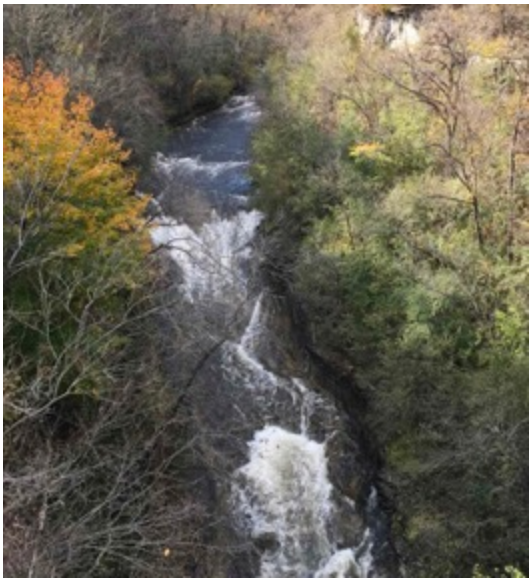
Natural Resource Management Plan
Vermillion Falls Park
Hastings, MN



Vermillion Falls

December 2019

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Acknowledgements

Friends of the Mississippi River would like to acknowledge the City of Hastings and the Tecla Karpen estate for funding that made this management plan possible.

EXECUTIVE SUMMARY

This document was developed for the City of Hastings as a first step for Friends of the Mississippi River to provide assistance in ecological management of Vermillion Falls Park, a 25-acre city-owned park located southeast of the Vermillion River at Vermillion Street (Highway 61). Although small, the park is ecologically important as part of a linear habitat complex along the Vermillion River. The park also provides important wildlife habitat and water quality benefits, and is a popular community amenity. The most notable feature at Vermillion Falls Park is the falls itself, which can be quite a roaring cascade, especially after significant rain events or spring melt. The falls can be most easily viewed from the overlook pavilion at the top of the falls. Excellent views of the rapids below the falls and the entire gorge can be seen further east, from the bridge over the river.

Historically, the property was likely dominated by oak savanna in the level upland areas and lesser amounts of mesic oak forest and maple-basswood forest in the ravines. Prior to becoming a city park, the property was apparently mostly in passive uses, especially associated with the railroad and visitors to the falls; there was no indication of past agricultural practices. A couple of the ravines at the park, however, were used for disposal of construction-type debris at some point in the past.

In the absence of natural fires that were historically common in the area, both native and non-native trees and shrubs have encroached onto the site, so the vegetative cover has progressed to the current condition of primarily oak forest, with some non-native dominated grassland in the west half of the site. Non-native invasive plant and animal species are well-established, especially earthworms and common buckthorn. The buckthorn ranges in size from very large to very small, indicating it initially established at the park decades ago and has been spreading ever since.

The site has been a City Park since the late 1960's, but there has been little ecological management over the years. The current native plant diversity throughout the park is low, but the canopy tree composition is mostly intact and portions of the park have some interesting ground cover plants, including Canada yew and walking fern, two relatively uncommon species. One state threatened species, kittentail, is also present at the park. Although intensive management and restoration is needed, there is good reason to believe much of the native plant diversity can be recovered.

The overarching objective for Vermillion Falls Park is to protect and improve the wildlife and water quality values of the site and to restore the ecological functions that the historical native plant communities provided, including:

- habitat for a diversity of wildlife species
- nutrient and water cycling
- carbon storage
- moderation of water-table levels
- erosion control
- filtration of nutrients, sediments and pollutants
- development and enrichment of soils

- local temperature moderation

The best way to accomplish those objectives is by restoring and enhancing native plant communities at the site. A robust and diverse native plant community offers the best protection against invasive species, climate change effects and loss of animal species diversity. This document describes the recommendations, methods and approximate costs for enhancing the ecological health of this park and restoring natural communities.

There were seven different types of vegetation cover at the site, among 15 different units. In order of quality, with the highest quality units having the most intact structure and species composition, the vegetation types were: mesic maple-basswood forest, mesic oak forest, dry oak forest, oak woodland-brushland, altered/non-native dominated deciduous forest, altered/non-native dominated deciduous woodland, and non-native dominated grassland with sparse trees.

The target plant communities at this site are southern dry mesic oak woodland (8.3 ac) in the more level upland areas in the eastern half of the site, southern dry savanna (4.2 ac) in the western half of the site, southern dry-mesic oak forest (3.3 ac) along the south bank of the river, and southern mesic maple-basswood forest (1.7 ac) in the dry gorge near the south side of the park.

The primary proposed restoration involves removing invasive, non-native shrubs and trees throughout the site, followed by enhancing the woodland and forests and restoring the grassland to savanna. If nothing else is done, removing non-native invasive woody plants would be the most important task and is by far the largest expense for management of this property. The estimated cost for the initial removal and follow-up control for two years for the entire site is about $90,000.

Additional restoration activities would involve re-seeding wooded areas and a complete eradication and replacement of ground cover vegetation (grasses and forbs) in the grassland units. These costs would be an additional approximately $28,000.

If initiated and completed in sequential order, it would take at least six to eight years to have the invasive woody plants mostly eradicated and savanna species restored to the grassland. Full control of the buckthorn to a point where it requires only modest annual maintenance could take 10 years or more. However, each year the investment will be less. Neither the buckthorn, nor most of the other invasives, will ever be fully eradicated because they are abundant in the landscape around the park. Volunteer events, such as brush hauls, can help offset the costs and serve as excellent opportunities to connect the community to the site.

Friends of the Mississippi River is committed to collaborating on the long-term management and restoration of this site. FMR has obtained grant funding for initial restoration and enhancement steps that will be adequate for the first two years of work. FMR is also able to help with the longer-term coordination and management of restoration activities.

INTRODUCTION

This Natural Resource Management Plan (NRMP) presents the site analysis and recommended ecological management and restoration for Vermillion Falls Park, owned by the City of Hastings, Minnesota.

Prior to European colonization, the vegetation at the project area consisted primarily of oak savanna – loosely described as prairie plants with scattered clusters of bur oak trees and brushland. As settlement occurred, both prairie and savanna communities were converted to agricultural and other uses, leaving less than 1% of each of these plant communities on the landscape, where they previously occupied over one-third of the state. What little was left has largely been degraded by lack of fire and invasion of non-native species, leading to a dominance of those species, decline of native species, and succession of savanna and grassland to forest. Vermillion Falls Park has been similarly altered, and is currently dominated by oak forest, with non-native grassland and small areas of maple-basswood forest and mesic oak forest.

This plan was developed to:

- Identify the existing condition of natural communities on the property
- Identify target natural communities and restoration goals
- Identify methods for improving the wildlife habitat and ecological functions of the property

The overarching objective of ecological restoration and management is to restore the ecological functions of a site, such as nutrient cycling, disturbance regime, carbon storage, and wildlife habitat. This is accomplished by increasing the biological diversity, which brings stability to the community, and by restoring processes such as fire, which restores nutrient cycling as well as a disturbance regime. Other objectives are to:

- Provide connectivity with other natural areas in the landscape
- Maintain and manage the property for water quality by avoiding or controlling any erosion that may develop
- Create a model of responsible land stewardship for park visitors
- Provide close-to-home opportunities for people to enjoy and interact with nature

A healthy functioning ecosystem inherently also provides important ecological services – those functions identified as beneficial for humans, including filtering pollutants from soil and water, absorbing air pollutants and carbon dioxide, and providing habitat for pollinators.

In general, the target condition often seeks to reflect the plant communities that were present at the time of European colonization (approximately 1850), as that would often provide the optimal biological diversity for a site and best support the native plants and animals of the region. Historical conditions, however, are not always appropriate when succession has moved a community too far in one direction, or where there are other desired uses for a site, such as recreation. The existing conditions at the eastern half of Vermillion Falls Park are mostly too far advanced past savanna to a forested community, and would be most suitably maintained as oak woodland.

Figure 1. Site Location

Disclaimer: Map and parcel data are believed to be accurate, but accuracy is not guaranteed. This is not a legal document and should not be substituted for a title search,appraisal, survey, or for zoning verification.

SITE INFORMATION

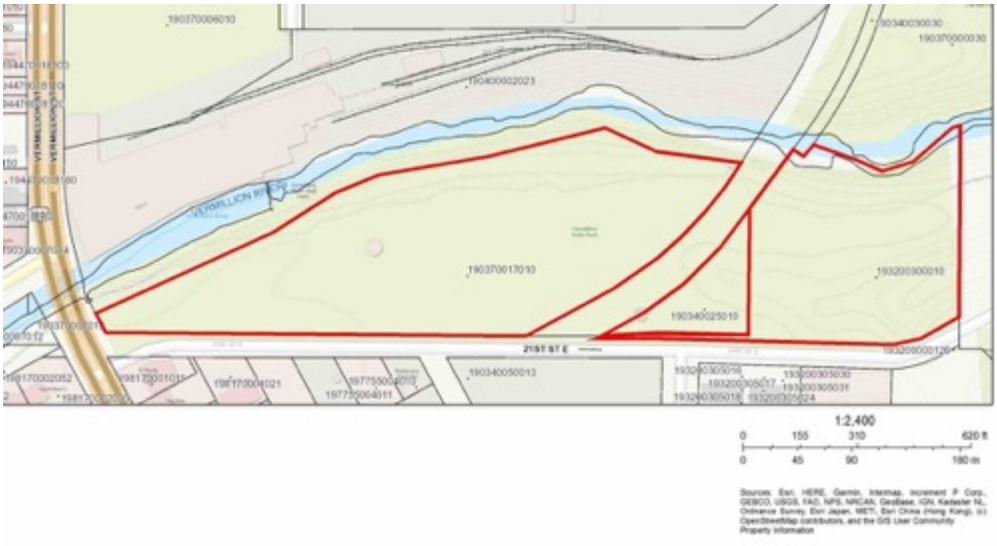
A. Location and governance

Address: Vermillion Falls Park is located on the east side of State Highway 61/Vermillion Street in Hastings, MN (**Figure 1**). The address is 215 21st St E, Hastings, MN 55033.

Parcel Information: The three parcels owned by the city total 20.87 acres (**Figure 2**).

Parcel Identification Numbers:
190370017010 13.02 ac
190340025010 1.22 ac
193200300010 6.63 ac

Figure 2. Parcel information



Project Area:
The actual on-the-ground park boundaries differ somewhat from the parcel boundaries. The total park size is about 25.1 acres (**Figure 3**). This management plan excludes the western mowed parkland, and includes the former railroad corridor, for a total of about 18.6 acres.

Note that the easternmost park parcel is posted as "State Property – Keep off" (photo right).

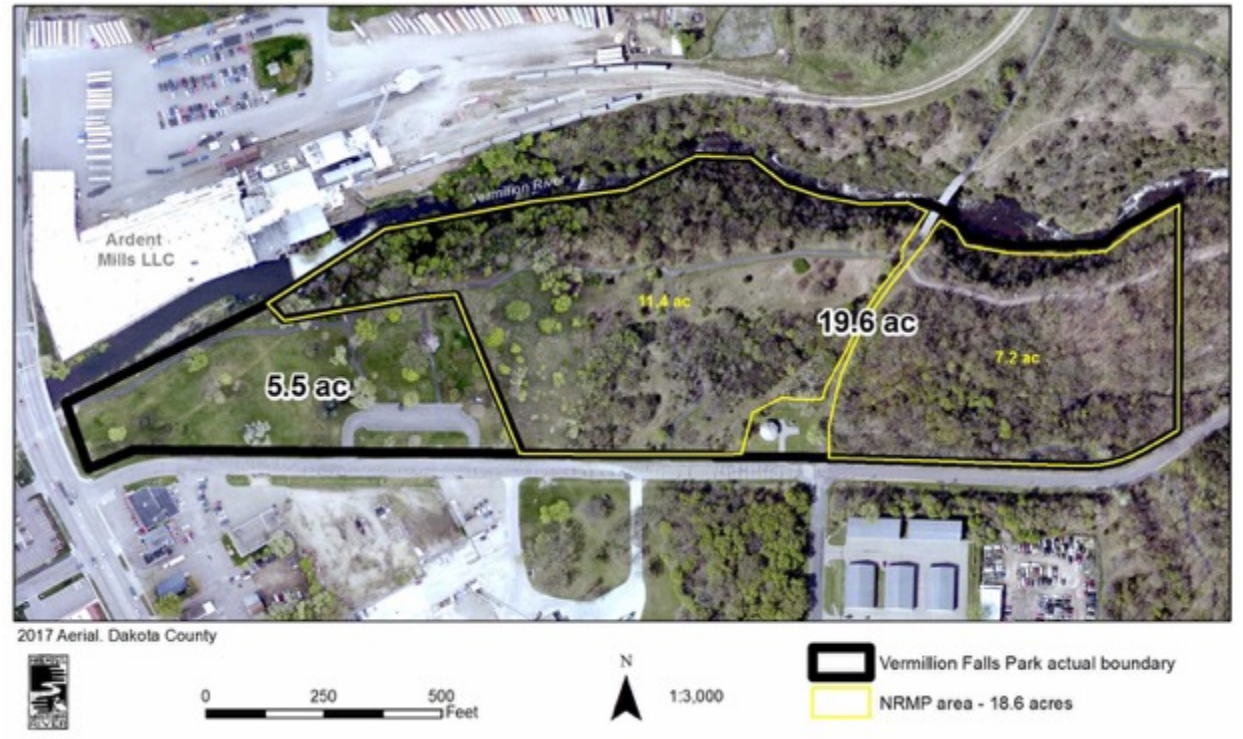
The park is approximately 1,762 feet wide at the widest east-west point, and a maximum of 634 feet from north to south. It has nearly 1,900 feet of river frontage.

Legal Description: Township 115, Range 27 (Dir 2), Section 34

Watershed: Vermillion River

Watershed Organization: Vermillion River Watershed Joint Powers Organization

Figure 3. Actual on-the-ground boundary of the park and the area of this NRMP.



Primary Site Administrator:
Chris Jenkins, Parks and Recreation Director
920 West 10th Street
Hastings, MN 55033
651-480-6176

B. Landscape Context

1. Proximity to established greenways

Vermillion Falls Park lies within the Metro Conservation Corridors, a regional land protection plan of the Department of Natural Resources (DNR) (**Figure 4**), which identifies lands that create a network of connectivity across the landscape for movement of wildlife and plants. Vermillion Falls Park is just outside the boundary of the Mississippi National River and Recreation Area (**Figure 4**). The park is similarly just outside the boundary of the Vermillion Bottoms-Lower Cannon River Important Bird Area (IBA), which nearly follows the MNRRA boundary. The IBA is a designation of the Audubon Society for sites that provide critical habitat to individuals or groups of vulnerable bird species.

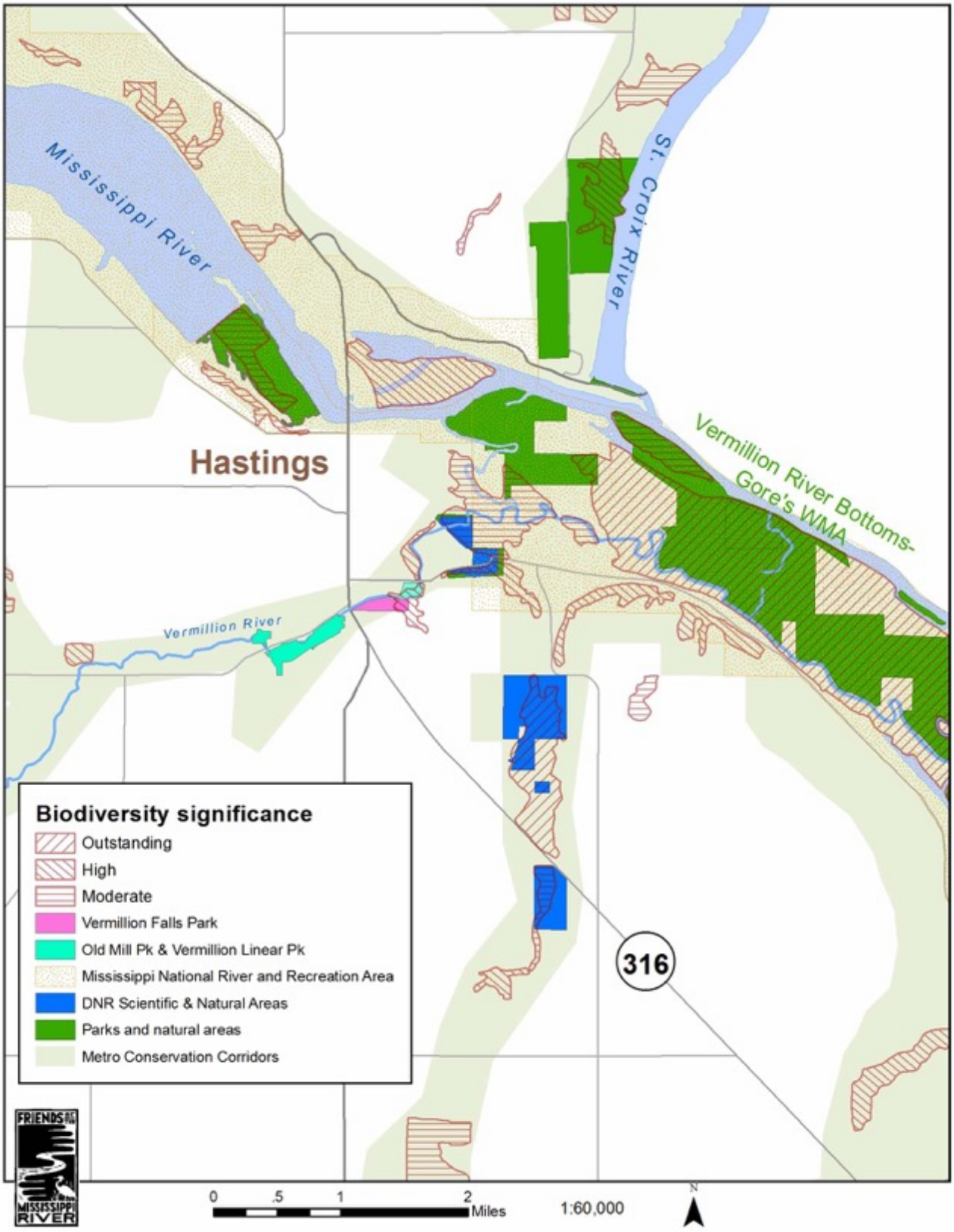
2. Ecological significance

Vermillion Falls Park is a significant ecological feature in the landscape due to its location on the Vermillion river and proximity to the Mississippi River, about 1.5 miles downstream, as well as its proximity to other natural areas. The Mississippi River is a globally significant flyway for migratory birds, with 60% of North American species using the corridor, including 40% of the North America's waterfowl and shorebirds. Although the park is small, it potentially provides some habitat for migratory and non-migratory bird species, many of which are declining throughout their range, in part due to habitat loss.

The park is connected to two other City of Hastings Parks; Vermillion Linear Park just upstream across Highway 61, and Old Mill Park downstream across the Vermillion River. The Minnesota Veterans home is downstream of Old Mill and contains significant natural areas, though not officially protected. Beyond that is the Hastings Scientific and Natural area, which is separated from Gores Pool Wildlife Management Area by about 0.25 miles. Gores WMA and the Vermillion River Bottoms have one of the largest expanses of floodplain forest in southeastern MN and have high to outstanding biodiversity (MN DNR County Biological Survey). Hastings Sand Coulee SNA, another area of outstanding biodiversity of nearly 300 acres, lies about a mile south of Vermillion Falls Park.

Vermillion Falls Park, along with other undeveloped lands near the river, serves an important role as a connector between these larger natural areas. A portion of the park itself (the eastern third) was ranked as high biodiversity. However, that ranking was from the early 1990's. Since then invasive woody plants (primarily buckthorn and honeysuckle) have cause significant degradation of much of the park, as they displace native plants and are generally detrimental to the long-term health of most wildlife species. If restored to native vegetation, however, the site could be very valuable for wildlife, including for pollinators. Urban and residential areas are becoming increasingly important for pollinator species, as suitable habitat has decreased in the larger landscape.

Figure 4. Regional Context



C. Land Use

1. Historical Land Use

Vermillion Falls Park was not evaluated for archeological significance, but the Mdewakanton Dakota Sioux long occupied the land in this region until 1854 and would certainly have traversed the area of the park next to Vermillion Falls. Further back, the Woodland mound-builders (c. 100 BCE to 600 CE) and the people of the Late Mississippian culture around 1000 CE were also known to have lived in the area (Dakota County Historical Society), and burial mounds have been found at nearby sites.

Beginning in the mid-1800's, European colonization dramatically changed the Dakota County landscape. Native prairie that dominated the county was converted to agriculture. Wetlands were drained and much of the Big Woods was also cleared. Fire, which had been a formative feature of the landscape, was suppressed as intense agricultural practices and urban development ensued. In 1990 a biological survey of the County, completed by the Minnesota Department of Natural Resources, showed less than 3% of the native plant communities that had been present in the 1850's remained. Landscape changes continue today in a somewhat different direction, with agricultural lands being converted primarily for residential and commercial uses.

Historical aerial photographs (**Figure 5**) provide some general information about the history of the park since 1937. The park does not appear to have been used for agriculture, although parts of it may have been pastured at one time. It seems more likely that it had some industrial activities associated with the mill and the railroad, and was otherwise mostly used as a park area where people came to see the falls. A dirt road to the falls can be seen even in the 1937 photograph.

The present-day Ardent Mills, located on the north side of the Vermillion River at Hwy 61, was first operating mill in MN, built in 1854 by Harrison Graham (Dakota County Historical Society). Though still operating today, it is no longer powered by the falls. In 1937 (**Figure 5**), the mill was already 83 years old. The railroad that crosses the river was active and in use, built to transport grain probably shortly after the mill was built. The scattered trees seen in the 1937 aerial reflect the historical plant community of the park, which was mostly oak savanna. The deep southeast gorge was forested and likely was forested historically. The adjacent landscape around the park was largely agricultural.

By 1957 there is a prominent road and turn-around loop at the falls, in the location of the present trail and picnic pavilion. The rest of the park does not appear to be specifically used and the railroad appears to no longer be in use. The southeast gorge and surrounding area has become dense forest, and the former savanna north of that is filling in. Adjacent to the park, there is still some farmland to the south, but more businesses and houses are nearby, including the houses at the west end of 18th St.

In spring 1965 the Vermillion River flooded at Hastings when ice piled up at the County Road 47 bridge. This event prompted formation of a natural resource group (predecessor of the Hastings Parks and Recreation Commission), which promoted the "Vermillion River Project" to seek protection of the entire river gorge. In 1968, the city received a federal LAWCON grant

(Land and water conservation) for this project, which included purchase of the parcel on the south side of the river from Edwin Hagen. This became Vermillion Falls Park. The grant funds were also used to enhance the park with tree and shrub plantings, paths, steps, railings and the covered outlook at the gorge overlooking the falls and mill (Jacobsen 1985). Some of these features were not completed until 1978 (Hastings Star 1978).

By 1970 the railroad was gone. East of the railroad bed was almost all forested, while it was still mostly open grassland to the west. Most of the houses on 18th St were present.

By 1991 (not shown) the current parking lot was present and the road to the falls had been converted to a trail and the existing picnic pavilion. Some of the present-day trails west of the railroad bed were present.

In 1995 Vermillion River trail bridge was completed, with new fencing, new lumber planks for the bridge deck, and an asphalt path to connect the bridge to Old Mill and Vermillion Falls Parks (Hastings Star Gazette 1995).

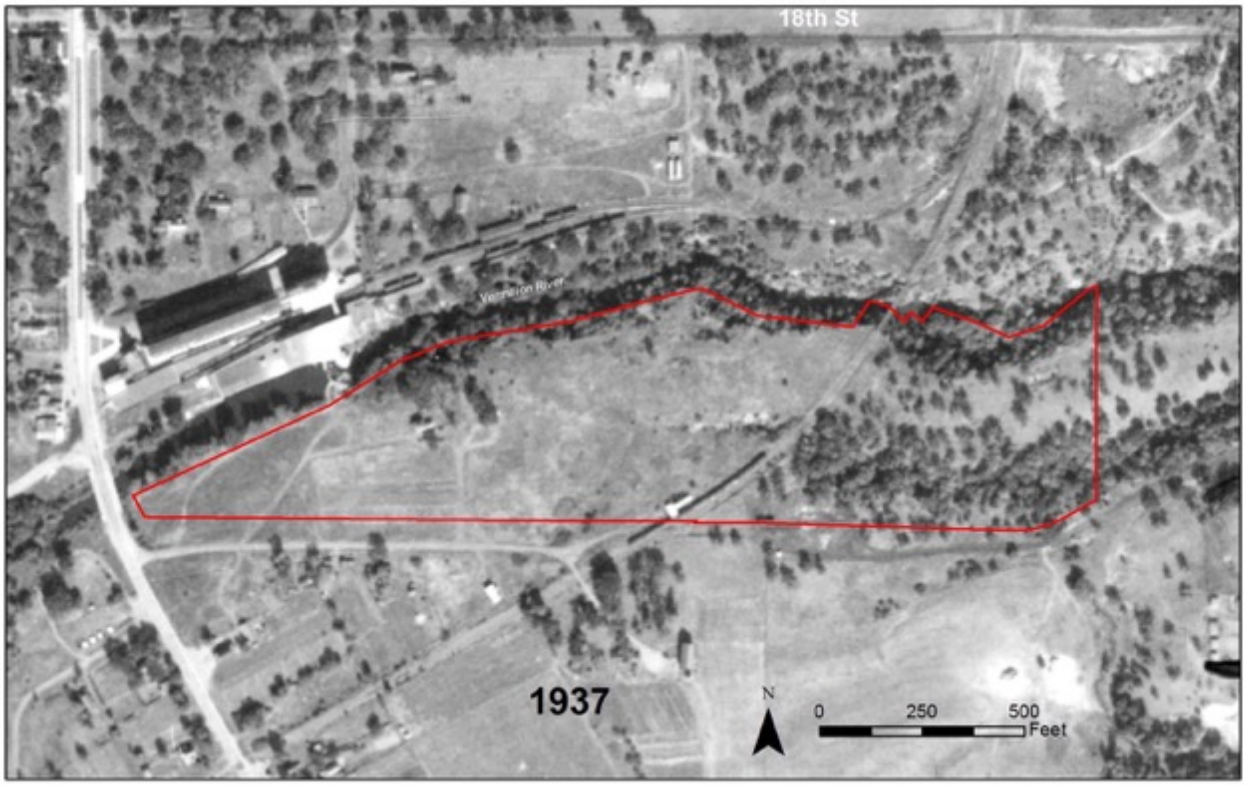
Primary changes by 1997 included construction of the drainage ditch in the western grassland and more woody cover in the western grassland. The trails were similar to what they are today, with the exception of the absence of the Greenway trail.

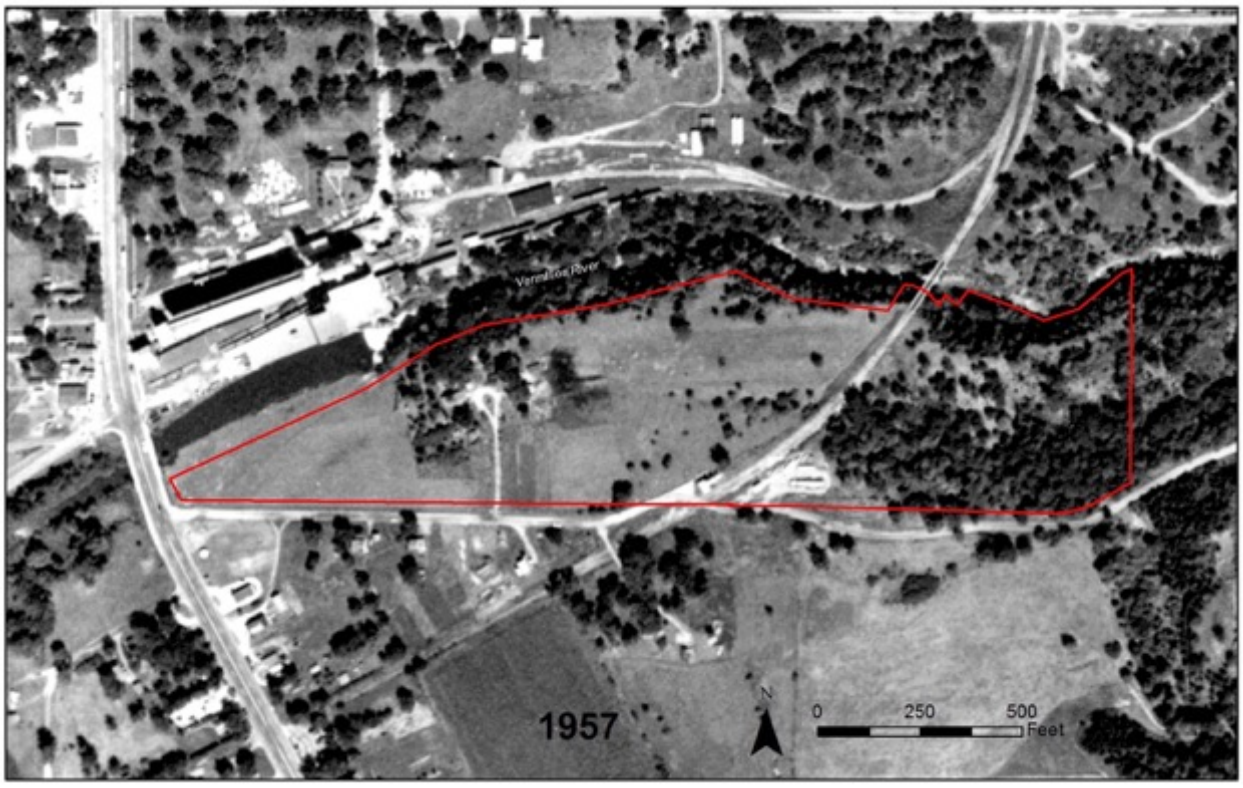
In 2002, federal grant funds were used to construct the trail underpass under the Vermillion Street bridge, thus connecting Vermillion Falls Park with Vermillion Linear Park to the west.

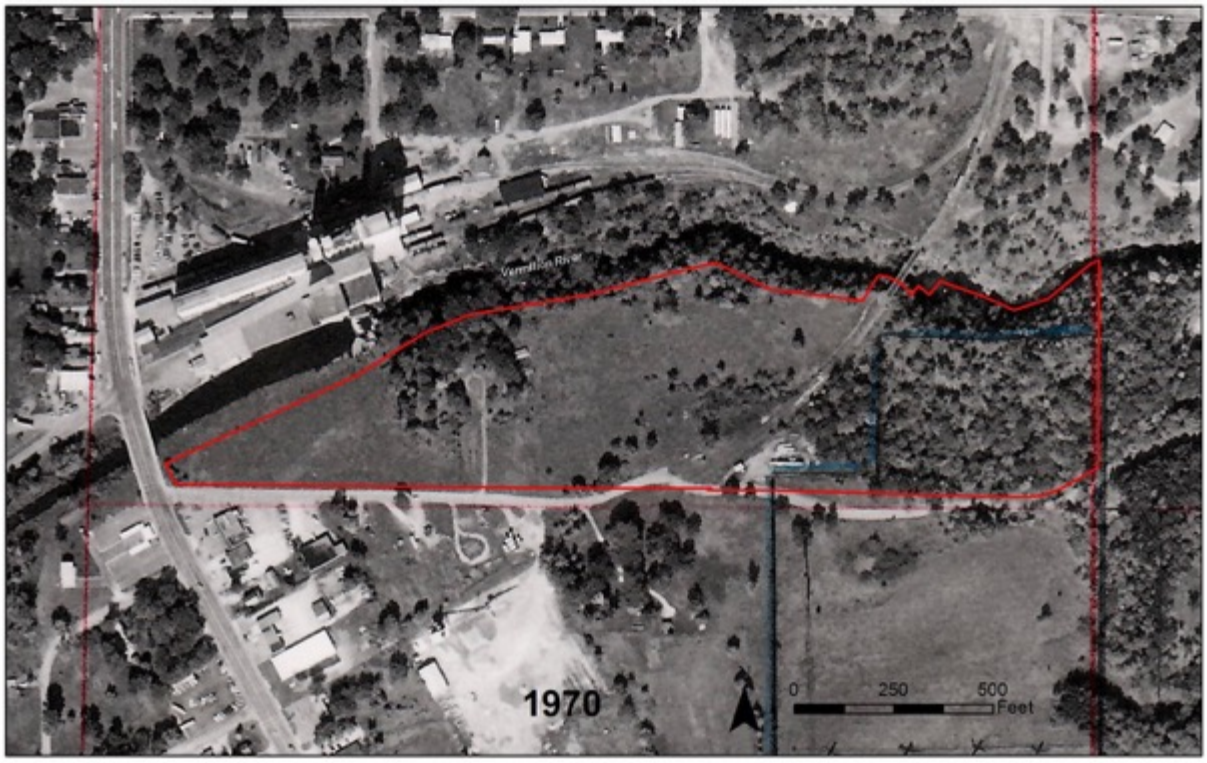
In 2005, the 50-foot high, 110-foot long floodwall was built below the ConAgra mill (now Ardent mill) to protect the bank from further erosion and preserve the mill.

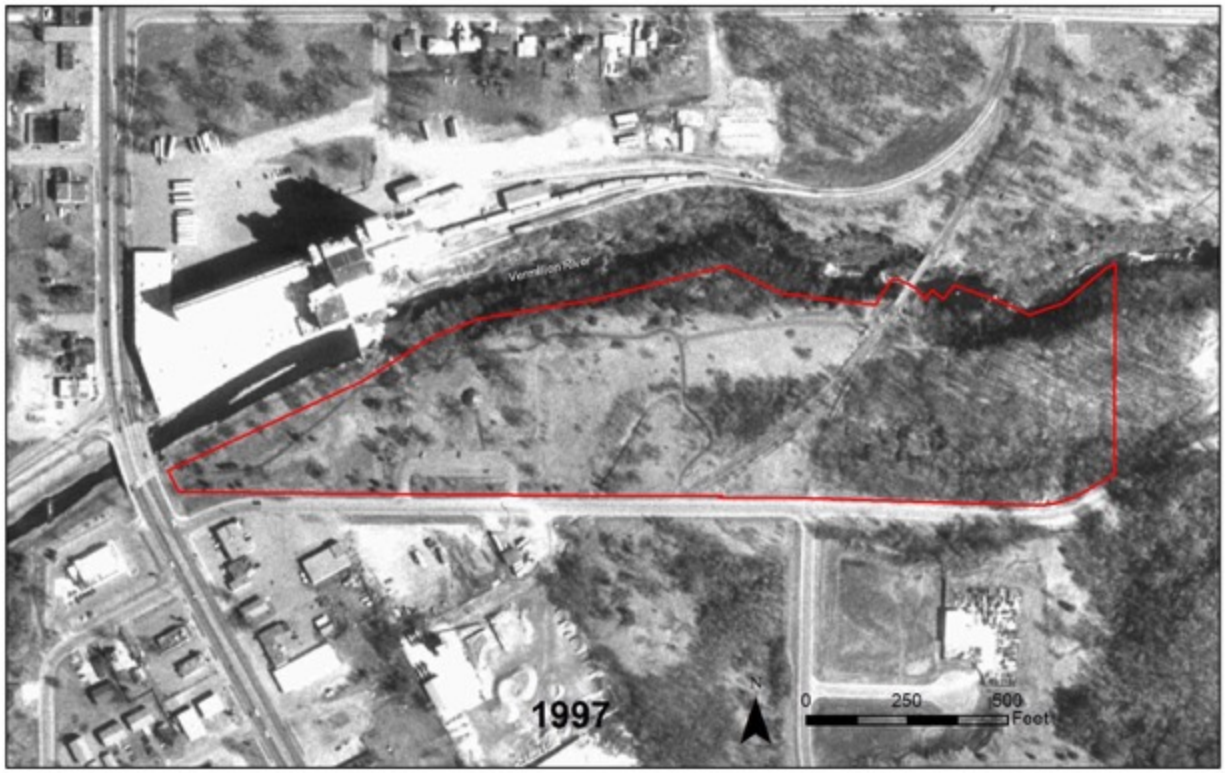
In 2017, the paved Vermillion River Greenway Trail was completed at the park, along the bluff top between the bridge and the Veterans Home property to the east. It is also part of the Hastings 10-mile scenic circuit.

Figure 5. Historical aerial photographs 1937-2000





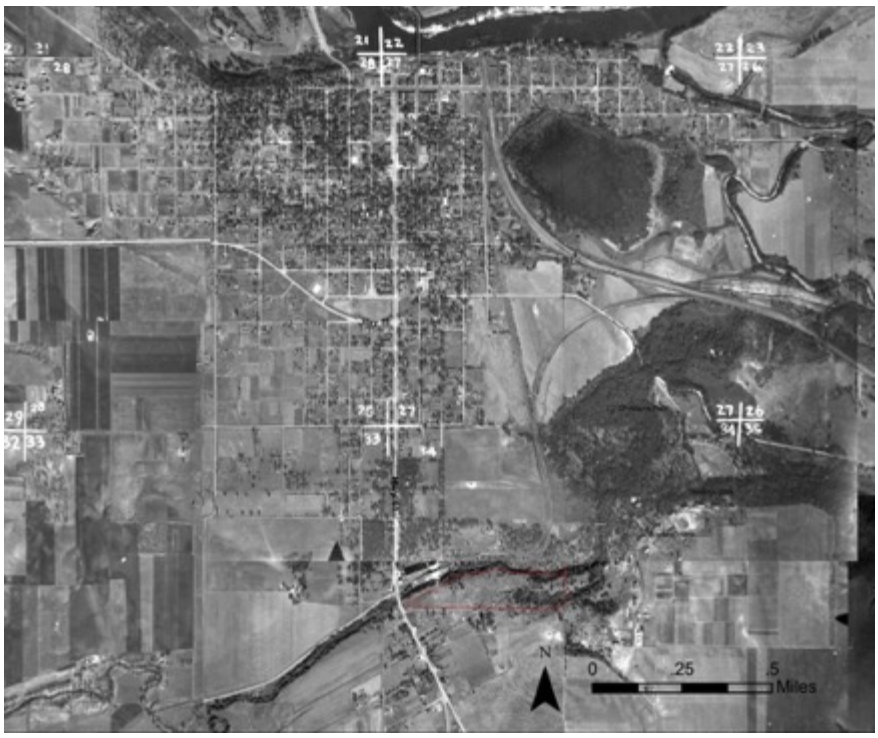




Aerial images source: MnGeoSpatial Commons, Dakota County.

2. Adjacent Land Use

Figure 6. Surrounding Landscape in 1937



The adjacency of a site to parkland, cultivated land, open areas, and residential sub-divisions can affect vegetation and wildlife management options, and may present opportunities to enlarge existing habitat areas, create corridors for wildlife movement, and determine the characteristics of local surface water hydrology.

In 1937, the earliest year that aerial photographs are available, the landscape near the park was almost entirely in agricultural use (**Figure 6**). There was some agricultural land directly south and west of the park, across the highway. While the river and the mill were north of the park, the remaining immediate landscape north and east of the park was mostly natural vegetation, mostly oak savanna.

Today, the park sits in a highly urbanized landscape. Ardent Mill still operates on the north side of the river, and natural land cover still flanks the river to the east all the way to the Mississippi. Most of that land is permanently protected, providing an excellent natural corridor along the Vermillion River. Beyond those parcels, land use to the north, south and west is largely commercial/industrial and residential. One important exception is the former agricultural land west of Highway 61 along the River, which is now Vermillion Linear Park. With restored prairie and woodland, this park further extends and enhances the natural corridor along the river. This corridor is an obvious benefit for wildlife and also very important for water quality protection by reducing erosion and improving bank stabilization.

D. Physical Conditions

The natural resources at Vermillion Falls Park are influenced and in large part determined by numerous physical conditions, especially local bedrock and surficial geology, soils, topography, and local and regional hydrology.

1. Geology

Glaciers were the primary force that shaped the landscape in Dakota County, carving valleys and leaving deposits such as the outwash plain that covers much of the county and resulted in the formation of prairie over much of the land. One of the last glacial period was about 16,000 years ago, when the Des Moines lobe advanced from the northwest through central Minnesota and eventually extended as far south as Des Moines, Iowa (MN Geological Survey 1998). Some of the meltwater drained eastward and carved a river valley to the Mississippi River in what is now the Vermillion River. Today's river is a much smaller relict of the glacial river.

In the area of Vermillion Falls Park, the surficial geology is actually bedrock outcrop (**Figure 7**), as any other deposits were mostly eroded away by the glaciers. The depth to bedrock is generally within five feet of the surface and is clearly seen at the park in many areas.

All the bedrock in Dakota County formed from marine sedimentary rock as a result of ancient oceans that covered the area in the Paleozoic age. Sand and clay and marine animals became compressed and formed a variety of sedimentary rock layers with different depths and characteristics.

The bedrock at Vermillion Falls Park is the Prairie du Chien Group, which consists primarily of dolostone (a sedimentary carbonate rock with a high amount of dolomite) with thin beds of sandstone and chert. Dolomite is similar to limestone, but limestone is a calcium carbonate mineral whereas dolomite is made of calcium magnesium carbonate. The Prairie du Chien group commonly outcrops on blufflands along the Mississippi River and it is quarried at nearby aggregate facilities. This bedrock crops out at the park in many areas, or is covered by thin soils. The bedrock at the park is karsted, wherein softer parts have dissolved and eroded away, leaving a pock-marked stone, sinkholes and fissures.

The falls were caused by erosion of sandstone layer (Jordan sandstone) that lies beneath the dolostone bedrock. As the soft sandstone eroded away, the dolostone above would collapse, resulting in a cataract. In addition to the main falls, a second gorge of similar height formed during glacial times in the southeast part of the park. This gorge no longer carries water except during major rain events.

2. Soils

Soil formation is the result of the interaction of five soil-forming factors: parent material (e.g. bedrock), climate, organisms, topographic position or slope, and time (Foth, 1990). Taken collectively, these factors can help determine the dominant plant and animal communities that helped form the soils. The "Soil Survey of Dakota County Minnesota" (1980), provides a generalized depiction and descriptions of soils in Dakota County. Soil types are important because they affect the vegetative and hydrologic features of the property and suggest the most appropriate vegetation type or use of the land.

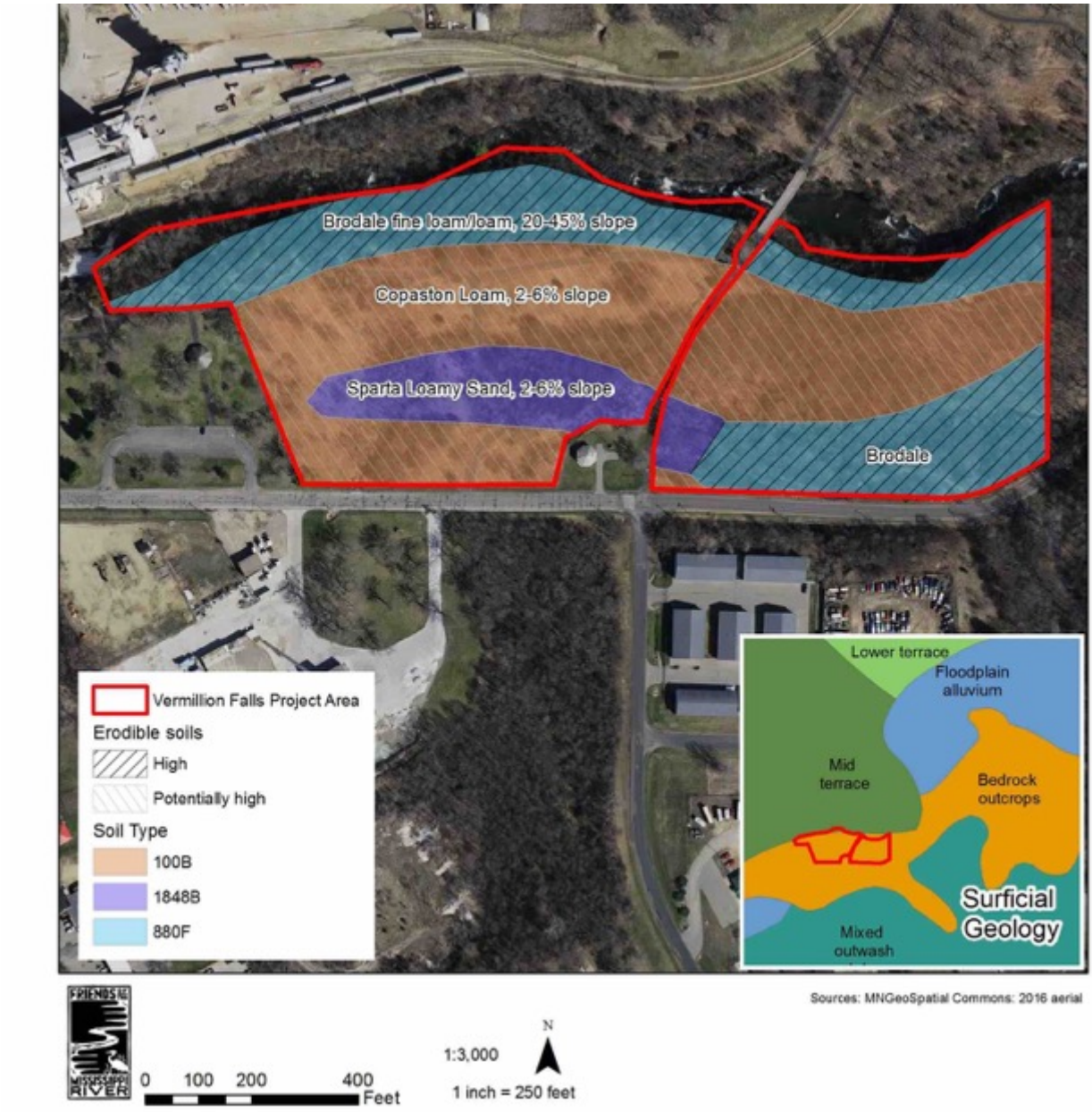
The dominant soil type at Vermillion Falls Park, covering about half of the park, is Copaston Loam (100B) with 2 to 6 percent slopes (**Figure 7**). This well-drained soil occurs on gentle slopes of terraces or benches. The surface layer and subsoil are about 18 inches of dark brown

loam overlying bedrock. Permeability is moderate to moderately rapid, available water capacity is low and runoff is medium. The organic matter content is moderate and the root zone is 12 to 20 inches. In terms of economic uses, the soil is considered poor for most cultivated crops due to droughtiness and erosion potential, and is best suited for pasture or for hay, which also helps to control erosion. It is rated "fair" for wild herbaceous plants, hardwood trees and woodland wildlife. The soil characteristics indicate the historic condition of the park would likely have been prairie or savanna and restoring those communities would certainly be a suitable land use. The high erosion potential should not present any problem for ecological work, but should be monitored during periods when the site may have little or no vegetative cover as part of the restoration process.

About a third of soils at the Park are Brodale-Rock Outcrop Complex (880F), with 18-45% slopes. This soil complex is found on steep to very steep stream valley side slopes. It is formed on loamy colluvium and residuum from limestone bedrock and is excessively drained. Permeability is moderate to moderately rapid, runoff is very rapid and available water capacity is low. The organic matter content is moderate. These areas are typically covered in native hardwoods, as they are at Vermillion Falls, which is the most suitable vegetation for the soil type. Maintaining good canopy and ground cover will help to control erosion.

About two acres of the Park in the western half of the site have Sparta Loamy Sand (1848B), 2-8 percent slope. This soil has rapid permeability in the upper layers but moderately slow in the subsoil. Available water capacity is low and runoff is slow and the organic matter content is moderately low. The soil is prone to drought and wind erosion and is poorly suited to crops. Drought is also an issue for use as hay or woodland, but is it fairly suited to these purposes. It seems clear that this soil type would be well-suited to prairie and savanna and was rated "fair" for wild herbaceous plants and hardwood trees and woodland/openland wildlife.

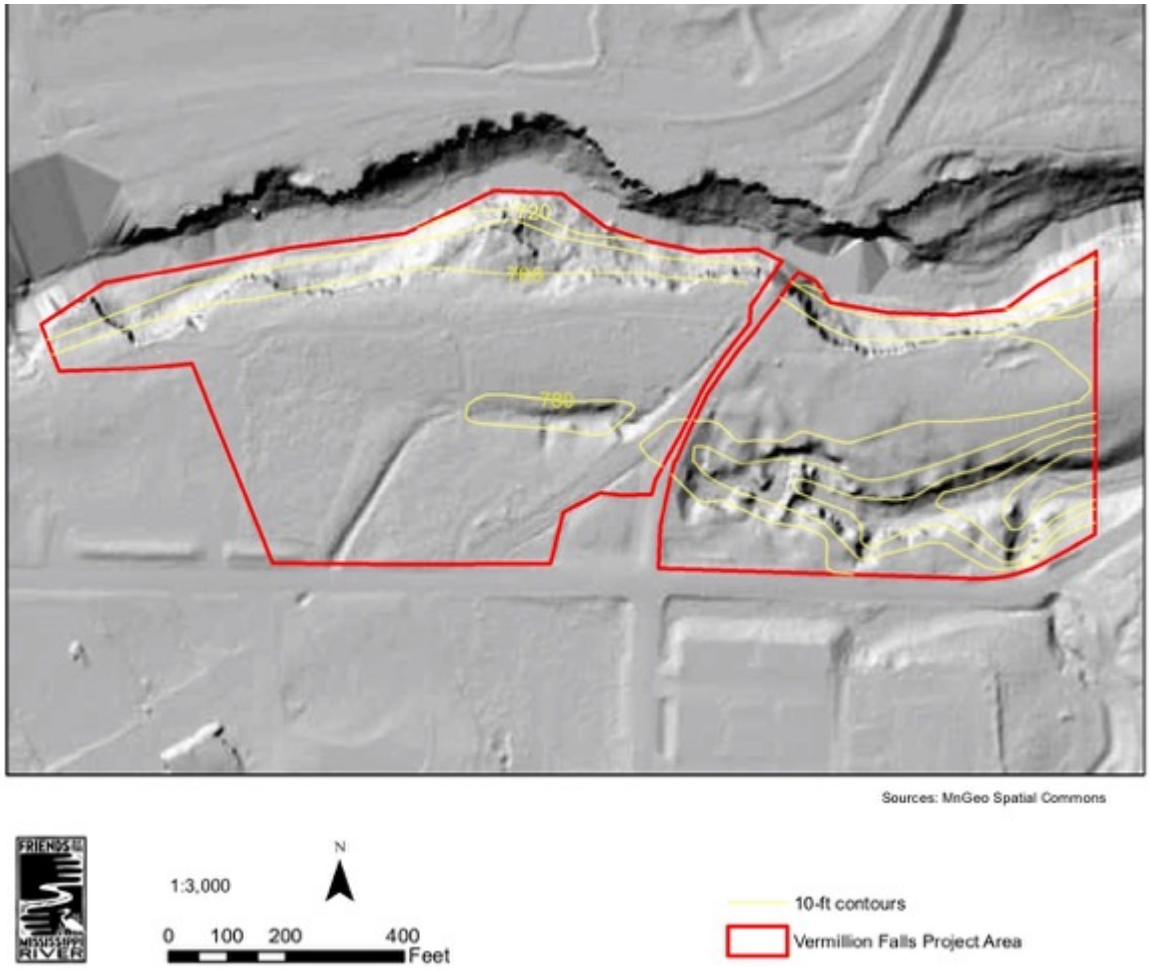
Figure 7. Surficial Geology and Soil Types



3. Topography

Topography and the orientation of slopes (aspect) are important factors in the development and formation of soil, potential for erosion, and the type and stability of vegetation that will grow in a given location. In general, more topographic variation will result in more complexity and diversity of vegetation communities and hydrologic features. For example, south and southwest facing slopes tend to be drier and warmer than north and north-east facing slopes.

Figure 8. Site Topography



Vermillion Falls Park has a somewhat diverse landscape, with steep, north-facing bluffs along the river and a mostly level to gently rolling terrain above the bluffs (**Figure 8**). The level terrain, however, is interrupted in the southeastern part of the park by a deep crevasse. The head of the ravine starts west of the railroad bed and eventually opens at the Vermillion River. The gorge drops about 35 feet from 780 to 745. The walls of the gorge are formed by a labyrinth of limestone towers and ridges (Prairie du Chien Formation). It was formed in basically the same process that created the falls and would have been a smaller falls at one time. The fissures, sinkholes, caves and ridges found in the ravine and along the River are characteristic of karst – limestone that has been eroded by dissolution.

The elevation at the park ranges from about 790 feet in the southwest corner to about 710 in the northeast. Various sources describe the fall at different heights, from about 35 feet to 50 feet. We derived a height of about 48 feet, based on interpretation of contour maps (Dakota County GIS). The top of the falls is at 774 feet, with an initial 48-foot drop followed by several rapids and small drops before leveling out to 690 feet east of the park.

4. Hydrology

There are two key interrelated hydrologic components of the property: surface water and groundwater. Surface water includes all the aboveground water – rivers, streams, wetlands, and lakes. The flowing waterways carry nutrients, sediment and pollutants off the land while the standing waters – wetlands and lakes – help to filter those particles out.

Groundwater

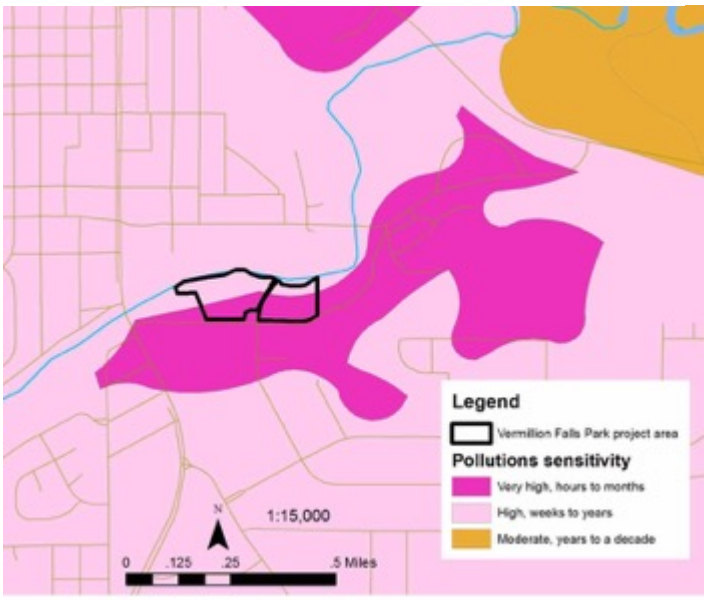
Groundwater accumulates below the surface of the land and is stored in complex, underground geologic layers of sand, gravel and porous rock. Groundwater provides drinking water for most Dakota County, irrigation water for agricultural crops, and process and cooling water used by industrial and manufacturing companies. Most of the County's groundwater is "highly sensitive" to surface contamination. Once an aquifer is polluted, it is very expensive or prohibitive to improve its quality to drinking water standards.

Given the importance and potential vulnerability groundwater, it is important to be aware of the potential for contamination from herbicide and other pesticide use. Factors to consider during natural resource management activities are depth to groundwater and the ability of the overlying material to filter pollutants.

Five relative classes of geologic sensitivity are based on time of travel ranges (Very High to Very Low). The pollution sensitivity is inversely proportional to the time of travel.

Groundwater sensitivity to contamination at Vermillion Falls Park is rated as **high to very high** (**Figure 9**). This means that contaminants will reach the groundwater in hours to months in the very high areas, and weeks to years in the high areas.

Figure 9. Sensitivity of grounddwater to contamination



While most ecological activities are unlikely to affect the groundwater, some consideration should be taken when applying herbicides. Most herbicides bind with soil particles and are not very mobile with water, but some mobility can occur, depending on soil components, depth etc. Soil organic matter content is considered the single, most important soil property affecting pesticide breakdown by microorganisms (Gardner). Soils at this site do not have a great deal of organic matter, so breakdown may be slower than optimal. Glyphosate is one herbicide that binds more tightly to soil particles than most other herbicides (Hartler), and should be considered if a more widespread broadcast herbicide is needed, such as to apply to a grassland in preparation for converting to prairie. In all cases, the least amount of herbicide should be use that can achieve desired results. For woody plants, for example, cut stumps should be treated using a sponge, or dauber, applicator. Foliar application to woody plants should be avoided.

Surface water

The most prominent surface water at Vermillion Falls Park is of course the Vermillion River. With 38 river miles above the falls, the river drains 372 square miles of Dakota County and a small portion of Scott County.

The other surface water at the park is a ponded waterway that flows through the southeastern corner of the Park. A drainage ditch was created further to the west that feeds into the ravine to provide drainage from south of the Park to the River, and another culvert in the southeast corner of the Park brings water flow from additional areas south of the Park. This latter waterway from the south is identified by the Vermillion River Watershed as a Buffer-Water Quality Corridor, meaning it is an identified waterway that must have 30-foot vegetated buffers maintained. It cuts through the southeast corner of the park and empties to the Vermillion River further east.

The Vermillion River itself is classified as a Conservation Corridor, requiring 150' vegetated buffers.

Vermillion Falls Park is too small of a site to be important for groundwater recharge, but it is located in a part of the state that has potentially high rates of recharge - 8 to 10 inches per year (Setterholm 2014). Most water that infiltrates at the land surface is returned to the atmosphere by plant transpiration and evaporation. Typically only a small fraction of infiltration water reaches the groundwater.

E. Rare Species and Wildlife

1. Rare Species

A search of the DNR Natural Heritage database* revealed one rare plant species at Vermillion Falls Park from 1997 – kitten-tails (*Besseya bullii*). Several individual plants were located in 2019 in an area with fairly dense buckthorn cover. More plants may appear as the site is managed and the canopy opens up.

One native plant community was also recorded for 1997 at the site - Southern dry sand-gravel oak savanna. Although virtually extirpated in the 22 years since then, there are tiny relicts of this historical plant community, with occasional little bluestem, Indiangrass, side oats grama, gray

goldenrod, and smooth aster. Numerous large bur oak trees with spreading branches can be found at the site.

There are three other rare plant species and two animal species listed by the DNR within a mile of the park. If managed and improved, the park could potentially provide habitat for several of the species, including the endangered rusty patched bumblebee and western fox snake.

**State of Minnesota, Department of Natural Resources (DNR). 2019. Rare Features Data included here were provided by the Division of Ecological and Water Resources, Minnesota DNR, and were current (as of June 2019). These data are not based on an exhaustive inventory of the state. The lack of data for any geographic area shall not be construed to mean that no significant features are present.*

2. Wildlife

A wildlife survey was not completed for the park. A few animals noted at the park were gray squirrel (including one albino), numerous white-tailed deer, American toad, and prairie skink. A feral cat was also seen in the bedrock boulders along the river.

F. Historical Vegetation

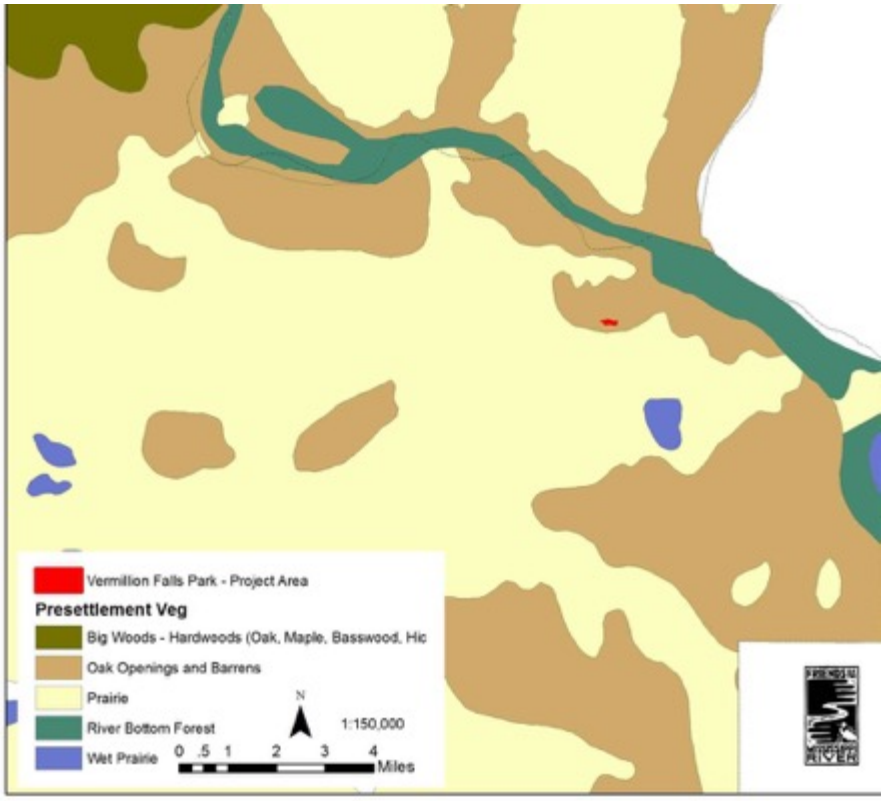
One important consideration for developing a natural resources management plan is to understand the types of vegetation found at a property or in the local area prior to European colonization. This information can be a helpful indicator of what plants may thrive on the property. Fortunately, field notes on vegetation were taken during original territorial surveys in the 1840s and compiled by Francis Marschner into a map of the state entitled "The Original Vegetation of Minnesota", published in 1974.

According to Marschner's map, the predominant plant community at Vermillion Falls Park in the 1840s was Oak Openings and Barrens, or what is typically referred to today as oak savanna (**Figure 10**). The plant community assignment is based on data from bearing trees, which were recorded every mile, and the trees closest to them. At Vermillion Falls, bur oak trees, 10 to 14 inches diameter, were the primary species recorded in the area. Some were quite far apart – 70 feet or more, which is indicative of savanna. The mapping was a generalization in some cases and it is quite possible that the Vermillion Falls Park site was in a complex of oak savanna and prairie.

Oak savanna is a transitional area between prairie and forest. It occurs on dry to moderately moist (mesic) sites throughout the deciduous forest-woodland zone and locally in the prairie zone. Although there are few relicts left to inform us what it may have looked like historically, a simple image of savanna is a complex of open grassland, dominated by prairie grasses and forbs, with scattered open grown oak trees, patches of aspens and scrub brush. The principal canopy species is bur oak with lesser amounts of northern pin, northern red, and white oak. Shrub cover is variable as well, but common species are blackberry, raspberry, gooseberry, dogwood, cherry, hazelnut, and prickly ash.

The dominant soil type at the Vermillion Park (Copaston complex) is a drought-prone soil that is suitable to oak savanna or prairie.

Figure 10. Vegetation at time of European Colonization



Ecological Land Classification

Figure 11. Ecological Subsection

The ecological classification of the park (**Figure 11)**, as defined by the MN DNR is as follows:

- Province: Eastern Broadleaf Forest
- Section: Minnesota and Northeast Iowa Morainal
- Subsection: Oak Savanna

This information is used to better understand the factors under which any particular area developed (e.g. climate, geology, topography, soils, hydrology) and how that area relates to surrounding areas. It also helps to inform restoration and management.

ECOLOGICAL EVALUATION

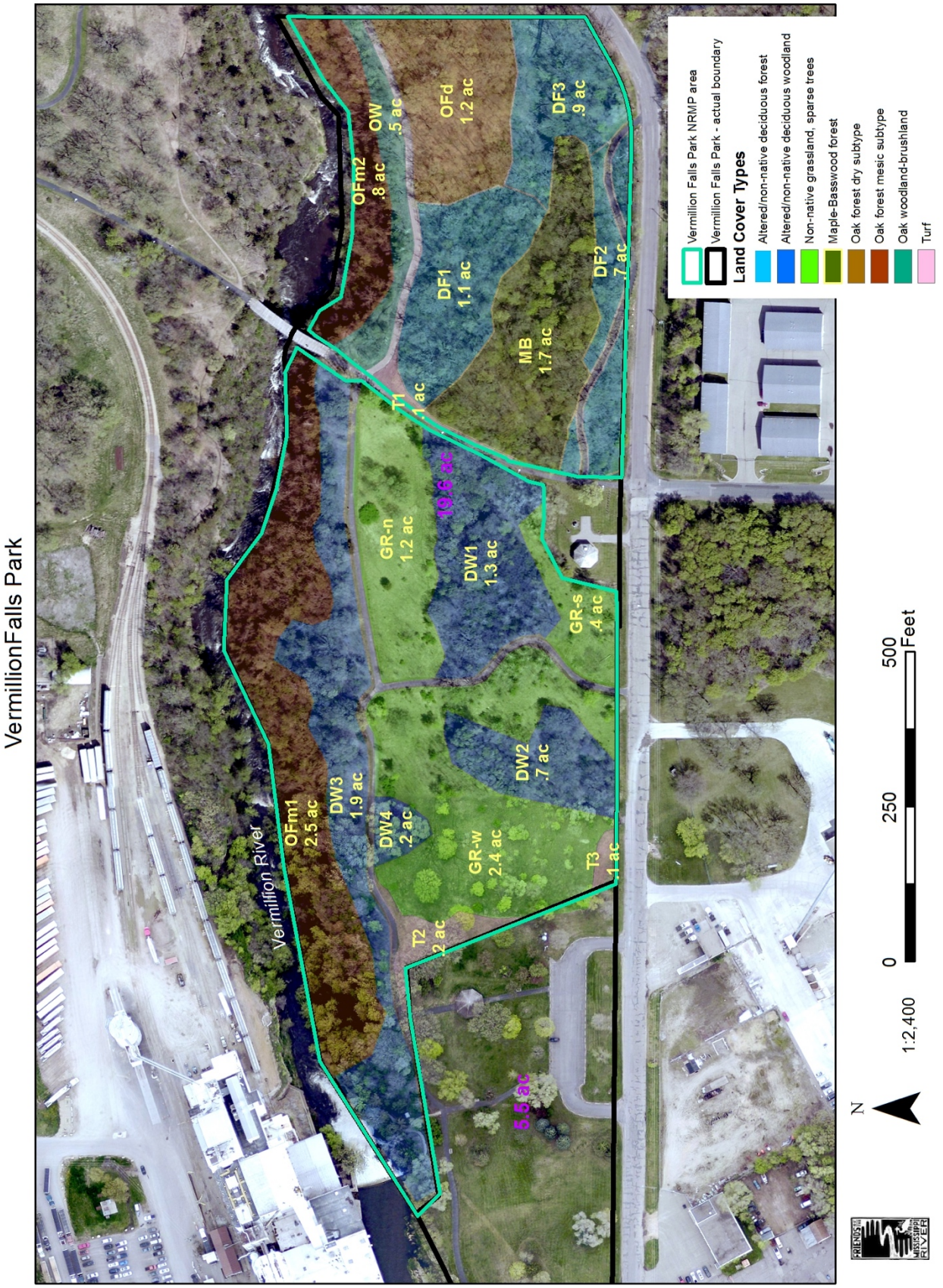
The Department of Natural Resources (DNR) developed a system called the Minnesota Land Cover Classification System (MLCCS), which defines and classifies all types of land cover. Dakota County has been entirely mapped in the MLCCS and this information was used as a basis for the site evaluation, which was conducted by FMR's ecologist in 2019. Using the polygons defined by the MLCCS, information for each land cover type was recorded and polygons adjusted as needed. The existing plant species were recorded, with an estimated relative percent coverage in each vegetation layer (tree, shrub, and ground layer) (**Appendix A**) [Note that within the text portion of this document, only the common names of plant species are used unless a species is not listed in one of the appendices, in which case the scientific name will also be shown]. Other site features evaluated and recorded were ecological concerns, such as erosion, invasive species, disease, etc.

The field observations then informed the land cover classification, which was modified as needed (**Figure 12).** Each of the land cover units (**Table 1**) is described in the paragraphs below.

Table 1. Existing Land Cover and Target Plant Community

Unit	MLCCS Code	MLCCS Description	ACRES
DF1	32170	Altered/non-native deciduous forest	1.1
DF2	32170	Altered/non-native deciduous forest	0.7
DF3	32170	Altered/non-native deciduous forest	0.9
			2.7
DW1	42130	Altered/non-native deciduous woodland	1.3
DW2	42130	Altered/non-native deciduous woodland	0.7
DW3	42130	Altered/non-native deciduous woodland	1.7
DW4	42130	Altered/non-native deciduous woodland	0.2
			3.9
GR-n	62220	Non-native dominated grassland, sparses trees	1.2
GR-s	62220	Non-native dominated grassland, sparses trees	0.4
GR-w	62220	Non-native dominated grassland, sparses trees	2.4
			4
MB	32150	Maple-Basswood forest	**1.7**
OFd	32113	Dry Oak Forest	**1.2**
OW	42120	Oak woodland-brushland	**0.5**
OFm1	32112	Mesic Oak Forest	2.5
OFm2	32112	Mesic Oak Forest	0.8
			3.3
T	62000	Mowed turf	0.4
			17.7

Figure 12. Existing Land over



The plant communities were evaluated based on qualities of an intact community, and were given rankings based on a very general assessment of select ecological criteria (Table 2). These are mostly subjective scores, but intended to give a general indication of the conditions. The plant communities will be discussed below in order of relative quality, from highest to lowest. While none of the units were high quality plant communities, the maple-basswood forest had the best representation of an intact community. Most of the forested communities had fairly good structure, with a canopy, sub-canopy, shrub layer and ground layer. The age classes however, were not balanced, especially lacking seedlings and saplings of the canopy species and all but the maple-basswood unit were moderately to severely impaired by non-native invasive species. The grassland units were the most degraded, with very low diversity of native species.

Table 2. Quality rankings of existing vegetation units.

			MB	Ofm	Ofd	OW	DF	DW	GR
Native species composition - based on intact community									
	High	High diversity (species richness and abundance)							
	Medium	Moderate diversity		2					
	Low	Low richness and/or abundance.	1		1	1	1	1	1
Structure - Canopy, subcanopy, shrub layer, ground layer.									
	High	Suitably balanced (for the plant community type)	3		3	3			
	Medium	Lacking or over dominant in one or more layer.		2					
	Low	Significantly lacking in vegetation layers, or dominated by one (e.g. shrubs)					1	1	1
Age classes of trees									
	High	Variety of sizes/ages			3				
	Medium	Some variety but not balanced.	2	2		2	2	2	
	Low	Mostly even-aged.							
Canopy tree recruitment (for species of intact community)									
	High	Seedlings and saplings of canopy trees	3		3				
	Medium	Seedlings and saplings of some canopy trees		2					
	Low	Few seedlings and saplings of canopy trees.				1	1	1	
Conservative forb species									
	High	Many conservative species		3					
	Medium	Some conservative spp	2						
	Low	Mostly early successional			1	1	1	1	1
Non-native/invasive plants									
	High	Few or none	3						
	Medium	Moderate levels		2	2	2			
	Low	Non-natives dominate.					1	1	1
18 Max score			14	13	13	10	7	7	4

A. Maple-Basswood Forest (MB)

The maple-basswood community is about 2 acres that straddles the south gorge east of the old railroad track (Photo 1). A culvert at the west end (Photo 2) connects the gorge to its head on the west side of the former railroad bed, which connects to a drainage ditch further west.

Photo 1. The limestone walls of the gorge.

As the name implies, sugar maple and American basswood dominate the community. Both are very leaf-dense trees that create a dense shade. While many plant species cannot grow well under dense shade, both sugar maple and basswood are shade-tolerant - the seedlings can persist in the deep shade until a light gap occurs.

Other typical canopy trees include bur and red oak, green ash and elm. Many shrub species do not grow well in the deep shade, including buckthorn, so the shrub layer tends to be quite sparse but may include ironwood, bitternut hickory, and pagoda dogwood. The soil is typically very rich, as the maple leaves are very abundant and the fallen leaves form a nutrient-rich compost. An intact maple-basswood community would support a diversity of wildflower species, many of which grow profusely in early spring before the trees leaf out, then die-back by early summer.

Photo 2. Culvert at west end of the gorge carries water during major rain events.

At Vermillion Falls Park the maple-basswood unit was the least degraded plant community, with few invasive non-native plants present. The canopy and shrub layers were relatively intact, but the ground layer lacked diversity.

Sugar maple was the dominant canopy tree and basswood was sub-dominant. Maple trees were up to 20-inches in diameter, though most were about 10-12 inches. Basswood trees were mostly about 10-12 inches. Other canopy trees in low abundance were hackberry (20-inch dbh), white oak (25-inch dbh), black cherry (6-inch dbh) and American elm (6-inch dbh). Ironwood and bur oak were in the subcanopy.

The shrub layer was sparse with occasional buckthorn and chokecherry. The ground layer was not very diverse, with about 24 species noted. The coverage was patchy, ranging from sparse to nearly 75 percent cover. Woody plants dominated, especially Virginia creeper and sugar maple seedlings (Photo 3). The forb cover was very low, less than 5 percent, but did include such representative species as wild leek, wood anemone, wild sarsaparilla, wild ginger, blue cohosh, and bloodroot.

The only significant invasive plant species at this unit was common buckthorn, which was in relatively low abundance.

Photo 3. The dense canopy inhibits the growth of may shrub species. The sparse ground layer is likely a result of earthworms.

B. Mesic Oak Forest (OFm1, OFm2)

Mesic oak forest covers the south side of the Vermillion River gorge, flanking the river. The two units are about 3.3 acres, although with the steep slopes the actual surface area would be larger. The east unit was nearly vertical and was too steep to traverse, so only the west unit (OFm1) is described here.

The terrain of these units included dolostone (similar to limestone) cliffs and jumbled boulders. The karst landscape included crevices, tunnels and fissures where softer stone has eroded away. A trail was built, probably when the park was first developed in the early 1970's, from the blufftop down to the river. The trail is steep and treacherous with boulders and roots (Photo 4). For the safety of individuals as well as the natural area, it is not recommended for general use and the City may not want to explicitly draw attention to it. But it does enable more adventurous individuals to explore a unique area.

Photo 4. Old steps can be seen at the top of this trail, which appears only somewhat rough in this section. Other portions were very bouldery.

The canopy trees in this unit were a mix of American elm, basswood, hackberry and boxelder. The coverage was moderately dense, with 50 to 75 percent cover. Subcanopy species were the same, with the addition of occasional black walnut.

The shrub layer was less than 50 percent cover. Although buckthorn was dominant, it was sparse in many areas. There were scattered large buckthorn at the west end of OFm1 (Photos 5 & 6), and dense stands of small stems and seedlings at the east end. Tatarian honeysuckle was also common. Other species in the shrub layer included saplings of canopy trees as well as pagoda dogwood, choke cherry, prickly ash, and very occasional red-berried elder.

Photos 5 and 6. Very large, scattered buckthorn at the west end of OFm1, and very dense, small stems toward the east end.

The ground layer had generally very dense cover in areas that were not boulder-strewn. The most diverse and interesting vegetation at the park was found in this area. The habitat of shady, moss-covered, limestone boulders is relatively uncommon, so it harbors several species that are not commonly encountered. Bulblet fern is common to this type of habitat and it dominated overall, with other abundant species including Jack-in-the-pulpit, clearweed, blue cohosh, enchanter's nightshade and jewelweed (Photo 7).

Photo 7. A dense and diverse ground cover of native plants, dominated by bulblet fern.

Photo 8. The evergreen shrub, Canada yew, was common on the limestone talus slopes.

Canada yew was another uncommon plant that was abundant at this unit. A beautiful, sprawling evergreen shrub found in cool ravines and talus slopes, it is at the western edge of its range in Minnesota. It is a favorite food of white-tailed deer, which are generally over-abundant, so its population has severely declined (Photo 8). The ruggedness of the gorge likely affords it good protection from over-browsing.

One of the most interesting species at the site was walking fern, an uncommon plant found on shady, moss-covered boulders. The distinctive leaf has a long extending tendril that anchors to the ground and sprouts a new plant, thus enabling the plant to "walk" (Photo 9).

Photo 9. The long-extended leaf tips of walking fern anchor in the ground and produce new plants.

The primary invasive non-native plants of concern in this unit were buckthorn and honeysuckle, both of which were fairly abundant. A few burdock plants were found but are not likely to become abundant due to the more shady conditions of this unit. Other non-native species, such as motherwort and creeping Charlie, are not generally an ecological concern as they don't impede the establishment or survival of native species. That is, they do not tend to reduce the native plant diversity.

C. Dry Oak Forest (OFd)

The dry oak forest, about 1.2 acres, was historically savanna but has matured into an oak forest over the decades. The dense canopy was dominated by bur, red and pin oak with some white oak as well. The largest tree found was a white oak, about 24 inches dbh (Photo 10). The other oaks were mostly in the 12 to14-inch range. Similarly sized bitternut hickory, basswood and black walnut were also present. The subcanopy had most of the canopy species plus ironwood, a few very tall buckthorn, an occasional red cedar and one black ash.

Photo 10. A white oak, about 24" dbh, was found just east of OF, outside the park. Note the 8.5x11" paper at the base.

Although buckthorn was the dominant species in the shrub layer, it was not very abundant. Other shrub layer species were green ash, ironwood, chokecherry and prickly ash. The shrub layer was about 25 to 50 percent cover.

The ground layer was dense and was dominated by Pennsylvania sedge, which had over 50 percent cover (Photos 11, 12). The seedling woody plants were mostly buckthorn, but there were also 11 native tree and shrub

seedlings. Vines were common, especially Virginia creeper. Forbs were very sparse, but included zigzag goldenrod, pointed-leaved tick-trefoil, wild geranium, and bloodroot.

Photos 11 & 12. OFd was characterized by moderately large canopy trees, a fairly open shrub layer, and fairly dense ground cover dominated by Pennsylvania sedge.

The primary invasive species of concern in this unit was buckthorn and to a lesser extent, honeysuckle. The lack of native oak forest diversity also needs to be addressed in the restoration process.

D. Oak Woodland-Brushland (OW)

The OW unit was about 0.5 acres along the blufftop east of the bridge. It would have been oak savanna historically and retains some of those features with an open canopy heavily dominated by oaks (mostly pin), an open shrub layer (Photos 13, 14), and occasional prairie plants in the ground layer.

Photo 13. General view of the OW unit, a narrow strip along the east blufftop.

Photo 14. The oaks in OW are prominent in their fall foliage.

Ironwood was the subdominant canopy species and few other species were found other than several green ash and one paper birch. Just two species were found in the subcanopy – ironwood and one black locust, a non-native invasive species, next to the trail.

Buckthorn and honeysuckle dominated the shrub layer, which was less than 25 percent cover. Buckthorn was most abundant at the far west end by the bridge (Photo 15). Several other interesting shrubs were found including round-leaved dogwood, hazelnut, and a mountain ash (possibly the European species).

Photo 15. A dense patch of buckthorn beneath a large bur oak at the west end of OW.

The ground layer was dense, but low diversity. Pennsylvania sedge dominated, buckthorn seedlings were common and a few seedlings of canopy trees were found. Occasional relicts of the former savanna were found – sideoats grama, little bluestem, Indiangrass, northern bedstraw, gray goldenrod, and sky blue aster.

The primary ecological concerns for this unit are buckthorn and honeysuckle and to a small extent black locust. There were very few other non-natives species found.

E. Altered Deciduous Forest (Units DF1, DF2, DF3)

The DF units (2.7 acres total) were all east of the old railroad bed and surrounded the maple-basswood forest that occupies the south gorge area. All of the DF units were characterized by a fairly dense canopy of native trees (around 75%), but an understory heavily dominated by buckthorn. The ground cover was also very degraded and dominated by buckthorn, although DF3 still retained a large number, but low abundance, of native species.

Although we found no indications of significant historical human activities in these units, such as logging, cropland, or even grazing, much of the park land has nevertheless become very degraded over time, with a dramatic loss of the species diversity and composition that was historically present. Multiple factors have played into this condition. The cessation of natural processes, such as wild fires and ungulate grazers, would have resulted in the gradual loss of prairie grasses and wildflowers as the woody plants took over. Native forest wildflowers never had a chance to move in because the forest condition is fairly new, but also because non-native invasive species, especially earthworms, common buckthorn, and Tatarian honeysuckle essentially got there first. This site is an example of how simply leaving the land "natural" is no longer an option if retaining native plant species and the host of wildlife that depend on them is desired.

In the DF units, bur oak was the dominant canopy tree, many of which had wide spreading branches indicative of the historical savanna vegetation cover (Photo 16). Many of these oaks were quite large, 20-inches diameter or more. American basswood and red oak were also abundant and sugar maple was present in the DF1 unit. Pin oak was also common, with one especially large tree (18-inch diameter) in DF2. Most of the trees besides the oaks were in the 8 to 12-inch diameter size, again indicating they established at the site after the oak trees were already mature.

Photo 16. Large bur oaks with spreading branches indicate former savanna. DF2

One small black locust tree, a non-native invasive species, was found on the edge of DF1. No other locust or Siberian elm were noted at this unit, but were found elsewhere at the site and should be noted if found. The subcanopy was somewhat sparse, with less than 25% coverage, except in the southeast part of DF2, which had an abundance of young black walnut and basswood. Ironwood was also common at all units. Other canopy species were largely absent in the subcanopy, especially oaks.

The shrub layer was heavily dominated by common buckthorn (Photo 17) and occasional honeysuckle, especially at the unit edges. Much of the buckthorn was small diameter, ½ to 1 inch, with scattered large diameter (up to 3 inches), especially near the edges. Native shrubs were very sparse, with a few chokecherry and prickly ash recorded.

Photo 17. Buckthorn formed a dense thicket in some areas, wih few native shrubs. DF1

Photo 18. The ground layer was a buckthorn carpet in DF1.

The ground layer was dense, but heavily dominated by buckthorn seedlings (Photo 18). Oak seedlings were largely absent. Other native tree species were quite sparse, but included hackberry, sugar maple, ironwood, basswood and choke cherry.

Ground cover forbs were very sparse, with about 12 species and less than 5% cover in DF1 and DF2. Species included Virginia waterleaf, enchanter's nightshade, cleavers, white avens, zigzag goldenrod, and hairy Solomon's seal. Evidence of heavy earthworm infestation could be seen in some areas, which were devoid of vegetation and leaf litter (Photo 19).

Photo 19. Bare ground here is evidence of abundant earthworms. DF2

Photo 20. The ravine in DF3 had less buckthorn and more native wildflowers.

Unit DF3 had much higher forb cover, 26 species and about 25% coverage. This was due in part to the unit having canopy openings, such as next to the trail, where savanna species such as bergamot and Canada goldenrod established.

Unit DF3 also differed from the other units because it included part of the ravine that crosses the southeast part of the park. The deeper shade of the gorge and north-facing slopes helped to deter buckthorn establishment and enabled native woodland wildflowers to persist, such as wild leek, wood anemone, blue cohosh, wild ginger, and bloodroot (Photo 20).

A culvert on the south side of the ravine carries stormwater runoff from south of the park, which reaches the Vermillion River east of the park (Photo 21). While the ravine is likely dry during summer months, 2019 was an unusually wet year and the bottom of the ravine remained ponded (Photo 22).

Overall, the DF units were generally very degraded with buckthorn, with DF1 being the most and DF3 the least degraded. If buckthorn were removed and adequately controlled, native vegetation could be re-established. It would be a many-year endeavor and some level of management would always be needed to maintain the native vegetation. Detailed management recommendations are provided in the next section. Besides buckthorn and honeysuckle there were no other species noted that are of significant concern.

Photo 21. Culvert carries stormwater from south. Much trash and rubble has been dumped nearby. DF3.

Photo 22. Much of the ravine in DF3 was ponded in 2019.

F. Altered Deciduous Woodland (DW1, DW2, DW3, DW4)

The DW units, 3.9 acres total, were all west of the old railroad bed and most closely integrated with the grassland. They were similar to the DF units in that both land cover types had a fairly dense canopy cover dominated by bur oak, a sparse subcanopy, and a dense shrub layer of mostly buckthorn (Photo 23). They differed in that the DW units were smaller units, mostly surrounded by grassland, with a more diverse canopy and ground layer. They were younger than the DF units, with fewer large trees besides the oaks.

As at the DF units, bur oaks were the largest trees, up to nearly 30 inches in diameter. They tended to be scattered, and had wide-spreading branches. Pin oak was also very abundant, with somewhat smaller diameters. Some of the smallest oaks were about 4-inches in diameter. There were some oaks in the subcanopy, but almost no recruitment in the ground layer.

Photo 23. Large bur oak with large buckthorn below. DW2.

Each of the DW units differed somewhat in the abundance of other canopy species besides oaks, but black walnut and American elm were found at all units, approximately 6 to 18 inches dbh. Hackberry was not abundant but found at most units, up to 15 inches dbh. Red cedar was common in DW3, which had more sun exposure. There were a few green ash and American basswood as well. Most of the canopy species were represented in the subcanopy, plus black cherry.

Also of concern was the abundance of Siberian elm, some quite large (Photo 24), which was found at all the units. This is another very invasive species that can take over natural areas and displace native species.

Photo 24. A 12-inch dbh Siberian elm towers over the trail at DW3.

Buckthorn ranged in size from four-foot tall to huge, 25-foot tall plants. Tatarian honeysuckle was also abundant, some with a 10-foot wide crown. There were few native shrubs except at DW4, where smooth sumac was abundant.

Buckthorn also dominated the ground layer with a dense seedling carpet and up to 75 percent coverage.

The DW3 unit was located along the bluff top and was a transitional area between grassland to the south and mesic river bank forest to the north. This unit also included the viewing pavillion at the top of the falls.

DW3 had the most diverse ground cover community, with 33 recorded species- more than twice that of the other units. The more open south-facing edge allowed more light to the ground and enabled many native savanna species to persist. Small pockets of prairie plants were found (Photo 25) including leadplant, bergamot, heart-leaved aster, whorled milkweed, and kittentails, a state-threatened species. At the same time, various woodland species were present, including lopseed, zigzag goldenrod, red baneberry, white snakeroot, clearweed and Canada mayflower.

Photo 25. Pockets of native prairie vegetation are found along the edge of DW3. Leadplant and other forbs seen here.

Day lilies found in the DW3 unit may be a relict from an earlier planting. Unfortunately, they can spread quite aggressively and should be removed.

DW1 differed from the other units because it straddled the ravine that bisects the southeastern part of the site. The ravine is fairly shallow in this section, about 4 to 10 feet deep. The vegetation is a jungle of young growth dominated by buckthorn, but the limestone ledges in the ravine are an interesting feature (Photo 26). Unfortunately, there was a significant amount of construction-type rubble and debris in the ravine, including wire, concrete, and rusted drums (Photo 27).

Photo 26. Limestone ledge in DW1 ravine.

Photo 27. Trash and debris, DW1.

DW2 also straddled a ravine, but it was a constructed drainage ditch (Photo 28). It was mostly dry much of the summer but held water in the heavy fall rains of 2019. This unit had some of the largest bur oaks as well as the largest buckthorn and honeysuckle.

The buckthorn and honeysuckle were removed from DW3 in fall 2019 as a pilot project for the site. The cleared trailside dramatically improved the views of the bluff edge and opened the views at the falls overlook (photos 29, 30, 31).

Photo 28. Culvert at the south end of the ditch that runs through DW2.

Photo 29. Dense buckthorn along trail before removal fall 2019. DW3.

Photo 30. After buckthorn removal along the trail, fall 2019. DW3.

Photo 31. The trail to the overlook at the falls was hidden behind a wall of buckthorn before the 2019 removal.

Ecological concerns at these units were the immense amounts of non-native woody plants – buckthorn, honeysuckle, and mature Siberian elm trees. If not controlled these species will continue to spread and degrade the rest of the plant communities at the park. There were not many herbaceous plants of significant concern, but daylilies should be controlled, smooth brome where present, and motherwort if it becomes abundant. The debris and trash in DW1 also needs to be removed.

G. Non-Native Grassland (GRw, GRn, GRs)

The GR units, 4 acres total, were also found entirely on the west side of the park. As the name implies, the GR units were dominated by non-native species, especially smooth brome in the ground layer, Tatarian honeysuckle and common buckthorn in the shrub layer, and Siberian elm in the canopy. The grassland structure was very mixed, with a high coverage of individual and small stands of tree and shrubs among the grasses and forbs (Photos 32-35).

Photos 32, 33. GRw - brome grass dominant, with many large trees and shrubs, especially honeysuckle and buckthorn.

Photo 34. Aspen grove on the east side of GRw.

Photo 35. General grassland view - Canada goldenrod is the primary forb here.

The canopy coverage was highest in GRw, where very large trees (Photos 36, 37, 38) comprised over 25 percent cover. Siberian elm dominated, including several large trees about 12-inches dbh. The subcanopy coverage was also about 25 percent overall, with Siberian elm and green ash dominant. Black locust was also abundant in GRw.

Buckthorn and honeysuckle dominated the shrub layer in GRw, with many very large plants, including buckthorn over 15 feet tall and wide-spreading honeysuckle. Native species in the shrub layer were sparse but included occasional red cedar, a few basswood, and smooth sumac, which was the dominant shrub in GRn (Photo 39).



Photos 36, 37, 38. Numerous large trees were found in the GRw grassland, such as this Siberian elm (left), American elm (center) and several boxelder (right).

Smooth brome and Kentucky bluegrass were heavily dominant in the ground layer. Yellow foxtail was also abundant. Native grasses were very sparse, with occasional clumps of Indian grass and big bluestem. Forb diversity was also low, with Canada and late goldenrod dominating. Although they are native, they are quite invasive and can displace most other grassland species. The other most notable (desirable) native species was bergamot, which was fairly common is some places.

GRs had a similar composition to GRw, including a large Siberian elm tree. It also had a very large (20-inch dbh) black walnut, with very sparse vegetation below it (Photo 40).

Photo 39. GRn is dominated by smooth sumac, with some brush and small trees.

Photo 40. Large black walnut, GRs.

Except for GRn, virtually the entire vegetation of the grassland units - trees, shrubs and ground cover - was made up of non-native invasive plant species. Restoring these units entirely would entail a nearly wholesale removal of existing vegetation and reestablishment, with some exception. Details are outlined in the Restoration section. GRn had a few small non-native trees, but was heavily dominated by smooth sumac. There were fewer non-native, invasive forbs and somewhat less brome grass than the other units. This unit could be managed less aggressively, retaining much of the sumac and working to increase then native forbs and grasses.

H. Parkland

Although not specifically included as part of this management plan, the western portion of the park is worth mentioning here. The 5.5 acres at the west end of the park consisted primarily of mowed turf with scattered coniferous and deciduous trees with paved trails from the parking lot to the overlook and along the river side (Photos 41 and 42). The primary structure is the picnic pavilion. Many of the trees were planted, but there were also some very large bur oak and other trees in the vicinity of the pavilion that are well over 100 years old (Photo 43).

While there were no significant ecological concerns for the parkland, it does present an opportunity for improved habitat. It would appear that most of the mowed turf is not used for recreational purposes, especially the western half. The City could consider converting this to native prairie vegetation, which would have multiple habitat values, especially for pollinators, and would be a great visual asset for park visitors. It would also enhance the habitat corridor between Vermillion Linear Park and Old Mill Park.

Photos 41 & 42. Mowed turf at the west side of the park.

Photo 43. Huge bur oak just west of GRw grassland in mowed parkland.

I. Ecological concerns

The site has numerous ecological threats, primarily due to invasive, non-native plant and animal species, especially earthworms and invasive woody plants. A total of ten plant species found at the site are listed by the MN Department of Agriculture and the Department of Natural Resources as noxious weeds. The most abundant species were common buckthorn, Tatarian honeysuckle, Siberian elm, black locust, and smooth brome (**Appendix D**).

Photo 1. *Earthworms, none of which are native to MN, were at the highest stage of abundance at the site. Arrows point to the middens – uneaten vegetative debris left in piles at the worm holes.*

The presence of these species is interconnected and the causes of their invasion cannot necessarily be controlled. Earthworms, for instance, play a major role in the establishment of invasive plant species by altering the soil structure and chemistry, which is detrimental to native plants. Buckthorn, in turn, benefits earthworms by providing leaves that are very high in nitrogen. This positive feedback loop ensures that both species continue to thrive at a site.

However, we can intercept this system. There is currently no method for controlling earthworms, so to that extent, the site will always be susceptible to invasion of non-native plant species. However, native plants can co-exist with earthworms, and if there a well-established native plant community, studies have shown it can be quite resistant to invasive plant species. Also, by removing invasive plants, conditions for earthworms decline and their populations also decline.

Earthworms were abundant throughout the property, and were scored as stage 5, the maximum invasion stage, using the Invasive Earthworm Rapid Assessment Tool (IERAT). Many areas were almost completely devoid of leaf litter and had very sparse vegetation, typical of Stage 5 invasion. Stage 5 is described as: no forest floor humus or fragmented leaves present, mineral soil present, earthworm casting abundant (>50% of forest floor/mineral soil interface covered), middens abundant (>9 in a 5-m radius) (**Photo 11**). Typically, in today's conditions, as worms alter the soil structure and duff layer, they create conditions that favor non-native invasive plants such as buckthorn and garlic mustard, which then invade and prevent native plants from growing. If those invasives were not present in the landscape, then native plants could gradually adjust to the mineral soil conditions. Although controlling earthworm populations is not feasible, it would be valuable to survey the population over time in high and low quality areas to evaluate any changes that may result from management activities. This could be a good volunteer or intern activity.

Common buckthorn can thrive in a wide range of soil and light conditions, enabling it to invade a wide variety of habitats. It forms dense thickets that crowd and shade out native plants, alters

nitrogen levels in the soil, hosts fungi that are detrimental to agricultural crops, and contributes to erosion and declining water quality. Recent research suggests it also releases compounds that are toxic to the embryos of native amphibian species. Its fruit is somewhat toxic, with a strong laxative effect on birds and other wildlife. As such, it provides little food value to animals that eat the berries. Studies have shown an increased rate of nest predation and subsequent population declines for birds that nest in buckthorn. Once established, a virtual carpet of buckthorn seedlings radiate outward from each "mother plant," displacing or preventing native plants from re-establishing these areas. The berries are dispersed by birds throughout the woodland. Trees that offer perches for birds are typically choked with buckthorn plants growing under their crowns. Buckthorn can dominate a vulnerable woodland or forest in a matter of 30 to 50 years.

Like buckthorn, **Tatarian honeysuckle** is an upright, deciduous shrub that was brought here from Europe and Asia. It is a very aggressive colonizer that displaces native forest shrubs and herbaceous plants by its invasive nature and early leaf-out. It also invades grassland areas. It has a very robust root system and a multi-stem trunk and is very difficult to eradicate. Birds eat the red or orange berries, spreading the plant to new locations.

Siberian elm and black locust are similarly invasive. They have prolific seed production and tend to germinate early and drop their leaves later than native plants. The readily spread and displace native plants.

While the ecological concerns for the park are significant, several units were less invaded (the maple-basswood forest, the mesic oak forest and the dry oak forest) and would have good potential for restoring the native plant community.

As with the forest, the primary concern for the grassland is the prevalence of the non-native invasive species and the lack of native species diversity. Restoring the grassland would entail a nearly entire replacement of the existing vegetation. Although a costly and time-consuming endeavor, it is feasible and not exorbitantly expensive.

The lack of natural fire throughout the state has also contributed to the altered native plant community compositions. This could be rectified by enacting a regular management program. Perhaps the largest ecological threat to this site may be from climate change. Ecologists don't fully understand yet the scope and details of how these changes may manifest, nor how to counteract them, but one approach, assisted migration, gradually introduces plants from slightly more southern zone (e.g within a few hundred miles). See **Appendix C** for additional information on these topics.

Other concerns for the park are the old trash dumps in several of the units, which should be removed. The park should also be monitored for on-going trash dumping, as was observed in some units.

Soil erosion is not currently a significant concern at the park because it is well-vegetated. However it should be considered for any new park activities in the future.

IV. ECOLOGICAL MANAGEMENT RECOMMENDATIONS

Ecological restoration is a long-term process. It takes many steps and many years to restore ecosystems to a semblance of their former functionality and diversity. Even under the best circumstances and human abilities, this can only be approximated. It took many decades to degrade the ecosystem and biological communities on the property, so it will not be restored in a short time.

Restoration should be viewed as a process and not as an end point. The ultimate goal is to achieve and maintain a diverse and somewhat self-sustaining natural community at the site, though this will not always proceed in a linear fashion. Using the concept of *adaptive management* will be the key to continual progress at the site. Adaptive management is an iterative process commonly used by land managers, which integrates evaluation and action into the restoration process. While an overall plan is established at the start of a project, as restoration steps are taken, results are monitored and evaluated to determine the next best steps in a constant feedback loop that looks like this: Assess Problem → Design → Implement → Monitor → Evaluate → Adjust → Assess Problem → and so forth. Thus, moving forward with restoration, each round of adaptive management refines and hones the process to better fit the conditions of the site. This strategy should be followed on the property.

A. Management Objectives

The overarching objective for Vermillion Falls Park is to protect and improve the wildlife and water quality values of the site and to restore the ecological functions that the historical native plant communities provided, including:

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

The best way to accomplish those objectives is by restoring and enhancing native plant communities to the site. A robust and diverse native plant community offers the best protection against invasive species, climate change effects and loss of animal species diversity. The primary plant communities at this site would be southern dry mesic oak woodland (8.3 ac) and southern dry savanna (4.2 ac), with lesser amounts of southern dry-mesic oak forest (3.3 ac) and southern mesic maple-basswood forest (1.7 ac).

According to the 2005 State Wildlife Action Plan for upland hardwood forests, recommended management practices that apply to this park include:

- Use natural disturbance return intervals to guide rotation periods.

- retain biological legacies (at site level).
- control invasive plants and animals.

In addition, DNR recommendations specify managing habitat for species of greatest conservation need (SGCNs) and monitoring SGCN populations.

B. Target Vegetation Communities

In determining target plant communities for restoration, we considered the following: historical conditions, existing conditions, and cost/benefits. For cost/benefit we consider the expense and potential ecological detriments of restoring a particular community versus the long-term benefit for wildlife and other habitat values. In some cases, a plant community's succession may have advanced too far to warrant restoration to the historical condition. A very overgrown savanna, for example, may be better restored to woodland rather than savanna. In other cases, a site that is extremely degraded and/or surrounded by degraded lands with invasive species may simply be a poor candidate for successful restoration.

Another consideration is the long-term maintenance of the site and the restoration. If a grassland area is very small or narrow, restoring it to prairie may not be worthwhile as there will likely be constant pressure from nearby invasive species. Or if a grassland cannot be burned due to adjacent conflicts, it may be too difficult to maintain it as a prairie. All of these and other factors need to be considered before initiating restoration plans.

As a standard for the target plant community goals, we used the Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Forest Province (DNR, 2005). This book describes the system developed by the DNR for identifying ecological systems and native plant community types in the State, based on multiple ecological features, such as major climate zones, origin of glacial deposit, plant composition, and so on. Target plant community recommendations for each of the land cover types are summarized in **Table 3**. The descriptions of each target plant community in the following paragraphs can be used as a guideline to help evaluate the progress of a restoration towards the intended condition.

The majority of Vermillion Falls Park was likely savanna, historically, with the exception of the gorge areas, which were either mesic oak forest or maple-basswood forest. However, oak savanna would be difficult to restore over the eastern half of the park because it has succeeded too far to oak forest and reversing that would cause more degradation to the site.

Most of the eastern half of site is recommended to be restored to oak woodland and most of the western half of the site is recommended to be oak savanna (**Figure 13**). The gorge areas are recommended to remain oak forest and maple-basswood forest. Specific restoration goals and methods are described for each management unit in the next section.

Table 3. Target plant communities

Unit	Existing Landcover	Acres	Soils	Target Plant community	Code
DF1	Altered deciduous forest	1.1	Copaston loam (droughty, erosion prone)	Southern dry-mesic oak woodland	FDs37
DF2	Altered/non-native deciduous forest	0.7	Brodale fine-loam/loam (droughty)		
DF3		0.9			
		2.7			
DW1	Altered/non-native deciduous woodland	1.3	Sparta loamy sand (droughty)	Southern dry-mesic oak woodland	FDs37
DW2		0.7			
DW3		1.9	Brodale fine-loam/loam		
DW4		0.2	Copaston loam	Southern dry savanna	UPs14
		4.1			
GR-n	Non-native dominated grassland, sparses trees	1.2	Copaston loam	Southern dry savanna	UPs14
GR-s		0.4			
GR-w		2.4			
		4			
MB	Maple-Basswood forest	**1.7**	Copaston loam	Southern mesic maple basswood forest	MHs39
OFd	Dry Oak Forest	**1.2**	Copaston loam	Southern dry-mesic oak woodland	FDs37
OW	Oak woodland-brushland	**0.5**	Brodale fine-loam/loam	Southern dry-mesic oak woodland	FDs37
OFm1	Mesic Oak Forest	2.5	Brodale fine-loam/loam	Sourthern dry-mesic oak forest	MHs37
OFm2		0.8			
		3.3			

The following plant community descriptions are excerpts from the DNR Native Plant Communities of Minnesota Field Guide (2005), with minor modifications for brevity and relevance. These descriptions can be used to help guide the restoration process toward these general conditions.

Southern Dry-Mesic Oak Woodland FDs37

Dry-mesic hardwood forests occur on undulating sand flats, hummocky moraines, and river bluffs, mostly on fine sand or sand-gravel soils. Historically, fires were common in this community, and many stands are on sites occupied by brushlands 100–150 years ago. The rotation of catastrophic fires was about 110 years, and the rotation of mild surface fires about 10 years.

The canopy cover is usually interrupted to continuous (50–100%). Bur oak and northern pin oak are the most common species. Northern red oak, white oak, and red maple are occasionally present. The subcanopy cover is patchy to interrupted (25–75%). The most common species are black cherry, red maple, and bur oak.

Because of the open canopy, the shrub layer is often very dense with patchy to continuous cover (25–100%). Common species include black cherry, red maple, chokecherry, American hazelnut (*Corylus americana*), gray dogwood (*Cornus racemosa*), prickly ash, Virginia creeper, and poison ivy.

The ground-layer cover is patchy to continuous (25–100%). Pointed-leaved tick trefoil (*Desmodium glutinosum*), Clayton's sweet cicely (*Osmorhiza claytonii*), hog peanut, Canada mayflower, and wild geranium are commonly present. Pennsylvania sedge is the most abundant graminoid.

Southern Dry Savanna UPs14

Southern dry savannas are sparsely treed communities with grass-dominated herbaceous ground layers on nearly level to steeply sloping sites with droughty soils.

Savannas form where fire recurs frequently enough to prevent trees and shrubs from dominating and shading out sun-loving herbaceous plants, but where frequency and severity are low enough to allow fire-tolerant trees to become established and sometimes reach maturity. Historically, savannas typically occurred in physical proximity to prairie, but where various factors provided some amelioration of the fire regime of the adjoining or surrounding prairie. These factors include streams, lakes, and steep topography, which limited the spread of fire and thus created conditions conducive to savanna formation in the prairie region. The very low productivity of sandy substrates as well as surface instability result in reduced fuel loads and thus fire intensity is lower in savannas than in typical prairies.

All savannas are highly sensitive to fire suppression, quickly succeeding to woodland and eventually to forest in the absence of fire. Dry savannas are more resilient than mesic savannas because the xeric conditions and lower fertility of the soils inhibit tree and shrub growth and reproduction. These same factors also greatly influence herbaceous species composition, eliminating species not adapted to either frequent drought or low nutrient availability. Before Euro-American settlement, browsing, grazing, and trampling by large ungulates were regular occurrences in dry savannas.

Southern Dry Savanna has the following general structure: ground cover of 25-100% grasses and 5-50% forbs, a patchy shrub layer (5-50% cover), and scattered individual or clumps of trees, with a total cover of typically 25-50%. It occurs on nearly level to steeply sloping sites with droughty soils. Moderate growing-season moisture deficits occur during most years, and severe moisture deficits are frequent, especially during periodic regional droughts.

Trees occur as scattered individuals or as scattered small clumps. Bur oak is most common, but northern pin oak is also usually present. The shrub layer is sparse to patchy (5–50% cover).

Leadplant and prairie rose (*Rosa arkansana*) are common low shrubs; chokecherry, American hazelnut (*Corylus americana*), and smooth sumac are the most important tall shrubs.

Mid-height grasses are most important, although tallgrass species are often important as well, especially where conditions tend toward mesic. Species composition varies with variation in soils and topography and is similar to that of dry prairie. Little bluestem and porcupine grass (*Stipa spartea*) are generally dominant; big bluestem and Indian grass are usually present and often common. Pennsylvania sedge, a woodland species, is often present.

Forb cover is sparse to patchy and includes ragweed Virginia ground cherry (*Physalis virginiana*), gray goldenrod, white sage (*Artemisia ludoviciana*), hairy and hoary puccoon (*Lithospermum carolinense and L. canescens*), hoary frostweed (*Helianthemum bicknellii*), and starry false Solomon's seal (*Smilacina stellata*).

Southern Mesic Sugar Maple-Basswood Forest MHs39a

Rich mesic hardwood forests on moderate to steep north-facing slopes on hummocky stagnation moraines, on till plains along the Minnesota River, and on middle and lower slopes on bedrock bluffs. Most often, canopy is strongly dominated by sugar maple with lesser amounts of basswood and, often, northern red oak or bur oak. Ironwood and sugar maple are the most abundant subcanopy species. Sugar maple is also common in the shrub layer with bitternut hickory, prickly gooseberry, chokecherry, and pagoda dogwood (*Cornus alternifolia*).

The canopy cover is interrupted to continuous (50–100%) and strongly dominated by sugar maple, with basswood, northern red oak, and occasionally red elm and American elm. The subcanopy cover is most commonly patchy to interrupted (25–75%); important species include sugar maple, ironwood, basswood, and bitternut hickory. The shrub-layer cover is rare to interrupted (5–75%); common species include sugar maple, bitternut hickory, basswood, prickly gooseberry, and chokecherry.

The ground-layer cover is interrupted to continuous (50–100%); important species include Virginia waterleaf, bloodroot, yellow violet *(Viola pubescens)*, large- flowered bellwort *(Uvularia grandiflora)*, wild leek *(Allium tricoccum)*, blue cohosh, and early meadowrue *(Thalictrum dioicum)*. Spring ephemeral species such as cut-leaved toothwort *(Cardamine concatenata)* and Dutchman's breeches *(Dicentra cucullaria)* are characteristic.

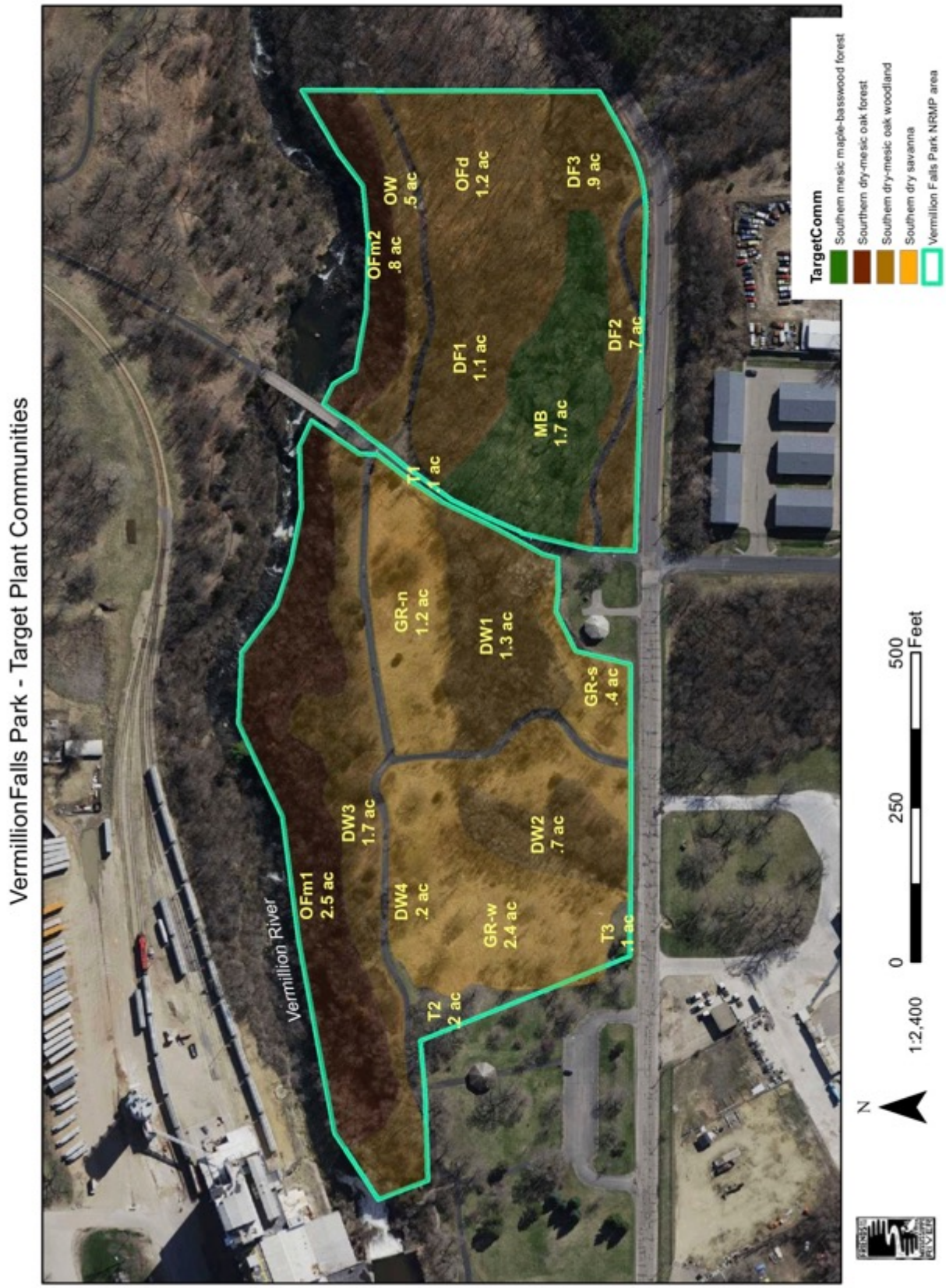
Southern Dry-Mesic Oak Forest MHs37

Dry-mesic hardwood forest occurring most often on thin, wind-deposited silt on crests and upper slopes of bedrock bluffs. The ground-layer varies from patchy to continuous. Important species include lady fern, pointed-leaved tick trefoil, Clayton's sweet cicely, enchanter's nightshade, wild geranium, hog peanut, and white snakeroot. Shrub layer cover is patchy to interrupted. Common species include red oak, black cherry, chokecherry, American hazelnut, Missouri gooseberry, and pagoda dogwood. Subcanopy species include basswood, black cherry, red oak, white oak and shagbark hickory. The canopy is interrupted to continuous. The most common species are red oak, white oak, and basswood.

Catastrophic disturbances were rare in this plant community. Analysis of Public Land Survey records indicates that the rotation of catastrophic fires was in excess of 1,000 years and the rotation of catastrophic windthrow was about 390 years. Events that resulted in partial loss of trees, especially light surface fires, were much more common, with an estimated rotation of about 20 years. Based on the historic composition and age structure of these forests, there would be two growth stages separated by a long period of transition.

Young oak forests (0-55 years), recovering from fire or wind, are dominated by red oak with some white oak, basswood, and American elm. Forests aged 55-99 years are in a transition period where red oak decreases and basswood, white oak, American elm and ironwood increase. Greater than 99 years, the mature forest consists of mixed stands of white oak, basswood, red oak and elm.

Figure 13. Target Plant Communities for Restoration



C. Ecological Management Recommendations

The first step for all the forested areas of Vermillion Falls Park will be the same - invasive woody removal. The exact methods may differ at different units, and the target communities are also different, but the invasive woody eradication goals are essentially the same, as outlined below. Additional management goals and methods for each of the units are described in more detail in the paragraphs below.

1. Goals

Goals for wooded areas:

- Within 6 years, the cover of non-native trees and shrubs larger than ½ inch diameter or 4-ft height has been reduced to less than 10% throughout the park.
- Within 6 years, the cover of non-native trees and shrubs LESS than ½ inch diameter is less than 25% throughout the park.
- Throughout management, impacts to native plant species are minimized. No net loss of native plant species cover or composition.
- Within 8 years, native herbaceous plant species richness has increased 20%.

Additional site-wide goals include:

- Annual monitoring to detect new ecological threats and to track the success of restoration activities. Regular vegetation surveys are completed, including tracking rare species, to evaluate vegetation trends.
- Local community members are engaged in site stewardship.

2. Restoration Steps

In general, the ecological tasks below would be completed sequentially for each work phase. Some tasks, however, would necessarily apply to the entire project area, especially the ecological monitoring and community engagement.

Community Engagement

Involving community volunteers in ecological restoration activities and educational nature outings is very important for promoting a stewardship ethic for natural areas. The more that people learn about and are involved in a natural area the more they will care for it and support the long-term management and protection of it. Vermillion Falls Park provides various opportunities for engagement. Volunteers could be involved in hauling non-native brush from the woods, searching for and pulling garlic mustard and bittercress, installing native shrubs, and conducting plant and animal surveys for species such as earthworms, breeding birds and pollinators. Friends of the Mississippi River has a long history of community engagement and has recruited thousands of volunteers over the years for these kinds of activities.

Ecological Monitoring

Ecological monitoring of the site is critical to provide baseline data on starting conditions and to evaluate changes over time. Plant and animal surveys can be used to better inform management and to adapt and adjust methods as needed. Vegetation survey plots have not been established

but a completed sitewide survey provides some baseline data. Annual surveys should be conducted at approximately the same time each year to provide the best comparative data. Ideally two surveys would be done to capture both early and late season species.
Ecological evaluation must also be completed on a longer time-frame to evaluate canopy health and regeneration. As new tree diseases and insect infestations evolve, it will be important to assess conditions and develop methods to counteract the impacts, such as tree removal and planting tree seedlings. Given the impacts from disease, windthrow and other issues, the natural disturbance levels are not likely to need "assistance", but selective tree harvesting should also be considered if needed. Disturbance is an important component of a forest and critical for regenerating both canopy and herbaceous species.

Maple-basswood forest unit (MB)

As the unit with the most intact plant community at the park, management of MB is the highest priority. The primary management need at this unit is the removal of non-native invasive woody plants, primarily buckthorn. In this unit it must be done by hand-cutting and stump-treating stems that are at least ½-inch diameter. Brush can be chipped where accessible along trail edges, otherwise hauled, stacked and burned in openings in the bottom of the ravine. In the following year (fall), a volunteer event could be held to scout for and pull seedling buckthorn, if they are in relatively low abundance. If new stems are too abundant, they can be treated (triclopyr) by wick application; foliar spraying should not be done in this unit. Alternatively, a bud-inhibitor herbicide could be considered. The unit will need to be evaluated to determine the best method. In subsequent years, interplanting or inter-seeding native wildflowers could be considered to increase the floral diversity. This could be a trial planting, to see how well they survive. Volunteers could be recruited for the event, and plantings should be enclosed in small fenced groupings to protect them from deer browse. Fencing should be low-visibility (e.g. green vinyl-coated wire).

Mesic Oak Forest (OFm1, OFm2)

Management of the OFm1 mesic oak is also a high priority, to protect the sensitive plants in that unit. Non-native, invasive woody plants, primarily buckthorn, are the main ecological threat. Initial cutting and stump-treating stems that at least ½-inch diameter at the base, or about 4-5 feet tall should be done with triclopyr or aquatic formula glyphosate herbicide. Buckthorn should be removed as much as possible from the slopes, where doing so is not dangerous. The OFm2 unit is a sheer cliff and cannot be accessed. Cut brush near the top of the bluff can be hauled to the trail where it can be chipped and removed. Brush at the bottom of the ravine will have to be stacked and burned. The number of burn piles should be strictly minimized. A central point can serve as the burn pile, with surrounding brush piles used to feed it. Where buckthorn is quite scattered or difficult to access (e.g. the eastern quarter of the unit), it can be cut and slashed.

In addition to the large stems, there are also many existing smaller stems, less than 5-feet tall, that are too small to stump treat, and more will emerge as the larger stems are removed. We do not recommend applying a foliar herbicide to these plants, as is commonly done after initial removal, because there are too many desirable plants in this area. Wick-applying herbicide could be considered.

Hand-pulling seedling or small saplings is not recommended at this unit due to the difficulty of the terrain and the highly erodible soils. An alternative to the wick-application of herbicide is

"critical cutting" (see Appendix C), wherein the plants are cut twice a year in late spring and early fall. If done regularly for several years it can deplete the buckthorn. But desirable native woody plants are typically also depleted. Also, the difficult terrain at this unit would make brush cutting quite challenging. The most likely scenario it to monitor the site and cut and treat stems when they become large enough (about ½ inch diameter at the base, or usually about 4 to 5 feet tall). Stems must be cut before they begin producing seed.

Dry Oak Forest (OFd)

As with the previous units, buckthorn removal is the primary management need at this unit, along with small amounts of honeysuckle. Brush near the trail edges can be chipped and hauled away. Where too far to haul, brush can be stacked and burned. After the initial removal, this unit should be burned the following spring to further reduce the buckthorn seedlings and to promote and maintain the native vegetation. Additional seeding of native woodland forbs and grasses is also needed. Seed can be broadcast immediately after the burn. Growth of dense vegetation such as native grasses can be very effective at suppressing buckthorn germination. The following fall, any young buckthorn plants should be treated with a wick-applied triclopyr herbicide, or possibly a bud-inhibitor, depending on size and abundance. This step will likely be needed again in another year or two. The unit should be evaluated after buckthorn removal to determine if additional steps are needed to promote germination of canopy tree species. In addition, native shrub species could be planted, such as American hazelnut, downy arrowwood, Juneberry, nannyberry and snowberry.

Oak Woodland-Brushland (OW)

This unit is in relatively good condition, needing removal of modest amounts of buckthorn, honeysuckle and black locust. If possible, it could be burned along with OFd. Savanna forbs and grasses could be interseeded after burning and where canopy openings allow. Follow-up buckthorn control will be needed, as per OFd.

Altered Deciduous Forest (Units DF1, DF2, DF3)

The DF units were very degraded with buckthorn, with DF1 being the most and DF3 the least degraded. If buckthorn were removed and adequately controlled, native vegetation could be re-established. It would be a many-year endeavor and some level of management would always be needed to maintain the native vegetation. DF1, because it has very little native ground cover vegetation, could be almost a complete eradication. The canopy trees would stay, of course. Large buckthorn could be cut and stump-treated, then the unit could be forestry-mowed to target smaller stems. If possible, the unit could be burned along with OFd, but there may be too much woody debris. The regrowth could be foliar sprayed in the first summer after removal. Since there are so few native plants to be concerned about, an earlier spray (e.g. August) will be best for effectiveness. The unit could be heavily overseeded with native grasses, then treated the following year with a bud-inhibitor to prevent any additional buckthorn plants from maturing.

DF2 and DF3 similarly need buckthorn removal by cut and stump-treat method. They are mostly too rugged and have too many trees for forestry mowing. They can also be burned where feasible, though DF3 may not burn on the slopes. The seedling flush can be managed by a foliar herbicide application in the first two years after the initial removal.

Portions of these units also have very sparse ground cover. They can be overseeded with native grasses to help prevent buckthorn germination. Additional evaluation will be needed after the brush removal to determine next steps.

The old trash pile in DF3 should also be removed.

Altered Deciduous Woodland (DW1, DW2, DW3, DW4)

Management of the DW units should be conducted along with the GR units as they are closely connected. At a minimum, buckthorn and honeysuckle should be eradicated. This has mostly been completed for DW3, although follow-up management of resprouts and seedlings will be needed.

Large trees of non-native species (primarily Siberian elm) will also need to be removed and if possible used for biofuels. However, there may not be enough to make that a viable option, in which case trees should be chipped and hauled away. Avoid burning large amounts of woody material, for the carbon release.

The old trash dump in DW1 should be removed, along with any other trash.

Daylilies, mostly in DW3, need to be eradicated to prevent further spread. Some of the smaller trees in DW3, especially where they are crowding large oak trees, could be removed to open the canopy to a more woodland condition and to enable more oak regeneration.

After the invasive woody plants are removed, these units should be burned, along with the oak woodland units (DF1,2,3, OFd, OW). Fire should be a regular management tool at these units to mimic the historical frequency. After invasive woody plants are controlled, these units can then be seeded with oak woodland species.

Grassland (GRn, GRs, GRw)

The initial step for these units will be removal of non-native invasive woody plants. This will be a significant endeavor since many of the trees and shrubs are quite large. Once the woody plants are removed, the grassland units can be burned, in either spring or fall, to remove the existing thatch. Following the burn, the units can be forestry mowed to get the tree stumps flush with the ground. This will enable equipment used for mowing, seeding and herbicide to easily traverse the site without hindrance, thus preventing weed patches that otherwise result when equipment has to avoid driving over tree stumps. Alternatively, tree stumps could be ground out, but that is a more costly effort and not strictly necessary, as the stumps will degrade in a few years.

All the units should be burned after the woody removal is complete, to remove the existing thatch. GRn has a mostly native cover of shrubs (sumac), so it will not need intensive eradication of vegetation. After invasive woody removal and a burn, native forbs and grasses can be broadcast at this unit, followed by two years of mowing, which will help to increase the native plant diversity.

For GRs and GRw, site preparation will continue after the burn, and will consist of applying herbicide to eradicate the existing vegetation. To minimize weed seed germination, it is beneficial to avoid disturbing the soil. If the soil is bare after the site preparation is complete, then the seed can be broadcast on the surface in the fall (or snow-seeded in late winter). If there is still thatch from the dead grasses, it may be necessary to either drill-seed the site or to expose the soil by lightly disking.

Following seeding, these units will need three years of management as part of the establishment process. Mowing is needed the first growing season, typically two or three times, to maintain a height of no more than 12-16 inches. A rear-dumping flail mower should be used so that cut material does not bury the new growth and mowing should be to a height of about 6 inches. Mowing too low would be detrimental to the new plants.

One mowing in late spring would be done the second growing season, and a prescribed burn would be done in the third growing season, if the site has adequate fuels. Spot-spraying or spot-mowing invasive weeds should begin in the second growing season, and all weedy plants should be prevented from producing seed.

In the long-term the grassland should be monitored and managed annually for invasive weeds and woody plants. A prescribed burn should be done every 3 to 5 years, as conditions dictate.

Vegetation surveys should be an integral part of the monitoring plan for this unit, to evaluate the establishment success of the new plants. Additionally, it would be very helpful to conduct pollinator surveys, both before and after restoration, to document how wildlife habitat changes to the site.

D. Restoration Schedule

1. Work Phases

Project work for each of the work phases will begin with non-native, invasive species control (primarily buckthorn). After non-native species removal, some areas will need supplemental seed and/or native forbs and shrubs.

A five-year Work Plan (**Table 4**) was developed to provide guidelines toward achieving the target communities shown in **Figure 14**. The table shows the work phases, activities, schedules, and estimated costs. A general time frame is shown for each phase, but note that "year 1" for each unit is independent of "year 1" in other units, though they may coincide. Note also that the costs shown are estimates, based on similar work at other sites, but actual costs may be higher or lower, depending on multiple variables. Furthermore, costs for project management and ecological monitoring are not included.

Table 4. Five-Year Work Plan

Phase 1: Non-native tree and shrub removal from east and riverside of park

Priority	Year	Season	Units	Ecological Task	Acres	Est Cost/ac	Est cost
1	1	Fall	MB	Hand-cut & stump treat non-native trees and shrubs > 0.5 inch diam. Chip near trails, stack & burn rest in base of ravine.	1.7	$ 900.00	$ 1,530.00
1	2	Late Sept/earl y Oct.	MB	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite. No later than early Oct.	1.7	$ 900.00	$ 1,530.00
1	3	Fall	MB	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite. (this step may need to wait until year 4).	1.7	$ 600.00	$ 1,020.00
4	4	Spring	MB	Install trial patches of native wildflowers, plus cages. Volunteers.			$ 1,200.00
							$ 5,280.00
1	1	Fall	OFm1	Hand-cut & stump treat non-native trees and shrubs > 0.5 inch diam. Stack/burn - minimal piles. Haul and chip at top of the bluff.	2.5	$ 2,200.00	$ 5,500.00
1	2	Fall	OFm1	Follow-up woody control: Apply bud inhibitor (Sept) OR wick-apply herbicide (Vastlan or Garlon 3a) to seedlings/short plants (Aug).	0.7	$ 1,600.00	$ 1,120.00
							$ 6,620.00
1	1	Fall	OFd	Hand-cut & stump treat non-native trees and shrubs > 0.5 inch diam. Chip as much as possible, stack/burn interior.	1.2	$ 1,900.00	$ 2,280.00
1	2	Spring	OFd	Rx burn along with OW and all the DF units (where feasible)	6.3		$ 6,800.00
1	2	Spring	OFd	Post burn, broadcast native woodland seed, especially grasses such as wild rye.	1.2	$ 800.00	$ 960.00
1	2	Late Sept/earl y Oct.	OFd	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite. No later than early Oct.	6.3	$ 900.00	$ 5,670.00
1	3	Fall	OFd	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite. (this step may need to wait until year 4).	6.3	$ 500.00	$ 3,150.00
3	4	Spring	OFd	Install trial groups of native shrubs, with wire cages. Volunteers			$ 2,500.00
							$ 21,360.00
1	1	Fall	OW	Hand-cut & stump treat non-native trees and shrubs > 0.5 inch diam. Chip and haul away.	0.5	$ 950.00	$ 475.00
1	2	Spring	OW	Rx burn along with OFd	0.5		
1	2	Spring	OW	Post burn, broadcast native savanna seed.	0.5	$ 800.00	$ 400.00
1	2	Late Sept/earl y Oct.	OW	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite. No later than early Oct.	0.5	$ 700.00	$ 350.00
1	3	Fall	OW	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite. (this step may need to wait until year 4).	0.5	$ 500.00	$ 250.00
							$ 1,475.00

Priority	Year	Season	Units	Ecological Task	Acres	Est Cost/ac	Est cost
1	1	Fall	DF1	Hand-cut & stump treat non-native trees and shrubs > 1 inch diam. Then forestry mow unit.	1.1	$ 3,000.00	$ 3,300.00
1	2	Spring	DF1	Rx burn along with Ofd unless too much woody debris.	1.1		
1	2	August	DF1	Broadcast apply Triclopyr (Vastlan or Garlon 3a) to buckthorn carpet. Must be in August.	0.9	$ 700.00	$ 630.00
1	2	Oct-Dec	DF1	Broadcast native oak woodland seed mix, heavy on grasses.	1.1	$ 950.00	$ 1,045.00
1	3	Sept	DF1	Follow-up woody control: Apply bud inhibitor.	1.1	$ 600.00	$ 660.00
3	3	Fall	DF1	Remove Trash			TBD
							$ 5,635.00
1	1	Fall	DF2	Hand-cut & stump treat non-native trees and shrubs > 0.5 inch diam. Chip and haul away.	0.7	$ 2,900.00	$ 2,030.00
1	2	Spring	DF2	Rx burn along with Ofd unless too much woody debris.	0.7		
1	2	Fall	DF2	Follow-up woody control: Apply bud inhibitor (Oct) OR wick-apply herbicide to seedlings/short plants (Aug).	0.7	$ 900.00	$ 630.00
1	2	Oct-Dec	DF2	Broadcast native oak woodland seed mix, heavy on grasses. Most of unit will need it.	0.7	$ 900.00	$ 630.00
1	4	Fall	DF2	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite.	0.7	$ 1,200.00	$ 840.00
							$ 4,130.00
1	1	Fall	DF3	Hand-cut & stump treat non-native trees and shrubs > 0.5 inch diam. Chip as much as possible, stack/burn interior.	0.9	$ 2,400.00	$ 2,160.00
1	2	Spring	DF3	Rx burn along with Ofd unless too much woody debris.	0.9		
1	2	Fall	DF3	Follow-up woody control: Apply bud inhibitor (Oct) OR wick-apply herbicide to seedlings/short plants (Aug).	0.9	$ 900.00	$ 810.00
1	2	Oct-Dec	DF3	Broadcast native oak woodland seed mix, heavy on grasses. Needed in occasional openings.	0.3	$ 900.00	$ 270.00
1	4	Fall	DF3	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite.	0.9	$ 900.00	$ 810.00
							$ 4,050.00
1	1	Fall	DW3	Hand-cut & stump treat few remaining buckthorn. shrubs > 0.5 inch diam. Haul and chip.	1.9	$ 400.00	$ 760.00
1	2	Spring	DW3	Rx burn along with OFd	1.9		
1	2	Spring	DW3	Post burn, broadcast native savanna seed.	1.9	$ 600.00	$ 1,140.00
1	2	Spring	DW3	Spot-spray daylily patches	1.9	$ 200.00	$ 380.00
1	2	Late Sept/earl y Oct.	DW3	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite. No later than early Oct.	1.9	$ 900.00	$ 1,710.00
1	3	Fall	DW3	Follow-up buckthorn control: wick-apply herbicide (Vastlan or Garlon 3a) to new seedlings or apply krenite. (this step may need to wait until year 4).	1.9	$ 400.00	$ 760.00
							$ 4,750.00
				Top priority tasks (note 2 tasks above are not top priority)			**$ 49,600.00**
				Additonal lower priority tasks			**$ 3,700.00**

Phase 2 Tasks - Non-native tree and shrub removal from west half of park

Priority	Year	Season	Units	Ecological Task	Acres	Est Cost/ac	Est cost
1	1	Fall	DW1, DW2	Hand-cut & stump treat non-native shrubs > 0.5 inch diam. Chip and haul away.	2	$ 2,900.00	$ 5,800.00
1	1	Fall	DW1	If possible, forestry mow to remove thicket of smaller stems. Beware of bedrock outcrops.	1.3	$ 1,200.00	$ 1,560.00
1	1	Fall	DW1, DW2	Cut & stump treat all non-native trees. Chip and haul away.	2	$ 2,900.00	$ 5,800.00
2	2	Fall	DW1	Remove old trash and debris	1.3		TBD
1	2	Aug	DW1, DW2	Broadcast apply Triclopyr (Vastlan or Garlon 3a) to buckthorn carpet. Must be in August.	2	$ 800.00	$ 1,600.00
		Spr	DW1, DW2	Purchase oak savanna seed, heavy on grasses	2	$ 600.00	$ 1,200.00
1	2	Oct-Nov	DW1, DW2	Broadcast native oak savanna seed mix (coordinate with seeding GR units)	2	$ 300.00	$ 600.00
1	1	Fall	GRw, GRn, GRs	Cut & stump treat non-native shrubs > 0.5 inch diam. Chip and haul away.	4	$ 2,900.00	$ 11,600.00
1	1	Fall	GRw, GRn, GRs	Cut & stump treat all non-native trees (some large). Chip and haul away.	4	$ 4,000.00	$ 16,000.00
							$ 44,160.00

Phase 3 Tasks - Savanna restoration of GR units

Priority	Year	Season	Units	Ecological Task	Acres	Est Cost/ac	Est cost
1	1	Sept	GRw, GRs, GRn	Rx burn	4		$ 3,500.00
1	1	Oct	GRw, GRs	Spray green-up 4-6 weeks after burn to eradicate existing (non-native) ground cover.	2.8	$ 300.00	$ 840.00
1	2	Summer - fall	GRw, GRs	Re-spray 2-3 times.	2.8	$ 700.00	$ 1,960.00
1	2	Spring	GRw, GRs	Purchase prairie/savanna seed, keep forbs and graminoids separate	2.8	$ 800.00	$ 2,240.00
1	2	Fall	GRw, GRs	Broadcast forb seed (Coordinate with seeding of DW units)	2.8	$ 500.00	$ 1,400.00
1	3	May	GRw, GRs	Drill grass seed very early spring.	2.8	$ 450.00	$ 1,260.00
1	3	Spr-Fall	GRw, GRs	Mow 2 times, flail mower, when vegetation is 12 inches, to height of 6 inches.	2.8	$ 500.00	$ 1,400.00
1	3	June	GRw, GRs	Mow once, flail mower, when vegetation is 12 inches, to height of 6 inches.	2.8	$ 500.00	$ 1,400.00
1	4	May	GRw, GRs, GRn	Rx burn	4		$ 3,500.00
1	4	May	GRw, GRs, GRn	Spot-spray/spot mow weeds as needed.	4	$ 500.00	$ 2,000.00
							$ 19,500.00
				TOTAL ALL PHASES			**$116,960.00**

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Appendix A: Plant Species Recorded at the Vermillion Falls Park

The following species were recorded at the park by Friends of the Mississippi River in 2019.

ALTERED DECIDUOUS FORESTS

				DF1		DF3	
Non-native	Ht (m)	Scientific Name	Common Name	Relative Cover *	Diam/Notes	Relative Cover	Diam/Notes
	10-35	**CANOPY (decid)**	**% cov of ht class**	**4**		**5**	Very dark
		Acer saccharum	sugar maple	2	6-16		
		Juglans nigra	black walnut			1	8"
		Prunus serotina	black cherry			1	10"
		Quercus ellipsoidalis	pin oak	1	10"		
		Quercus macrocarpa	bur oak	2	12"	3	20"
		Quercus rubra	red oak			2	12"
x		*Robinia pseudoacacia*	black locust	0.1	edge		
		Tilia americana	American basswood			2	10"
	5-10	**SUBCANOPY (deciduous)**		**2**		**2**	
		Acer saccharum	sugar maple	1			
		Juglans nigra	black walnut			1	
		Juniperus virginiana					
		Ostrya virginiana	ironwood	1		1	6"
		Tilia americana	American basswood	1		1	
	1.5-3	**SHRUB (decid)**		**4**		**3**	
x		*Lonicera tatarica*	Tatarian honeysuckle	1			
		Prunus virginiana	choke cherry	1			
x		*Rhamnus cathartica*	common buckthorn	4	0.5-3", esp edges.	3	
		Zanthoxylum americana	prickly ash			1	
	0-1.5	**GROUND LAYER**		**4**		**5**	
	0-0.5	**Deciduous**		**4**		**4**	
		Acer saccharum	sugar maple	1		1	
		Celtis occidentalis	hackberry	0.1			
x		*Lonicera tatarica*	Tatarian honeysuckle	1		1	
		Prunus virginiana	choke cherry	0.1			
x		*Rhamnus cathartica*	common buckthorn	4	Almost solid, 1-8"	3	
		Rubus occidentalis	blackcap			1	
		Ostrya virginiana	ironwood	0.1			
		Tilia americana	basswood			0.1	
		Toxicodendron radicans	poison ivy			1	
			No. Spp	6		6	
	0-0.5	**Climbers**		**1**		**2**	
		Menispermum canadense	Moonseed	0.1		0.1	
		Parthenocissus inserta	woodbine	1			
		Parthenocissus quinquefolia	Virginia creeper			1	
		Vitis riparia	Wild grape vine	0.1		1	
			No. Spp	3		3	
	0-0.5	**Herbaceous cover & ferns**		**1**		**2**	
		Ageratina rugosum	white snakeroot			1	
		Allium tricoccum	wild leek			0.1	
		Anemeone quinquefolia	wood anemone			0.1	

ALTERED DECIDUOUS FORESTS continued

		Anemone cylindrica	thimbleweed			0.1	
		Aralia nudicaulis	wild sarsaparilla			0.1	
		Arisaema triphyllum	Jack in the pulpit			0.1	
		Asarum canadense	wild ginger			1	south by road
		Caulophyllum thalictroides	blue cohosh			1	
		Circea lutetiana	enchanters nightshade	0.1		0.1	
		Galium aparine	cleavers	0.1			
		Galium asprellum	rough bedstraw			1	
		Galium triflorum	sweet-scented bedstraw			0.1	
		Geranium maculatum	wild geranium			1	
		Geum canadense	white avens	0.1		0.1	
		Hackelia virginiana	Virginia stickseed			1	
		Heptatica acutiloba	sharp-lobed hepatica			0.1	
		Hydrophyllum virginianum	Virginia waterleaf	1		1	Abundant SE
		Impatiens capensis	Spotted touch-me-not			0.1	
		Mianthemum racemosa	false Solomon's seal	0.1		0.1	
		Monarda fistulosa	bergamot			0.1	south edge
		Polygonatum pubscens	hairy solomon's seal	0.1		0.1	
		Ranunculus abortivus	Little leaf buttercup	0.1			
		Sanguinaria canadense	bloodroot	0.1		0.1	
		Smilax sp	carrion plant			0.1	
		Solidago canadensis	Canada goldenrod			0.1	
		Solidago flexicaulis	zigzag goldenrod	0.1		1	
x		*Taraxacum officinale*	dandelion			0.1	
		Thalictrum dioicum	early meadowrue	0.1		1	
		Viola sp	Violet	0.1			
			No. Spp	11		26	
	0-0.5	**Graminoids**		**1**		**2**	
		Carex pennsylvanica	Pennsylvania sedge	1		2	
			No. Spp	1		1	
			Total No. ground Layer species:	**21**		**36**	

* Relative Cover Classes for individual species and vegetation layers: 0.1 (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%).

ALTERED DECIDUOUS WOODLANDS

				DW1		DW2		DW3		DW4	
Non-native	Ht (m)	Scientific Name	Common Name	Relative cover*	Diam/Notes	Relative cover*	Diam/Notes	Relative cover*	Diam/Notes	Relative cover*	Diam/Notes
	10-35	**CANOPY (decid)**	**Cover of ht class***	**4**		**4**		**4**		**4**	
		Acer negundo	boxelder	1						3	10-14"
		Celtis occidentalis	hackberry	1		1	15"	1	5		
		Fraxinus pensylvanica	green ash					1			
		Juglans nigra	black walnut	2	6"	1	15"	1		1	6
		Juniperus virginiana	red cedar					2			
		Populus tremuloides	quaking aspen	2	6-10"						
		Quercus ellipsoidalis	pin oak	2	12"			3	4,6,10,20"		
		Quercus macrocarpa	bur oak	3	Dominant in west. 10-20"	3	Dom. Mostly 10". Huge 28"	2	4, 8, 20 some spreading	2	5
		Quercus rubra	red oak					2	8		
		Tilia americana	American basswood					1	4, 10	1	5
		Ulmus americana	American elm	2	Dom in east: 8,10,12,18"	1	10	1			
x		*Ulmus pumila*	Siberian elm	0.1		1		2	Huge, 12" dbh.	3	6,8,10
			No. Spp	8		5		10		5	
	5-10	**SUBCANOPY (deciduous)**		**2**		**1**		**2**		**0**	
		Celtis occidentalis	hackberry	1	4"						
		Fraxinus pensylvanica	green ash			1		0.1			
		Juglans nigra	black walnut	1							
		Populus tremuloides	quaking aspen	1							
		Prunus serotina	black cherry	1				1			
		Quercus macrocarpa	bur oak					1			
		Tilia americana	American basswood	1				1	3,2		
				5		1		4		0	
	1.5-3	**SHRUB (decid)**		**4**		**4**		**0**		**2**	
		Fraxinus pensylvanica	green ash			0.1		1			
x		*Lonicera tatarica*	Tatarian honeysuckle	2		2	Huge-10' wide	0.1		1	
		Prunus virginiana	choke cherry					0.1			
x		*Rhamnus cathartica*	common buckthorn	4	1-2"	4	Huge-25' tall			1	
		Rhus glabra	smooth sumac							2	
		Tilia americana	American basswood					1			
		Zanthoxylum americana	prickly ash	2							
			No. Spp	3		3		4		3	
	0-1.5	**GROUND LAYER**		**5**							
	0-0.5	**Deciduous**		**3**		**4**		**3**		**4**	
		Acer negundo	boxelder					0.1			
		Acer saccharum	sugar maple					0.1			
		Celtis occidentalis	hackberry	0.1				0.1			
		Fraxinus pensylvanica	green ash							1	
x		*Lonicera tatarica*	Tatarian honeysuckle	1		1		0.1		2	
		Prunus virginiana	choke cherry					0.1			
		Quercus macrocarpa	bur oak					0.1			
x		*Rhamnus cathartica*	common buckthorn	3	dom (sdl)	4		2		4	
		Tilia americana	basswood			0.1		0.1			
		Toxicodendron radicans	poison ivy	1				2			
		Unk	non-native nursery plant	0.1							
		Zanthoxylum americana	prickly ash					0.1			
			No. Spp	5		3		10		3	
	0-0.5	**Climbers**		**2**							
		Parthenocissus inserta	woodbine					1			
		Parthenocissus quinquefolia	Virginia creeper	1				2			
		Vitis riparia	Wild grape vine	1		1		2			
				2		1		3		0	

ALTERED DECIDUOUS WOODLANDS continued

	0-0.5	**Herbaceous cover & ferns**						**4**			
		Achillea millefolium	yarrow					0.1			
		Actaea rubra	red baneberry					0.1			
		Ageratina rugosum	white snake root	0.1				0.1			
		Anemone cylindrica	thimbleweed					0.1			
		Asclepias verticillata	whorled milkweed					0.1			
		Besseya bullii	kittentail					0.1	2 plants, no flowers		
		Circea lutetiana	enchanters nightshade					0.1			
		Galium aparine	cleavers	0.1							
		Galium boreale	northern bedstraw					0.1			
		Galium triflorum	sweet-scented bedstraw	1				0.1		0.1	
		Geum canadense	white avens	0.1		1		1			
		Hackelia virginiana	Virginia stickseed	0.1							
x		*Hemerocallis sp*	daylily					1	Spot spray		
		Impatiens capensis	Spotted touch-me-not					0.1			
x		*Leonurus cardiaca*	motherwort	1						0.1	
x		*Melilotus alba*	white sweet clover					0.1		0.1	
		Mianthemum canadense	Canada mayflower					0.1			
		Monarda fistulosa	bergamot					0.1			
		Phryma leptostachya	lopseed					0.1			
		Pilea sp	clearweed	1							
		Ranunculus abortivus	Little leaf buttercup	0.1							
		Solidago canadensis	Canada goldenrod					1			
		Solidago flexicaulis	zigzag goldenrod					2			
		Symphyotrichum cordifolius	Heart-leaved aster					0.1			
x		*Taraxacum officinale*	dandelion					0.1			
		Triosteum perfoliatum	horse gentian							0.1	
x		*Verbascum thapsus*	common mullein							0.1	
		Viola sp	Violet					0.1			
			No. Spp	7		1		15		5	
	0-0.5	**Graminoids**						**2**		**2**	
x		*Bromus inermis*	smooth brome							2	
		Carex blanda	Carex blanda	0.1				0.1			
		Carex pensylvanica	Pennsylvania sedge					0.1			
		Carex radiata	eastern star sedge					0.1			
		Carex sp	carex sp	0.1							
		Leersia virginica	white grass					1			
		Schizachyrium scoparius	little bluestem					1			
			No. Spp	2		0		5		1	
			Total No. ground Layer species:	**16**		**5**		**33**		**9**	

* Relative Cover Classes for individual species and vegetation layers: 0.1 (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%).

DRY OAK FOREST (OFd) AND OAK WOODLAND-BRUSHLAND (OW)

				OFd		OW	
Non-native Inva-sive	Ht (m)	Scientific Name	Common Name	Relative cover*	Diam/notes	Relative cover*	Diam/notes
	10-35	**CANOPY (decid)**	**% cov of ht class ***	**5**		**3**	
		Betula papyrifera	paper birch			0.1	
		Carya cordiformes	bitternut hickory	1	10		
		Fraxinus pensylvanica	green ash			1	
		Juglans nigra	black walnut	1	10		
		Ostrya virginiana	ironwood			2	
		Prunus serotina	black cherry	2	12		
		Quercus alba	white oak	1	10, 18,24		
		Quercus ellipsoidalis	pin oak	2	12	3	10
		Quercus macrocarpa	bur oak	2	18	2	16
		Quercus rubra	red oak	2	12, 14	1	
		Tilia americana	American basswood	1	12		
	5-10	**SUBCANOPY (deciduous)**		**3**		**2**	
		Fraxinus nigra	black ash	0.1			
		Juglans nigra	black walnut	1			
		Juniperus virginiana	red cedar	1		1	
		Ostrya virginiana	ironwood	2	4"	1	
		Quercus macrocarpa	bur oak	1		1	
		Rhamnus cathartica	buckthorn	2			
x		*Robinia pseudoacacia*	black locust			0.1	4" by trail
		Sorbus sp	mountain ash species			0.1	European or
		Tilia americana	American basswood	1			
	1.5-3	**SHRUB (decid)**		**3**		**2**	
		Cornus rugosa	round-leaved dogwood			1	
		Corylus cornuta	beaked hazelnut			1	
		Fraxinus pensylvanica	green ash	1			
x		*Lonicera tatarica*	Tatarian honeysuckle	1		2	
		Ostrya virginiana	ironwood	0.1			
		Prunus serotina	black cherry			1	
		Prunus virginiana	choke cherry	0.1			
		Quercus macrocarpa	bur oak			0.1	
x		*Rhamnus cathartica*	common buckthorn	2	2" on edges. 20% total	2	Mostly west end.
		Tilia americana	basswood	0.1		1	
		Zanthoxylum americana	prickly ash	1		1	
	0-1.5	**GROUND LAYER**		**4**		**4**	
	0-0.5	**Deciduous**		**2**		**2**	
		Acer negundo	boxelder	0.1			
		Acer saccharum	sugar maple	0.1	sdl		
		Carya cordiformes	bitternut hickory	0.1			
		Juniper virginiana	red cedar	0.1		0.1	
x		*Lonicera tatarica*	Tatarian honeysuckle	1		0.1	
		Ostrya virginiana	Ironwood	1			
		Prunus serotina	black cherry	0.1		1	
		Quercus macrocarpa	bur oak	0.1		0.1	
		Quercus rubra	Red oak			0.1	

DRY OAK FOREST (OFd) AND OAK WOODLAND-BRUSHLAND (OW) continued

x		*Rhamnus cathartica*	common buckthorn	2	sdl only	2	
		Ribes missouriensis	Missouri gooseberry	0.1		1	
		Tilia americana	basswood	0.1			
		Toxicodendron radicans	poison ivy	0.1		0.1	
		Zanthoxylum americana	prickly ash	0.1			
			No. Spp	13		8	
	0-0.5	**Climbers**		**3**			
		Parthenocissus inserta	woodbine	1			
		Parthenocissus quinquefolia	Virginia creeper	2			
		Smilax tamnoides	bristly greenbriar			0.1	
		Vitis riparia	Wild grape vine	1			
			No. Spp	3		1	
	0-0.5	**Graminoids**		**4**		**3**	
		Bouteloua curtipendula	sideoats grama			0.1	
		Carex blanda	Carex blanda	1		1	
		Carex pennsylvanica	Pennsylvania sedge	4		3	
		Leersia virginica	white grass	0.1			
		Schizachyrium scoparius	little bluestem			1	
		Sorghastrum nutans	Indiangrass			0.1	
			No. Spp	3		5	
	0-0.5	**Herbaceous cover & ferns**		**1**		**1**	
		Anemeone cylindrica	thimbleweed			0.1	
		Desmodium glutinosum	pointed leaved tick-trefoil	0.1			
		Galium asprellum	rough bedstraw	1			
		Galium boreale	northern bedstraw			0.1	
		Galium triflorum	sweet-scented bedstraw	1			
		Geranium maculatum	wild geranium	0.1			
		Geum canadense	white avens			0.1	
x		*Melilotus alba*	white sweet clover			0.1	
		Potentilla simplex	common cinquefoil	1			
		Sanguinaria canadense	bloodroot	0.1			
		Solidago canadensis	Canada goldenrod			1	
		Solidago flexicaulis	zigzag goldenrod	1		1	
		Solidago nemoralis	gray goldenrod			0.1	
		Symphyotrichum cordifolius	Heart-leaved aster			1	
		Symphyotrichum oolentangiense	sky blue aster			0.1	
			No. Spp	7		9	
			Total No. ground Layer species:	**26**		**23**	

* Relative Cover Classes for individual species and vegetation layers: 0.1 (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%).

GRASSLAND

				GRw		GRn		GRs	
Non-native	Ht (m)	Scientific Name	Common Name	Relative cover*	Diam (in), Notes	Relative cover*	Diam (in), Notes	Relative cover*	Diam (in), Notes
	10-35	**CANOPY (decid)**		**3**				**1**	
		Acer negundo	Boxelder	2	18				
		Fraxinus pensylvanica	green ash	1	6"				
		Juglans nigra	black walnut					1	20"
		Populus deltoides	cottonwood	1	12				
		Populus tremuloides	quaking aspen	1	8" East edge				
		Quercus macrocarpa	bur oak	1	10", 20" west of trail				
		Ulmus americana	American elm	1	15"				
x		*Ulmus pumila*	Siberian elm	3	Dom. 12", 8"			1	Huge 12" at SE corner
			No. Spp	7		0		2	
	5-10	**SUBCANOPY (deciduous)**		**3**		2(25%)			
		Fraxinus pensylvanica	green ash	2		2	Dominant		
		Juglans nigra	black walnut			1			
		Juniperus virginiana	red cedar			1			
		Morus alba	white mulberry	1					
		Prunus sertotina	black cherry			1			
x		*Rhamnus cathartica*	common buckthorn						
x		*Robinia pseudoacacia*	black locust	2					
		Tilia americana	American basswood			1			
x		*Ulmus pumila*	Siberian elm	3					
			No. Spp	3		4		0	
	1.5-3	**SHRUB (decid)**		3		4		2	
		Juniperus virginiana	red cedar	1		0.1			
x		*Lonicera tatarica*	Tatarian honeysuckle	2		2		2	
x		*Rhamnus cathartica*	common buckthorn	2		2	15 ft tall	2	
		Rhus glabra	smooth sumac			4			
		Tilia americana	basswood	1					
			No. Spp	4		4		2	
	0-1.5	**GROUND LAYER**		**5**		**5**			
	0-0.5	**Deciduous and vines**		**1**		**3**		**2**	
		Acer negundo	boxelder	0.1		1			
		Fraxinus pensylvanica	green ash	1		1			
		Juglans nigra	black walnut	0.1		1			
		Juniperus virginiana	red cedar			1		0.1	
x		*Lonicera tatarica*	Tatarian honeysuckle	0.1					
		Parthenocissus inserta	Virginia creeper	1		1			
		Prunus serotina	black cherry			1			
x		*Rhamnus cathartica*	common buckthorn	0.1				2	
		Rhus glabra	smooth sumac	0.1					
		Rubus occidentalis	blackcap			2		2	
		Zanthoxylum americana	prickly ash	0.1					
			No. Spp	8		7		3	
	0-0.5	**Herbaceous cover & ferns**		**3**		**3**		**2**	
		Asclepias syriaca	common milkweed			1			
x		*Asparagus officinale*	asparagus	0.1					
		Cirsium dicolor	field thistle			1			
		Galium aparine	cleavers	0.1					
		Galium triflorum	fragrant bedstraw			0.1			
x		*Hemerocallis fulva*	daylily	0.1					
x		*Linaria vulgaris*	butter and eggs	1		1			

GRASSLAND continued

x		*Melilotus alba*	white sweet clover	1					
		Monarda fistulosa	bergamot	1		2		1	
x		*Nepeta cataria*	catnip	0.1					
		Physalis virginiana	Virginia ground cherry	0.1					
		Pyrola americana	round-leaved pyrola			0.1			
		Solidago canadensis	Canada goldenrod	2		2		2	
		Solidago gigantea	late goldenrod	2					
		Symphyotrichum sp	white aster	0.1					
		Symphyotrichum oolentangiense	sky blue aster	0.1		0.1			
x		*Taraxacum officinale*	dandelion	1					
x		*Tragopon dubius*	goats beard			0.1			
x		*Trifolium repens*	white clover			0.1			
x		*Verbascum thapsus*	common mullein	0.1					
		Verbena stricta	hoary vervain	0.1		0.1			
			No. Spp	15		11		2	
	0-0.5	**Graminoids**		**4**		**4**		**4**	
		Andropogon gerardii	big bluestem	0.1		1			
x		*Bromus inermis*	smooth brome	4		4		4	
		Carex blanda	Blandings sedge			1			
x		*Poa pretensis*	Kentucky bluegrass	3		2			
x		*Poa spp*	Turf grass			2			
x		*Setaria glauca*	yellow foxtail			1		2	
		Sorghastrum nutans	Indian grass			1			
			No. Spp	3		7		2	
			Total No. ground Layer species:	**26**		**25**		**7**	

* Relative Cover Classes for individual species and vegetation layers: 0.5 (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%).

MAPLE-BASSWOOD FOREST (MB)

Non-native	Ht (m)	Scientific Name	Common Name	Relative Cover	Diam/Notes
	10-35	**CANOPY (decid)**	**% cov of ht class**	**5**	**very dense**
		Acer saccharum	sugar maple	3	dbh: 8", 10", 20"
		Celtis occidentalis	hackberry	1	20"
		Prunus serotina	black cherry	1	8"
		Quercus alba	white oak	1	25"
		Tilia americana	American basswood	2	10, 12"
		Ulmus americana	American elm	1	6,6"
			No. Spp	6	
	5-10	**SUBCANOPY (deciduous)**		**3**	
		Ostrya virginiana	ironwood	2	
		Quercus macrocarpa	bur oak	1	
			No. Spp	2	
	1.5-3	**SHRUB (decid)**		**1**	**very sparse**
		Prunus virginiana	choke cherry	1	
x		*Rhamnus cathartica*	common buckthorn	1	
			No. Spp	2	
	0-1.5	**GROUND LAYER**		**2-4**	
	0-0.5	**Deciduous**		**1**	
		Acer saccharum	sugar maple	1	
		Celtis occidentalis	hackberry	0.1	
x		*Rhamnus cathartica*	common buckthorn	0.1	
		Tilia americana	basswood	0.1	
		Ulmus americana	American elm	0.1	
		Zanthoxylum americana	prickly ash	0.1	
			No. Spp	6	
	0-0.5	**Climbers**		**2**	
		Menispermum canadense	Moonseed	0.1	
		Parthenocissus quinquefolia	Virginia creeper	2	
		Vitis riparia	Wild grape vine	0.1	
			No. Spp	3	
	0-0.5	**Herbaceous cover & ferns**		**1**	
		Allium tricoccum	wild leek	0.1	
		Anemeone quinquefolia	wood anemone	0.1	
		Aralia nudicaulis	wild sarsaparilla	0.1	
		Arisaema triphyllum	Jack in the pulpit	0.1	
		Asarum canadense	wild ginger	1	
		Caulophyllum thalictroides	blue cohosh	0.1	
		Circea lutetiana	enchanters nightshade	0.1	
		Impatiens capensis	Spotted touch-me-not	0.1	
		Mianthemum racemosa	false Solomon's seal	0.1	
		Polygonatum pubscens	hairy solomon's seal	0.1	
		Sanguinaria canadense	bloodroot	0.1	
		Solidago flexicaulis	zigzag goldenrod	0.1	
		Thalictrum dioicum	early meadowrue	0.1	
			No. Spp	13	
	0-0.5	**Graminoids**		**1**	
		Carex pennsylvanica	Pennsylvania sedge	1	
		Carex sp	carex sp	1	
			No. Spp	2	
			Total No. ground Layer species:	**24**	

* Relative Cover Classes for individual species and vegetation layers: 0.1 (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%).

MESIC OAK FOREST

				MF1	
Non-native	Ht (m)	Scientific Name	Common Name	Relative cover*	Diam (in), notes
	10-35	**CANOPY (decid)**	**% cov of ht class**	**4**	
		Acer negundo	boxelder	2	10, 14
		Celtis occidentalis	hackberry	2	12, 15
		Tilia americana	American basswood	2	
		Ulmus americana	American elm	2	18
			No. Spp	4	
	5-10	**SUBCANOPY (deciduous)**		**2**	
		Acer negundo	boxelder	1	4
		Celtis occidentalis	hackberry	1	4
		Juglans nigra	black walnut	1	
		Tilia americana	American basswood	2	
			No. Spp	4	
	1.5-3	**SHRUB (decid)**		**3**	
		Celtis occidentalis	hackberry	1	
		Cornus alternifolia	pagoda dogwood	1	
x		*Lonicera tartarica*	Tartarian honeysuckle	2	
		Prunus virginiana	choke cherry	1	
x		*Rhamnus cathartica*	common buckthorn	2	West: large,
		Sambucus racemosa	Red berried elder	0.1	
		Tilia americana	basswood	1	
		Zanthoxylum americana	prickly ash	1	
			No. Spp	8	
	0-1.5	**GROUND LAYER**		**5**	
	0-0.5	**Deciduous**		**3**	
		Rubus occidentalis	blackcap	0.1	
		Taxus canadensis	Canada yew	2	
		Toxicodendron radicans	poison ivy	0.1	
		Ulmus americana	American elm	0.1	
			No. Spp	4	
	0-0.5	**Climbers**		**3**	
		Dioscorea villosa	wild yam	0.1	
		Menispermum canadense	Moonseed	0.1	
		Parthenocissus inserta	woodbine	2	
		Parthenocissus quinquefolia	Virginia creeper	2	
		Vitis riparia	Wild grape vine	0.1	
			No. Spp	5	
	0-0.5	**Graminoids**		**1**	
		Carex pennsylvanica	Pennsylvania sedge	1	
		Carex sp	carex sp	1	
			No. Spp	2	
	0-0.5	**Herbaceous cover & ferns**		**4**	
		Aquilegia canadense	Columbine	0.1	
x		*Arctium minus*	burdock	0.1	
		Arisaema triphyllum	Jack in the pulpit	2	
		Cystopteris bulbifera	bulblet fern	2	
		Asplenium rhizophyllum	walking fern	0.1	
		Caulophyllum thalictroides	blue cohosh	2	
		Circea lutetiana	enchanters nightshade	2	
		Dryopteris sp	wood fern species	0.1	
		Geum canadense	white avens	0.1	
x		*Glechoma hederacea*	creeping Charlie	1	
		Impatiens capensis	Spotted touch-me-not	2	
x		*Leonurus cardiaca*	motherwort	0.1	
		Mianthemum racemosa	false Solomon's seal	1	
		Pellaea glabella	smooth cliff brake	0.1	
		Phryma leptostachya	lopseed	0.1	
		Polypodium virginianum	Polypody fern	1.0	
		Pilea sp	clearweed	2	
x		*Solanum dulcamara*	bittersweet nightshade	0.1	
		Solidago flexicaulis	zigzag goldenrod	1	
			No. Spp	19	
			Total No. ground Layer species:	**30**	

* Relative Cover Classes for individual species and vegetation layers: 0.1 (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%).

Appendix B: Plant Species for Restoration at Vermillion Falls Park

The following species lists are based on data collected by the MN DNR of species recorded at native MN plant communities. The lists are not comprehensive – there may be other species suitable for a site – nor will all species listed necessarily be needed or available from nurseries. Detailed species lists and quantities will need to be developed by an ecologist after site preparation and additional evaluation. All seed and plant material used at the property should be of Minnesota origin, ideally from within 100 miles of the site. Nurseries should provide seed/ plant origin information.

Southern dry mesic oak (maple) woodland FDs37

Genus	Species	Common Name	Freq %
Forbs, ferns			
Amphicarpaea	*bracteata*	hog-peanut	76
Anemone	*quinquefolia*	wood anemone	40
Apocynum	*androsaemifolium*	spreading dogbane	38
Aquilegia	*canadensis*	columbine	40
Aralia	*nudicaulis*	wild sarsaparilla	60
Aster	*macrophyllus*	large-leaved aster	49
Aster	*sagittifolius*	tail-leaved aster	18
Athyrium	*filix-femina*	lady-fern	51
Circaea	*lutetiana*	enchanter's nightshade	60
Desmodium	*glutinosum*	pointed-leaved tick-trefoil	78
Galium	*triflorum*	three-flowered bedstraw	51
Geranium	*maculatum*	wild geranium	69
Maianthemum	*canadense*	Canada mayflower	73
Osmorhiza	*claytonii*	Clayton's sweet cicely	78
Osmunda	*claytoniana*	interrupted fern	20
Phryma	*leptostachya*	lopseed	60
Polygonatum	*biflorum*	giant Solomon's-seal	27
Pteridium	*aquilinum*	bracken	51
Pyrola	*elliptica*	shinleaf	20
Sanicula	*marilandica*	Mariland black snakeroot	36
Smilacina	*racemosa*	false Solomon's-seal	60
Smilacina	*stellata*	starry false solomon's	22
Thalictrum	*dioicum*	early meadow-rue	31
Trientalis	*borealis*	starflower	20
Uvularia	*sessilifolia*	pale bellwort	60
Graminioids			
Carex	*pensylvanica*	Pennsylvania sedge	84
Elymus	*hystrix*	bottlebrush grass	11
Festuca	*subverticillata*	nodding fescue	11
Oryzopsis	*asperifolia*	mountain rice grass	40
Shrubs			
Amelanchier spp		Juneberry	47
Cornus	*racemosa*	gray dogwood	67
Cornus	*rugosa*	round-leaved dogwood	16
Corylus	*americana*	American hazelnut	80
Corylus	*cornuta*	beaked hazelnut	22
Diervilla	*lonicera*	bush honeysuckle	33
Prunus	*virginiana*	chokecherry	82
Ribes	*cynosbati*	gooseberry	49
Ribes	*missouriense*	Missouri gooseberry	24
Sambucus	*racemosa*	red-berried elder	20
Symphoricarpos	cmx	snowberry	20
Viburnum	*rafinesquianum*	downy arrow-wood	49
Viburnum	*lentago*	nannyberry	42

Canopy Trees			
Betula	*papyrifera*	paper-birch	20
Fraxinus	*pennsylvanica*	green ash	9
Ostrya	*virginiana*	Ironwood	19
Populus	*tremuloides*	quaking aspen	27
Populus	*grandidentata*	big-tooth aspen	11
Prunus	*serotina*	black cherry	29
Quercus	*macrocarpa*	bur oak	67
Quercus	*rubra*	northern red oak	33
Quercus	*alba*	white oak	29
Quercus	*ellipsoidalis*	pin oak	60
Ulmus	*americana*	American elm	21
Additional species that belong in the plant community, but would probably not be planted at Ravine Park.			
Acer	*rubrum*	Red maple	27
Rubus	*ideaus*	red raspberry	64
Rubus	*allegheniensis*	blackberry	47
Toxicodendron	*rydbergeii*	poison ivy	67
Zanthoxylum	*americanum*	prickly ash	67

Southern Dry-Mesic Oak Forest MHs37

The species listed below were taken from the DNR Plant Community guide. The canopy species probably will not need to be planted, but were included as reference.

Genus	Species	Common Name	[3]Freq	[4]Abund	[5]Index
Forbs, ferns, graminoids					
Actaea	*rubra*	Red baneberry	60	2	120
Adiantum	*pedatum*	Maidenhair fern	40	3	120
Amphicarpaea	*bracteata*	Hog-peanut	60	4	240
Anemone	*americana*	Round-lobed hepatica	20	3	60
Apocynum	*androsaemifolium*	Spreading dogbane	20	3	60
Aquilegia	*canadensis*	Columbine	20	3	60
Aralia	*nudicaulis*	Wild sarsaparilla	60	6	360
Aralia	*racemosa*	American spikenard	40	2	80
Arisaema	*triphyllum*	Jack-in-the-pulpit	60	4	240
Aster	*sagittifolius*	Tail-leaved aster	20	3	60
Athyrium	*filix-femina*	Lady-fern	100	5	500
Botrychium	*virginianum*	Rattlesnakefern	20	5	100
Carex	*pensylvanica*	Pennsylvania sedge	40	2	80
Caulophyllum	*thalictroides*	Blue cohosh	40	3	120
Circaea	*lutetiana*	Enchanter's nightshade	80	8	640
Cryptotaenia	*canadensis*	Honewort	60	3	180
Desmodium	*glutinosum*	Pointed-leaved tick-trefoil	80	18	1440
Dioscorea	*villosa*	Wild yam	20	3	60
Galium	*triflorum*	Three-flowered bedstraw	60	3	180
Geranium	*maculatum*	Wild geranium	100	7	700
Geum	*canadense*	White avens	80	3	240
Hackelia	*spp.*	Stickseed	40	3	120
Hydrophyllum	*virginianum*	Virginia waterleaf	60	4	240
Impatiens	*spp.*	Touch-me-not	40	4	160
Maianthemum	*canadense*	Canada mayflower	60	3	180
Mitella	*diphylla*	Two-leaved miterwort	20	3	60
Osmorhiza	*claytonii*	Clayton's sweet cicely	80	10	800
Osmunda	*claytoniana*	Interrupted fern	40	5	200
Phryma	*leptostachya*	Lopseed	100	6	600
Polygonatum	*pubescens*	Hairy Solomon's-seal	20	3	60
Polygonatum	*biflorum*	Giant Solomon's-seal	40	3	120
Pteridium	*aquilinum*	Bracken	20	5	100
Sanguinaria	*canadensis*	Bloodroot	80	3	240
Sanicula	*marilandica*	Mariland black snakeroot	60	3	180
Smilacina	*racemosa*	false Solomon's-seal	80	3	240
Thalictrum	*dioicum*	Early meadow-rue	100	4	400
Uvularia	*grandiflora*	Yellow bellwort	100	3	300
Uvularia	*sessilifolia*	Pale bellwort	20	3	60
Veronicastrum	*virginicum*	Culver's root	20	3	60
Viola	*Viola sp*	Violet	60	2	120

Southern Dry Mesic Oak Forest MHs37 (continued)

Genus	Species	Common Name	[3]Freq	[4]Abund	[5]Index
Shrubs					
Cornus	*alternifolia*	Pagoda dogwood	100	6	600
Cornus	*racemosa*	Gray dogwood	20	1	20
Corylus	*americana*	American hazelnut	40	9	360
Corylus	*cornuta*	Beaked hazelnut	40	2	80
Prunus	*virginiana*	Chokecherry	60	4	240
Rosa	*blanda*	Smooth wild rose	20	1	20
Sambucus	*racemosa*	Red-berried elder	40	3	120
Symphoricarp	cmx	Snowberry	20	3	60
Viburnum	*rafinesquianum*	Downy arrow-wood	40	3	120
Viburnum	*lentago*	Nannyberry	20	1	20
Canopy Trees (>10m)					
Acer	*rubrum*	Red maple	20	88	1760
Acer	*saccharum*	Sugar maple	40	9	360
Betula	*papyrifera*	Paper-birch	20	1	20
Carpinus	*caroliniana*	Blue beech	20	3	60
Carya	*cordiformis*	Bitternut hickory	40	3	120
Celtis	*occidentalis*	Hackberry	60	2	120
Ostrya	*virginiana*	Ironwood	40	9	360
Prunus	*serotina*	Black cherry	100	9	900
Quercus	*rubra*	Northern red oak	100	31	3100
Quercus	*alba*	White oak	60	46	2760
Tilia	*americana*	Basswood	40	4	160

[3]Frequency: Number of releve plots in which species occurs divided by total number of releve plots, multiplied by 100

[4]Abundance: Average percent cover of species within the community. It is most appropriate to interpret each value as a cover class similar to those used for original data collection (see text of report for more details)

[5]Index of Commonness: Frequency multiplied by Abundance

Southern Dry Savanna (UPs14)

Species Lists taken from Terrestrial and Palustrine Native Plant Communities in East-central Minnesota (DNR 2005). Restoring a full complement of species for any type of restoration is not feasible. For savanna and prairie, the following guidelines can be used, depending on funding.

Low diversity: 20-30 species (6-8 grasses, 15-20 forbs, 1 low shrub)
Moderate diversity: 35-40 species (9-11 grasses, 25-30 forbs, 2-3 low shrubs)
High diversity: 50-60 species (12-14 grasses, 30-40 forbs, 3-4 low shrubs)

Genus	Species	Common Name	[3]Freq		Genus	Species	Common Name	[3]Freq
Forbs & low shrubs								
Physalis	*virginiana*	Ground-cherry	100		*Allium*	*stellatum*	Prairie wild onion	11
Helianthemum	*bicknellii*	Hoary frostweed	89		*Asclepias*	*tuberosa*	Butterfly-weed	11
Antennaria	*spp.*	Pussytoes	89		*Comandra*	*umbellata*	Bastard toad-flax	11
Dalea	*purpurea*	Purple prairie-clover	78		*Fragaria*	*virginiana*	Common strawberry	11
Lechea	*stricta*	Prairie pinweed	67		*Silene*	*antirrhina*	Sleepy catchfly	11
Viola	*pedatifida*	Prairie bird-foot violet	67		*Sisyrinchium*	*campestre*	Field blue-eyed grass	11
Potentilla	*arguta*	Tall cinquefoil	67		*Desmodium*	*canadense*	Canadian tick-trefoil	11
Amorpha	*canescens*	Lead-plant	56		*Thalictrum*	*dasycarpum*	Tall meadow-rue	11
Aster	*oolentangiensis*	Sky-blue aster	56		*Arabis*	*divaricarpa*	Spreading rock-cress	11
Campanula	*rotundifolia*	Harebell	56		*Penstemon*	*grandiflorus*	Large-flowered beard-tongue	11
Asclepias	*syriaca*	Common milkweed	56		*Aralia*	*nudicaulis*	Wild sarsaparilla	11
Artemisia	*ludoviciana*	Western mugwort	44		*Prenanthes*	*racemosa*	Smooth rattlesnake-root	11
Smilacina	*stellata*	Starry false Solomon's-seal	44		*Ranunculus*	*rhomboideus*	Prairie buttercup	11
Geum	*triflorum*	Prairie smoke	44		*Heuchera*	*richardsonii*	Alum-root	11
Coreopsis	*palmata*	Stiff tickseed	44		*Chrysopsis*	*villosa*	Prairie golden aster	11
Dalea	*candida*	White prairie-clover	44					
Solidago	*nemoralis*	Gray goldenrod	44		**Grasses, Rushes and Sedges**			
Liatris	*aspera*	Rough blazing star	44		*Andropogon*	*gerardii*	Big bluestem	100
Lespedeza	*capitata*	Round-headed bush-clover	44		*Carex*	*siccata*	Hay sedge	78
Aster	*ericoides*	Heath aster	44		*Eragrostis*	*spectabilis*	Purple lovegrass	78
Helianthus	*pauciflorus*	Stiff sunflower	33		*Schizachyrium*	*scoparium*	Little bluestem	78
Galium	*boreale*	Northern bedstraw	33		*Cyperus*	*lupulinus*	Hop-like cyperus	67
Aster	*sericeus*	Silky aster	33		*Koeleria*	*pyramidata*	June-grass	67
Anemone	*cylindrica*	Long-headed thimbleweed	33		*Sorghastrum*	*nutans*	Indian grass	67
Rudbeckia	*hirta*	Black-eyed Susan	33		*Sporobolus*	*heterolepis*	Prairie dropseed	67
Asclepias	*ovalifolia*	Oval-leaved milkweed	33		*Stipa*	*spartea*	Porcupine-grass	67
Arabis	*hirsuta*	Hairy rock-cress	33		*Carex*	*pensylvanica*	Pennsylvania sedge	44
Penstemon	*gracilis*	Slender beard-tongue	22		*Panicum*	*perlongum*	Long-leaved panic grass	44
Mirabilis	*hirsuta*	Hairy four-o'clock	22		*Bouteloua*	*curtipendula*	Side-oats grama	33
Solidago	*speciosa*	Showy goldenrod	22		*Elymus*	*trachycaulus*	Slender wheatgrass	33
Phlox	*pilosa*	Prairie phlox	22		*Panicum*	*lanuginosum*	Hairy panic grass	33
Delphinium	*carolinianum*	Prairie larkspur	22		*Calamovilfa*	*longifolia*	Sand reed-grass	22
Smilax	cmx.	Carrion-flower	22		*Panicum*	*linearifolium*	Linnear-leaved panic grass	22
Apocynum	*androsaemifolium*	Spreading dogbane	11		*Panicum*	*oligosanthes*	Few-flowered panic grass	22
Oenothera	*biennis*	Common evening-primrose	11		*Agrostis*	*hyemalis*	Rough bent-grass	11
Artemisia	*campestris*	Tall wormwood	11		*Aristida*	*basiramea*	Base-branched three-awn	11
Pedicularis	*canadensis*	Wood-betony	11		*Bouteloua*	*gracilis*	Blue grama	11
Euphorbia	*corollata*	Flowering spurge	11		*Bouteloua*	*hirsuta*	Hairy grama	11
Monarda	*fistulosa*	Wild bergamot	11		*Bromus*	*kalmii*	Kalm's brome	11
Geranium	*maculatum*	Wild geranium	11		*Calamagrostis*	*canadensis*	Bluejoint	11
Anaphalis	*margaritacea*	Pearly everlasting	11		*Carex*	*brevior*	Short sedge	11
Solidago	*missouriensis*	Missouri goldenrod	11		*Carex*	*tenera*	Marsh-straw sedge	11
Solidago	*rigida*	Stiff goldenrod	11		*Muhlenbergia*	*cuspidata*	Plains muhly	11

Appendix C: Potential Ecological Impacts

Non-native and Over Populated Native Animals

A. Earthworms

No species of earthworms were native to the northern part of the U.S. since the last glaciation over 10,000 years ago. During the last century, "litter dwelling," "soil dwelling" and "deep burrowing" species of have been introduced - primarily as cast-off bait from anglers. Since then, they have become established and are very invasive in woodlands and forests. These species move into new areas in waves, one species following another, with ultimately the largest worms, night-crawlers, invading and becoming established. Earthworms have a very negative impact on native forest communities. As they tunnel into the top layers of soil they consume large amounts of leaf litter (duff). This results in soil compaction and a marked decrease in the duff layer, which is important for numerous plants and animals. Where there used to be several inches of the light, fluffy duff layer in native forests and woodlands, there is now only a trace or often none at all, with compacted, bare soil often prevalent. This situation results in increased erosion and nutrient runoff which is detrimental to lakes and streams. The lack of duff layer and soil compaction have negative ramifications on native forb populations, especially spring ephemerals which have evolved under conditions that required thick duff layers. The reduced duff also results in reduced populations of many native animals that rely on it, such as ovenbirds, salamanders and other species. In contrast, earthworm activity favors conditions for invasion by garlic mustard and common buckthorn.

B. White-tail Deer

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

Today, browsing by deer, not grazing, has a more significant negative impact on woodlands. Deer populations in the metropolitan area have greatly increased over the last century due to both direct and indirect causes. The conversion of native forest, woodland, savanna, and prairie first to agricultural land and then to more "suburbanized landscapes" have favored deer.

Fragmentation of forests and managing for large gaps and residential lots with linear woodlands has greatly increased the suburban "edge effect." Deer prefer areas with large amounts of long, linear forest/woodland edge that can be used both as open areas to feed and wooded areas for cover. Active management for deer hunting by wildlife managers has also had a direct increase in deer abundance. Deer prefer to feed on many of the native forbs, shrubs, and tree seedlings. Although deer will eat buckthorn and honeysuckle, they do not prefer them if given the choice. This combination of factors greatly increases the browsing pressure on the few natives that can

survive earthworm and buckthorn. The lack of oak regeneration, typical of such woodlands, is one result of these conditions.

The synergistic effect of the three factors, fire suppression, earthworm infestation, buckthorn/honeysuckle invasion, and high deer browsing pressure has resulted in a situation of oak woodland decline. Although difficult to turn around, this decline can be ameliorated and possibly reversed, under appropriate management activities.

Climate Change

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

According to the DNR Wildlife Action Plan 2015-2025:

Climate change impacts anticipated for forested areas include: "Insect damage, larger blowdown areas, droughts, and fire are expected to interact, resulting in many forests, particularly ones on marginal soils, becoming savannas. Invasive species, including earthworms, may limit the establishment and growth of native tree seedlings and other understory plants (Galatowitsch et al. 2009). Deciduous forests within the prairie-forest border are severely fragmented by agriculture and urban/ suburban sprawl. Should fragmentation increase, thereby creating smaller forest patches and increasing edge habitat, the ability of some plant and animal species to adapt to climate change could become progressively limited. Reasons for this include increased predation on wildlife, the spread of invasive species, and competition from other native species that prefer forest edge."

Appendix D: List of Noxious and Invasive Plants

Numerous annual, biennial or perennial plants have been designated by the Minnesota Commissioner of Agriculture as being injurious to public health and the environment. A few of the most common species are listed below. Bolded species have been found at Vermillion Falls Park. The site should be monitored regularly for any other species and control measures taken immediately if any are detected.

- Oriental Bittersweet: a fast-growing vine that overwhelms other plant communities.
- **Common or European Buckthorn**
- Glossy Buckthorn: a great threat to wetlands, where it can form dense stands that cause the growth of other species to be suppressed. It is also an alternative host to fungi that infects oats.
- **Tatarian Honeysuckle**: displace native plants in grassland, savanna, forest edges and open woodland.
- Multi-flora Rose: forms small to large infestations often climbing into trees, invades forest and forest margins.
- Garlic Mustard: significant negative impact on forest understory.
- Giant Knotweed: forms dense stands where it can crowd out native vegetation.
- Japanese Knotweed: forms dense thickets that exclude native vegetation and greatly alters ecosystems.

The MN DNR maintains a list of additional invasive terrestrial plants, below. Bolded species were found at Vermillion Falls. All of these species are considered detrimental to native plant communities and should be managed, with the possible exception of creeping Charlie. Unless in a very localized area, this species is too pervasive to be able to control it. However, it does not tend to completely impede native species.

amur maple	**creeping Charlie**	leafy spurge	reed canary grass
amur silver grass	crown vetch	meadow knapweed	Russian olive
birdsfoot trefoil	cut-leaved teasel	musk thistle	**Siberian elm**
black locust	dalmation toadflax	narrowleaf bittercress	Siberian pea shrub
black swallowwort	giant hogweed	phragmites	**smooth brome grass**
British yellowhead	Grecian foxglove	Norway maple	spotted knapweed
bull thistle	hairy vetch	orange hawkweed	tree of heaven
butter and eggs	hoary alyssum	oxeye daisy	**white sweet clover**
Canada thistle	Japanese barberry	perennial sow thistle	yellow sweet clover
common tansy	Japanese hedge-parsley	poison hemlock	wild parsnip
common teasel	Japanese hops	purple loosestrife	yellow iris
cow vetch		Queen Ann's lace	yellow star thistle

Additional species found at Vermillion Falls that should be managed are burdock, daylily, Kentucky bluegrass and any others that may be detected in the future.

Appendix E: Methods for Controlling Non-native Invasive Woody Plant Species

Common Buckthorn, Tatarian Honeysuckle, Siberian Elm, and Black Locust are some of the most common woody species likely to invade native woodlands or prairies in Minnesota. Buckthorn and honeysuckle are European species that escaped urban landscapes and invaded woodlands in many parts of the country. They are exceedingly aggressive and, lacking natural disease and predators, can out-compete native species. Invasions result in a dense, impenetrable brush thicket that reduces native species diversity.

Siberian elm, native to eastern Asia, grows readily, especially in disturbed and low-nutrient soils with low moisture. Seed germination is high and seedlings establish quickly in sparse vegetation. It can invade and dominate disturbed areas in just a few years. Black locust is native to the southeastern United States and the very southeastern corner of Minnesota. It has been planted outside its natural range, and readily invades disturbed areas. It reproduces vigorously by root suckering and can form a monotypic stand.

Chemical Control

The most efficient way to remove woody plants that are 1/2 inch or more in diameter is to cut the stems close to the ground and treat the cut stumps with herbicide immediately after they are cut, when the stumps are fresh and the chemicals are most readily absorbed. Failure to treat the stumps will result in resprouting, creating much greater removal difficulty. All herbicides should be applied by licensed applicators and should not be applied on windy days. Care should be taken to avoid application to other plants.

In non-freezing temperatures, a triclopyr herbicide such as Vastlan or Garlon 3a, or a glyphosate herbicide (e.g Roundup) can be used for most woody species, **except** legumes such as black locust. It is best to add a marker dye to make treated stumps more visible. In winter months, Garlon 4 is typically used, mixed with a penetrating oil. Diesel fuel should never be use as it is more toxic in the environment and for humans. However, Garlon 4 will cause a "kill-ring" and should only be used at very degraded sites. Garlon 4 should NOT be use at Vermillion Falls Park due to the sensitivity of the groundwater to contamination and the potential for high quality herbaceous plants. For plants in the pea family, such as black locust, an herbicide with the active ingredient clopyralid can be more effective than glyphosate. Common brand names for clopyralid herbicides are Transline, Stinger, and Reclaim.

FMR recommends using foam or dauber type applicators to apply herbicide. These methods eliminates overspray, reduces chemical use, and increases the chemical efficacy as more chemical goes into the plant.

Ideal weather conditions for herbicide work are during the growing season (when the plants are biologically active) and especially when soil moisture levels are low. Some studies have shown that when soil moisture is high, herbicide is more likely to move out of the roots of the treated plant into the soil, potentially having lethal effects on nearby plants and simultaneously sub-lethal effects on the treated plant (Dornbos & Pruim 2012). Fall is typically the best time for

buckthorn removal work because they retain their leaves longer than any other woody plant so it is very easy to locate them. Fall is also a good time for most other woody plant control as it is easier to move through the woods, native plants are dormant so impacts to them are minimal. Most material will need to be cut with brush cutters and chainsaws, by properly trained professionals.

In the year following initial cutting and stump treatment, there will be a flush of new seedlings as well as resprouting from some of the cut plants (e.g. stumps that were missed or where the chemical was not fully effective). A foliar application of herbicide is a common treatment approach, where the herbicide (e.g. triclopyr or glyphosate) is broadcast sprayed on the surface of the leaves. For buckthorn and Siberian elm, this should be done in fall, when desirable native plants are dormant and when the target plant is pulling resources from the leaves down into the roots. Results can be highly variable and treatment cannot be too late in the fall, when the leaves have "hardened" and do not accept chemical well.

Furthermore, these herbicides will affect native herbaceous plants and may cause significant mortality, even when non-target plants are dormant. This method should **NOT** be used in high quality locations unless specific methodology is approved, such as foam application on very dense stands or use of a wick applicator. Glyphosate is non-specific while triclopyr targets broadleaf plants and does not harm graminoids.

Another option is to use a bud-inhibitor such as Krenite (active ingredient – fosamine ammonium), which is applied in fall to prevents bud formation in the spring. This herbicide can be effective, though results can be highly variable. When effective, results are seen in the year following treatment and can take some months. It is most suitable for small plants that can be completely treated.

Basal bark herbicide treatment is another effective control method. A triclopyr herbicide such as 10% Garlon 4, mixed with a penetrating oil, is applied all around the base of the tree or shrub, taking care to minimize overspray or run off. This method typically causes a significant "kill ring" and should NOT be used at Vermillion Falls.

Mechanical Control

Mechanical methods for woody plant removal include girdling, hand-pulling, weed wrenching, forestry mowing, repeated cutting and browsing.

Girdling is one method to destroy large, undesirable trees and shrubs without cutting them down. It is most suitable when there are small numbers of large stems, and is especially useful in less public areas, such as interior woods. The method involves removing bark in a band around the tree, just to the outside of the wood. If girdled too deeply, the tree will respond by resprouting from the roots. Typically two rings are cut and to guarantee effectiveness, herbicide is often applied to the lower girdle ring. Girdled trees die slowly over the course of one to two years. Girdling should ideally be done in late spring to mid-summer when sap is flowing and the bark easily peels away from the sapwood. Girdling will leave a dead tree, which can provide good habitat for many species. However, it can also be a hazard as it will eventually fall down, so it should be used with some discretion.

Weed-wrenching and hand-pulling are similar, except hand-pulling requires no tools (optional use of a pliers) and is suitable for seedlings or very small saplings (less than 3 ft tall), whereas weed wrenches involve use of a weed extracting tool and is used on larger plants, up to about 2-inches diameter. Both methods can be done any time when the soil is moist and not frozen. Disadvantages to both methods they are time-consuming and require that the dirt be shaken off each plant that is pulled. They also, especially weed wrenching, create a great deal of soil disturbance and should not be used on steep slopes or anywhere that desirable native forbs are growing. The soil disturbance also creates opportunities for weed germination. This method is best used in areas that have very little desirable native plant cover. It could be used at Vermillion Falls as a good volunteer activity to remove seedling plants in low-abundance areas, such as the maple-basswood forest.

Forestry mowers are large machines that essentially grind everything in their path. The mower can be set at different heights, and can cut at or just below the surface of the soil. It is important to mow as LOW as possible because it destroys the root collar where resprouting occurs. But even at slightly high cutting heights, the mower tends to shatter the stems and can be a very effective tool for significantly reducing buckthorn levels. The mulch from mowing also serves to suppress new buckthorn seedlings and can dramatically reduce the seedling "carpet" that typically happens after large plants are removed. The mower is best used on frozen soils to reduce impacts. At Vermillion Falls, a mower would be most effective in areas where buckthorn is very dense and fairly small (e.g. ½-inch to 1-inch diameter at the base), such as the DF1 and DW1 units. However, the DW1 unit in particular has some bedrock outcrops so mowing would have to be done with care to avoid damage to machines.

One approach is to mow a stand, then return the following fall to foliar spray the resprouts. The downside to this method is that the resprouts can be from large trunks with very large root-stock, and a foliar application is unlikely to kill them. So an alternative method, though more costly, is to hand-cut and treat larger stems (e.g. >1-inch diameter), then follow-up with forestry mowing to grind the material and cut the small stems.

Repeated cutting is another potential control method. It consists of cutting the plants (by hand or with a brush cutter) at critical stages in the growth cycle. Cutting in mid spring (late May) intercepts the flow of nutrients from the roots to the leaves. Re-cutting in fall (about late September) intercepts the flow of nutrients from the leaves to the roots. Depending on the size of the stem and other factors such as weather conditions and the amount of available light, many plants may die within a few years, with two cuttings per year. However, this method is costly and requires diligence in precise timing.

Using of ***browsing animals***, especially goats, is another means of control. This is best used on small stems – 4 ft or less. Goats primarily defoliate the stems, weakening the plant. If the plants are small and this is done repeatedly (ideally twice a year), this method can significantly reduce the invasive plant over time. However, there are several limitations to the use of goats, including the fact that they do not discriminate between desirable native plants and undesirable non-native plants; they eat everything in sight. It is also a costly method as many years of browsing are

needed and results are variable. For these reasons, we do not recommend this method at Vermillion Falls.

Stems, Seedlings and Re-sprouts

Prescribed burning is the most efficient, cost effective, and least harmful way to control very small stems, seedlings, and resprouts of all woody plants. It also restores an important natural process to fire-dependant natural communities (oak forests, for example). Burning can only be accomplished if adequate fuel (leaf litter) is present and can be done in late fall or early spring, depending site conditions. Burning will primarily kill small seedlings – first year plants. It will top-kill larger plants, but also weakens them, making them easier to control with other methods, such as follow-up mow or foliar herbicide. If burning is not feasible, critical cutting and/or foliar application are alternatives. Or do nothing and re-cut/treat new growth in 3-5 years.

Torching can also be used as an alternative to prescribed burning. While effective, it is not cost effective for sites with dense buckthorn.

Disposal

Cut material can be disposed of in various ways, including chipping, forestry mowing, rot piles, burning and cut/drop.

Chipping cut brush is one of the most effective ways to dispose of large amounts of cut material with the least environmental impacts. Brush can be chipped on-site and blown back into the woods or it can be hauled off-site to a compost facility or sometimes to a utility where it can be used as biofuels. If blown into the woods it should be dispersed so depths do not exceed about 3 inches. The wood chip will slowly degrade and will suppress buckthorn seedling germination.

Forestry mowing can be used to either mow chip brush that has been gathered into moderately sized piles, or to mow an entire site where the brush has been cut and treated but not stacked.

Rot piles or wildlife piles consist of small brush piles (e.g. 8 ft tall or less, similar length & width) that are left in the woods as wildlife cover. This should be used as a supplement to other methods, and there should not be more than a 2-3 piles per acre. With the public use at Vermillion Falls, we recommend minimal rot piles, but it may be cost effective for some of the fringe areas of the park.

Stack and burn: This is often the easiest and most cost-effective method to handle large amounts of brush. It does, however, have some of the worst environmental impacts, with the release of carbon. Still, it is often the only suitable method at large or inaccessible sites. If this method is used, burn piles should be minimized to reduce burn scars.

Cut and drop: In areas where brush is not dense, it can be cut up into smaller pieces and left on the ground where it will decompose in one to three years. This method is especially useful on slopes to reduce erosion potential. As Vermillion Falls is a very visible public park we would recommend generally avoiding this method.