majority of stabilizing roots in grass plants, both native and non-native, are within the first foot of soil, and root density decreases with depth below the soil surface. Thus, in small streams with bank heights less than 1-2 feet, grasses can contribute to bank stability. Native grasses and forbs have limited effectiveness in stabilizing banks higher than 1-2 feet, and turf grass has almost no soil retention properties beyond 3-4 inches.

Riparian shrubs such as shrub willows, dogwood species, and alder have extensive root systems that can stabilize banks up to 3 feet in height, generally. Tree roots can extend several feet below the surface, but most riparian and flood tolerant trees such as silver maple, red maple, and various willow species have their densest roots within three feet of the ground surface. Riparian trees will also grow roots parallel to shorelines, thus imparting additional structural stability. When bank heights exceed 3 feet and beyond the depth of tree roots, undercutting can occur. Some trees are better than others at stabilizing soils. In banks under 3-4 feet in height, the bank stability provided by tree willows can withstand extremely high shear stresses, can provide essentially erosion-proof banks, and in in small streams can limit channel incision. Longer lived species such as silver maple and cottonwood can also provide this type of stabilization, but over a longer growing period.

It is important to recognize that different types of grasses provide higher root densities and depths than others, as do some tree species. Similarly, primary colonizing trees such as boxelder or black walnut do not provide dense root systems comparable to willow or cottonwood species. The role of canopy shading should also be quantified when considering the stabilizing effects of vegetation. Larger trees have larger root systems, but mature second and old growth forests can have relatively bare understories. Primary growth or early second growth forests can still maintain dense riparian shrub systems, depending on the width of the stream and the amount of sunlight reaching the banks.

In North Pennito Creek, the 1994 stabilization project has limited tree growth below bankfull, but vegetative stability was not part of the riprap design. Trees and shrubs have since grown at the top of bank, and some have grown out of the riprap lower down the bank slope. In this case, roots are in select locations providing stability to the riprap that would otherwise have mobilized, but vegetation does not contribute significantly to overall channel stability below the top of bank due to the geotextile and riprap placement limiting growth.

*Drought and flooding issues* – There is very little wetland vegetation along the North Pennito channel, and the native species found are fairly typical upland or floodplain tree species. Red oak is typically an upland species, but it is found growing near the channel in this case, due to the groundwater elevation being below the channel bed for much of the stream length. The banks could support a fairly wide range of typical Midwest upland and floodplain forest species.

**Conclusions**

- Localized scour, bluff erosion and loss of stabilizing stone is occurring in several locations, but overall channel stability is good. Erosion should continue to be monitored.
- The upper banks, floodplain surface and valley walls are stable, with a few exceptions.
- The upper watershed is either urban or a managed grass waterway, while the lower watershed downstream of Buckeye Road has a primary growth forest canopy with occasional monument trees.
- Riparian vegetation in the upper watershed, if maintained as turfgrass, should be evaluated for roughness and soil stabilization, and modified as needed to minimize erosion.
- Riparian vegetation in the lower watershed should continue to be managed as forest, with control of invasive trees, shrubs and forbs to the extent practical. Any channel restoration

planned should incorporate the use of native trees, shrubs and grasses. Wood debris on the forest floor should be left in place.

- Because each greenway has different topography, soils, slope, runoff and vegetation characteristics, management of each greenway in Madison needs to happen individually. North Pennito Creek has unique characteristics that may not have any similarities to other greeenways, and so the solutions for improvement here will likely not apply to any other site.

**<u>Citations</u>**


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