Gateway North Open Space Natural Resource Management Plan

Prepared for:

The City of Cottage Grove, Minnesota

Prepared by:

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January, 2012

This Natural Area Management Plan and Work Plan has been reviewed and approved by:

Landowner

_____ Date: _____
John Burbank, Senior Planner, City of Cottage Grove, MN

Minnesota Land Trust

_____ Date: _____
Anne Murphy, Conservation Stewardship Director, Minnesota Land Trust

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INTRODUCTION

This Natural Resource Management Plan presents the site analysis and recommended management and land use activities for the 54-acre natural area called the Gateway North Open Space (GNOS) property. This document can be changed only by written agreement by both the City of Cottage Grove and Minnesota LandTrust.

The GNOS property is owned by the City of Cottage Grove, Minnesota. The eastern 43 acres of the GNOS property have a conservation easement on them. The western arm of the GNOS property, formerly known as "Camel Humps", consists of approximately 11 acres that do not have a conservation easement on them, but are designated Park and Open Space by the City of Cottage Grove. Most of this property is located on steep slopes. Only the bluff top and the center of the woodland actually have relatively flat terrain. The site is bounded by Highway 61 to the southwest, and a combination of open space and residential development to the north, east, and west. The Mississippi River is nearby, approximately 1.5 miles to the southwest.

The most notable feature of this property is that it contains a remnant bluff prairie. This bluff prairie, technically called a "Dry Bedrock Bluff Prairie (Southern Subtype), UPs13c, was noted as an "element occurrence" by the Minnesota County Biological Survey (MCBS) in 1987, and was ranked with "fair estimated viability" and had an S-rank of "S3". The native plant community (NPC) types and subtypes recognized in Minnesota have been assigned conservation status ranks (S-ranks) that reflect the risk of elimination of the community from Minnesota. There are five ranks:
S1 = critically imperiled
S2 = imperiled
S3 = vulnerable to extirpation
S4 = apparently secure; uncommon but not rare
S5 = secure, common, widespread, and abundant
These ranks are determined using methodology developed by the conservation organization Nature Serve and its member natural heritage programs in North America. S-ranks were assigned to Minnesota's NPC types and subtypes based on information compiled by DNR plant ecologists on: 1) geographic range or extent; 2)area of range occupied; 3) number of occurrences; 4) number of good occurrences, or percent area of occurrences with good viability and ecological integrity; 5) environmental specificity; 6) long-term trend; 7) short-term trend; 8) scope and severity of major threats; and 9) intrinsic vulnerability.

Notes from the MCBS record describe the dry bluff prairie "on a southwest-facing sandstone bluff above Highway 61", and that "the prairie was dominated by native graminoids (little blue stem, side oats grama, hairy grama, Schweinitz's flatsedge, plains muhly grass". The soils are derived from disintegrating sandstone that outcrops along the upper slope. One cliff has a sand cave that is approximately fifteen feet deep. The prairie has been altered by encroachment of woody species including smooth sumac, poison ivy,

boxelder, and common buckthorn. Smooth brome, an introduced invasive grass from Europe, dominates to the east and also at the top of the bluff.

The rest of the site is comprised of former oak woodland and savanna, which is now overgrown with woody vegetation and is more forest-like. The woodlands have a great deal of topographic relief with several ravines and ridges that wind through the property. Some very large old trees, mainly oaks, are growing on the property, which impart a mature character to the woodlands/forests.

Prior to European settlement, this site sat right on the border of two landcover types: prairie to the south and "oak openings and barrens" (today referred to as savanna) to the north. The landscape would have been much more open than today, with primarily prairie and scattered groves of scrubby oaks and shrubs. The composition is almost reversed today, dominated by woodland with scattered small prairie openings including a few nodes of prairie scattered mainly throughout the southern portion of the property.

Falling within the "St. Paul Baldwin Plains and Moraines" ecological subsection (**Figure 10**), this site represents an excellent opportunity to retain and restore habitat for wildlife species. There are several potential Species of Greatest Conservation Need (SGCN) that could be harbored at the GNOS property, and that will be a focus of this plan. Habitat loss and degradation has been the primary causes of problems for SGCNs species in the subsection, with prairie, oak savanna, and grassland currently containing the most species, so the GNOS property has the potential for significant conservation value in the region. The DNR recommends to stabilize and increase SGCN populations in oak savanna and prairie areas by managing invasive species, using prescribed fire and other practices to maintain savanna and prairie, to encourage restoration efforts, to manage grasslands adjacent to native prairie to enhance habitat, and to provide technical assistance and protection opportunities to interested individuals and organizations. These are also the top priorities of this management plan and will be explored in depth herein.

The purpose of this management plan is to:

- Identify the existing ecological conditions on the property
- Identify best management practices to maximize wildlife values, and retain and improve water quality and increase community diversity
- Document allowable uses and activities of the property

Specific ecological and cultural goals for this property are to:

- Increase coverage and diversity of native plant species and reduce non-native species
- Provide connectivity with other natural areas in the landscape and along the river corridor
- Maintain and manage the property for water quality by controlling runoff and nutrient loading
- Create a model for responsible private land stewardship

- Utilize this property to guide construction and surface water management activities on adjacent land (if developed) in a manner that protects and fosters natural community establishment
- Utilize this property to enhance and expand the ecological functions of the property

SITE INFORMATION

Owner name, address, city/township, county and phone:
City of Cottage Grove, Minnesota
7516 80th Street South
Cottage Grove, MN 55016
Contact Person: John M. Burbank, AICP, Senior Planner
651-458-2825

Township, range, section: T27N, R21W, Sections 7 Southeast ¼ and
T27N, R21W, Section 8, Southwest ¼.

Watershed: Mississippi River

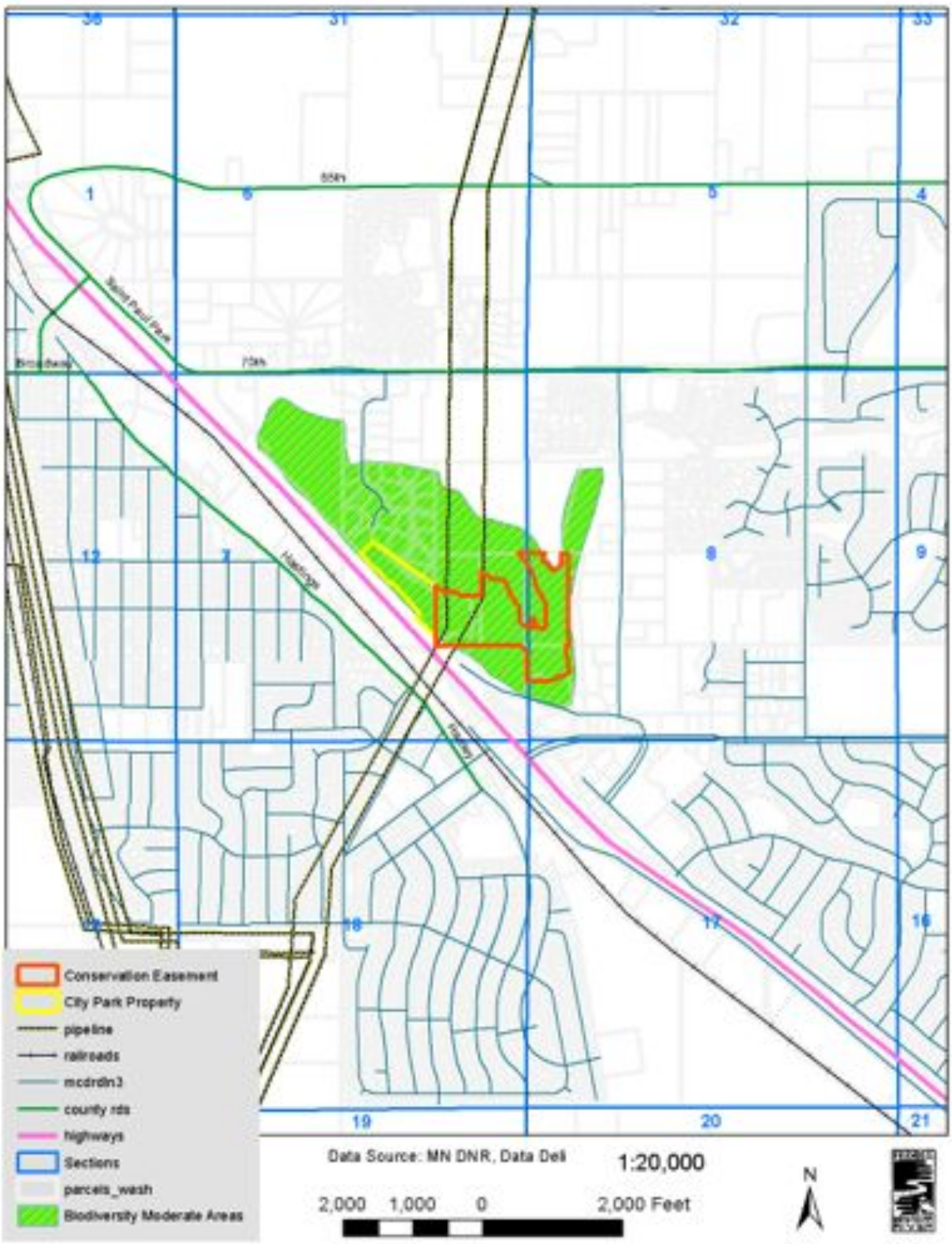
Watershed District: South Washington County

Parcel Identification Numbers:
0702721420007, 0702721410004, 0702721410008, 0802721330052, and 0802721320011.

Natural Area Conservation Easement: 43 acres, to be held by the City of Cottage Grove (**Figure 1**). 11 acres designated City Park and Open Space by the City of Cottage Grove and not under conservation easement, but to be managed as a whole with the conservation easement land. The conservation purposes of the Easements are to provide significant public benefit by preserving and protecting in perpetuity the Conservation Values of the Protected Property. The identified Conservation Values include the undeveloped and relatively natural character of the property, the wooded bluffs and hillsides, and public access to the property for low-impact outdoor recreation, education, and nature observation. The Easements allow for public access, planned vegetation management under an approved management plan and limited improvements including the creation of a scenic overlook.

Element occurrence: There is one element occurrence on the property, which is not a specific species but rather an entire assemblage of them, a community. The community is called "Dry Bedrock Bluff Prairie (Southern) and it's Native Plant Community Code is UPs13c. This occurrence was last observed in 1987 by Minnesota County Biological Survey staff (J. C. Almendinger) from the Mn DNR. It was ranked as "fair estimated viability" and its State-Rank was "S3".

Figure 1 **NATURAL AREA EASEMENT**



LANDSCAPE CONTEXT

Proximity to established greenways

Several different greenway corridor-planning efforts have taken place in Washington County to designate the most important parcels to consider for permanent protection and/or natural resource restoration, based on various ecological criteria. This property is located in a network of city parks that form a loose greenway corridor (**Figure 2**). This greenway corridor leads from the northeast end of the GNOS property, northward through Hardwood Parkway, then eastward through Cottage Grove Trailway Corridor, then through Kingston Park, then through the Cottage Grove Trailway Corridor again. Off to the east and south of this corridor is the large Ravine County Park. This corridor is not continuous, being interrupted several times by roads along the way.

The GNOS property is also tenuously connected to a greenway corridor that runs along a trail on the north side of Hwy 61, which goes northwest for about 1.5 miles, then goes eastward and slightly north for about 5 miles (across Military Road and County Rd 19), then heads south for about 4 to 5 miles through natural open spaces and meets Cottage Grove Ravine Regional Park and back again to Hwy 61. The weak link or "pinch point" in this corridor is the narrow lane between Hwy 61 and Goodview Ave S. and Goodview Bay. If this lane could be somehow widened or enhanced it would allow wildlife to move through and connect to the greater corridor to the north and east. This is something for the City to consider.

The GNOS property is very near one arm of the Metro Conservation Corridors (MeCC), a regional land protection plan of the DNR (**Figure 2**). During the next update of the MeCC in 2012, Friends of the Mississippi River will petition the DNR to extend the MeCC to include the GNOS property.

In addition to these local and regional corridors, the GNOS property is also located along the Mississippi River bluffs, a globally important migratory bird corridor.

Ecological significance and wildlife value

The GNOS park and easement property is included in an area that was delineated by the Minnesota DNR as having moderately significant biodiversity. They compared many natural and open space sites across the county to develop this ranking as part of the Minnesota County Biological Survey that started in the 1980's. This ranking was based on the remnant bluff prairie. Not much prairie remains in this ecological subsection (St. Paul Baldwin Plains and Moraines), so it is important to protect, restore, and, if possible, expand every remnant (MN DNR, 2006. *Tomorrow's Habitat for the Wild and Rare*).

The areas surrounding the GNOS property are currently developed on three sides, west, south, and east, and new homes were being constructed on the north side at the time this document was being prepared, so the "urban pressure" on this property is great. Providing connectivity to conservation corridors is the key to providing enough space for genetically viable populations for many wildlife species here.

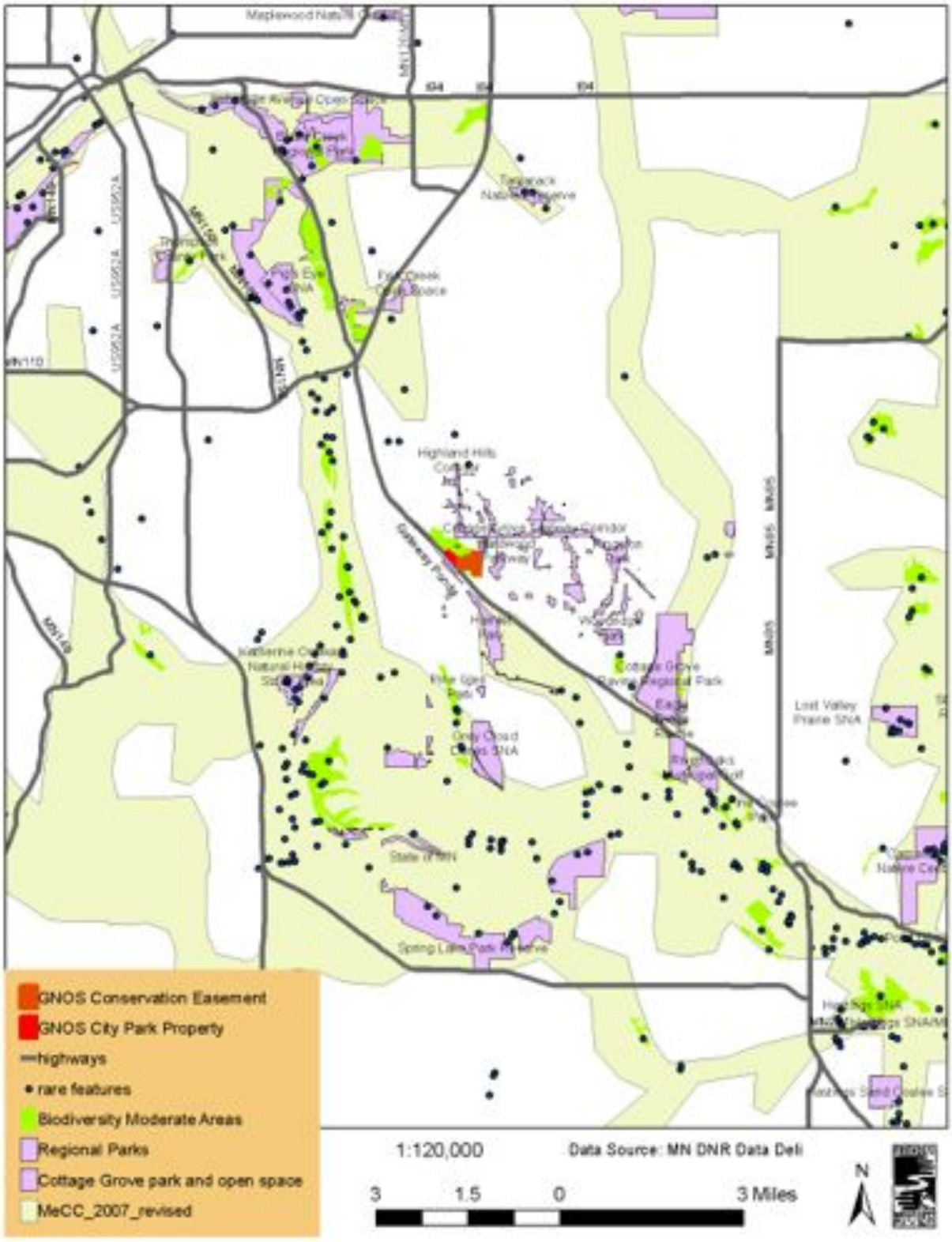


FIGURE 2 LANDSCAPE CONTEXT

SITE GEOLOGY AND GROUNDWATER

The surficial geology of the site consists of three main types: dissected bedrock, superior lobe deposits, and post-glacial fluvial deposits (**Figure 3**). The *dissected bedrock* is St. Peter sandstone of middle Ordovician origin, which is discontinuously exposed generally mantled by less than five feet of sandy to rocky colluvium and loess (Meyer, Baker, and Patterson, 1990). The *superior deposits*, which occupy the majority of the site, are outwash sand, loamy sand, and gravel; cobbly in places; commonly overlain by two to five feet of loess. The outwash plains are highly collapsed in places, particularly over buried bedrock valleys, owing to ice-block melt out. These deposits were laid down by Superior Lobe meltwater that flowed from the ice front to lay down wide plains of outwash (So). Following the retreat of the Superior Lobe, the Grantsburg sublobe (an offshoot of the large Keewatin Des Moines Lobe) advanced upon the site. The sediment load from this sublobe differed from that of the earlier ice advances, in that it contained abundant silicaceous shale. Meltwater from the receding Grantsburg sublobe and Des Moines lobe cut the upper terrace level within the Mississippi River valley. The southern outlet stream of Glacial Lake Agassiz, Glacial River Warren, followed the present course of the Minnesota River valley to St. Paul, and then flowed down the Mississippi River valley, cutting the wide middle- and low-level terraces preserved in southwestern Washington County

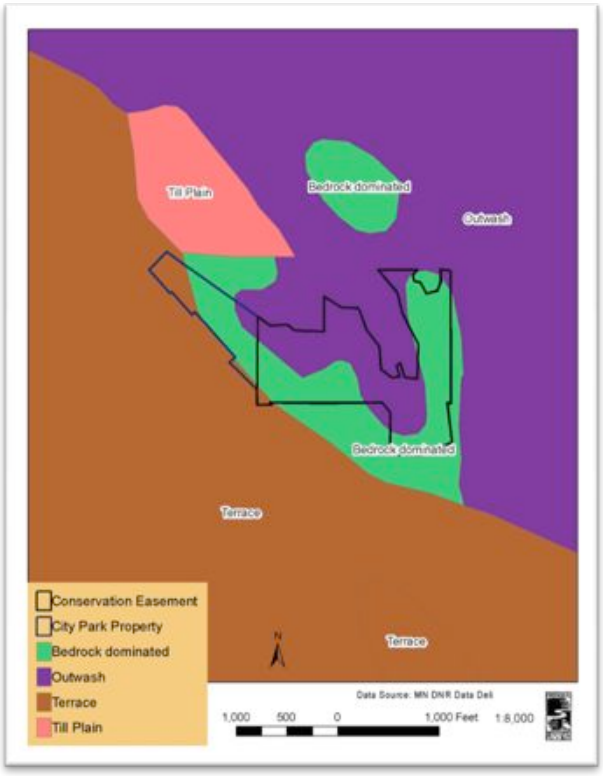


Figure 3. Surficial Geology.

The Prairie du Chien contains the primary aquifer that is used for drinking water throughout the region. Although not as close to the surface as other bedrock formations in this location, the sensitivity of the Prairie du Chien groundwater system to pollution is ranked as high, since there is very little confining layer between the surface and the bedrock layer. High means that contaminants will probably reach the system in a matter of weeks to years. This has heavy implications on how management of this site should proceed and on what should be allowed and not allowed on this site, in terms of potential pollution and contaminants.

SOILS AND TOPOGRAPHY

The soil types are summarized in **Table 1** and illustrated in **Figure 4.** The predominant soil types of the site are Brodale flaggy loam (488F), Waukegan silt loam (411B, C), and Dickman sandy loam (327B). The other prominent soil type is the exposed bedrock, Dorerton-Rock outcrop complex (1819F). Other soils present are Chetek sandy loam (155B, C, D), Mahtomedi loamy sand (454D, F), and Hubbard loamy sand (7B).

Table 1. Soils.

Soil Code	Soil Name	Percent Slope	Acres	Soil Family	Hydric (Yes or No)	Drain-age*	Erod-ibility**
488F	Brodale flaggy loam	25 to 65	20	Loamy skeletal, carbonatic, mesic entic Hapludolls	N	ED	HEL
411B	Waukegan silt loam	1 to 6	7.4	Fine-silty over sandy, or sandy skeletal mixed, mesic Typic Hapludolls	N	WD	PHEL
411C	Waukegan silt loam	6 to 12	6.1	Fine-silty over sandy, or sandy skeletal mixed, mesic Typic Hapludolls	N	WD	PHEL
411	Waukegan silt loam TOTAL	-	13.5	Fine-silty over sandy, or sandy skeletal mixed, mesic Typic Hapludolls	N	WD	PHEL
1819F	Dorerton-rock outcrop complex	25 to 65	10.6	Loamy skeletal, mixed, mesic Typic Hapludalfs	N	WD	HEL
327B	Dickman sandy loam	1 to 6	5.1	Sandy, mixed, mesic Typic Hapludolls	N	SED	PHEL
155B	Chetek sandy loam	1 to 6	1.1	Coarse-loamy, mixed Eurtic Glossoboralfs	N	SED	PHEL
155C	Chetek sandy loam	6 to 12	1.4	Coarse-loamy, mixed Eutirc Glossoboralfs	N	SED	PHEL
155	Chetek sandy loam TOTAL	-	2.5	Coarse-loamy, mixed Eutric Glossoboralfs	N	SED	PHEL
7B	Hubbard loamy sand	1 to 6	1.4	Sandy, mixed Udorthentic Haploborolls	N	ED	HEL
454D	Mahtomedi loamy sand	12 to 18	0.6	Mixed, frigid, Typic Udipsamments	N	ED	HEL
454F	Mahtomedi loamy sand	25 to 65	0.4	Mixed, frigid, Typic Udipsamments	N	ED	HEL
454	Mahtomedi loamy sand TOTAL	-	1	Mixed, frigid, Typic Udipsamments	N	ED	HEL
TOTAL ALL SOILS			54.1				

*WD = well drained, SED = somewhat excessively drained, ED = excessively drained

**HEL = Highly erodible PHEL = Partially highly erodible NHEL = Not highly erodible

The letters in the code indicate the percent slope, with B = 1 to 6%, C = 6 to 12%, D = 12 to 18%, and F = 25 to 65% slopes. As can be seen, many of the soils on this property contain very steep slopes.

Soil formation is the result of the interaction of five soil-forming factors: parent material, climate, organisms, topographic position or slope, and time (Foth, 1990). Taken collectively, these factors can help determine the dominant floral and faunal communities that helped form the soils. Brodale, Waukegan, Dickman, and Hubbard are *mollisolls*, which are prairie soils, generally deep, dark in color, and rich in cations, and thus would have been dominated by graminoid vegetation (prairie or savanna) pre-settlement.

The Dorerton and Chetek soil units are *alfisols*, which are generally considered to be forest soils, and thus would have likely supported forests and/or woodlands in pre-settlement times. An exception to this would be the Dorerton soils where the slope is very steep and southwest-facing: this would have been very dry and thus would have burned frequently enough to have been dominated by prairie. Thus the presence of the "bluff prairie" today. The Dorerton soil that has the northeast-facing slope (on the opposite side of the ridge from the bluff prairie) would have likely been either dry oak woodland or savanna, since it would have been moister and thus seen fewer fires. The top of the ridge would have been either woodland or savanna or alternating between the two, depending on weather conditions and fire frequency.

There are no wetlands on this property or hydric soils. All of the soils on the property are either well-drained, or excessively well-drained, and they do not pond or accumulate organic matter. There is a great potential, however, for erosion, considering the high percentage of steep slopes on the property. Care should be taken to not denude these highly erodible slopes, or much sediment will potentially erode away to the lower spots at the bottoms of slopes and in ravines and depressions on slopes. Maintaining herbaceous vegetation is the best way to prevent erosion, since the fine roots of these types of plants holds onto the fine soil particles.

There are two caves that are located in the Dorerton soil unit, on the steep outcropped bedrock face. The largest one is on the southwest-facing cliff and another is on the western end, facing west.

The topography of the property ranges quite widely, from 950 feet above sea level down to 790, a difference of 160 feet. This difference is quite dramatically displayed on the bluffs side of the property. Views of the surrounding landscape are quite stunning from the high vantage points of the bluff ridges. A long stretch of the Mississippi River valley can be seen from on top of the bluff ridge. The top of the ridge is relatively flat, but as it extends westward, the elevation drops down to that of the highway.

The east side of the property also has quite steep, east-facing, and some south-facing , slopes, occupied by oak woodland/forest. Several ravines cut through the wooded portions of the property. These ravines are rather broad and not very steep.

Figure 4. Soils and Topography.

RARE SPECIES

The one record of element of occurrence is not for any particular species, but rather for a group of them, namely the plant community called "bluff prairie". There is not mention of any rare or state-listed species within this property, and none were observed by FMR ecologists during field surveys. However, there may be some rare species present that were not found yet, and it is recommended to monitor for them during different parts of the year, so as to have a better chance of encountering them.

HISTORIC VEGETATION

One of the best information sources available on plant communities that were present at the time of European settlement comes from the 1850's Public Land Surveyor (PLS) notes, which recorded plant species (usually "bearing trees") at each one-mile node. A compilation of those notes was converted into a map showing the plant communities of the entire state (Marschner 1974). The region where the GNOS property is located was on the border of two cover classes: "oak openings and barrens" and "prairie" (**Figure 5**). Oak openings and barrens is an area that consisted of patches of scrubby oaks and shrubs with many prairie "openings", similar to what we would today call savanna. Prairie was an area dominated by tall and short to medium sized grasses and forbs (wild flowers), with patches of shrubs and very few to no trees. Note that the soils data and the pre-settlement vegetation data concur.

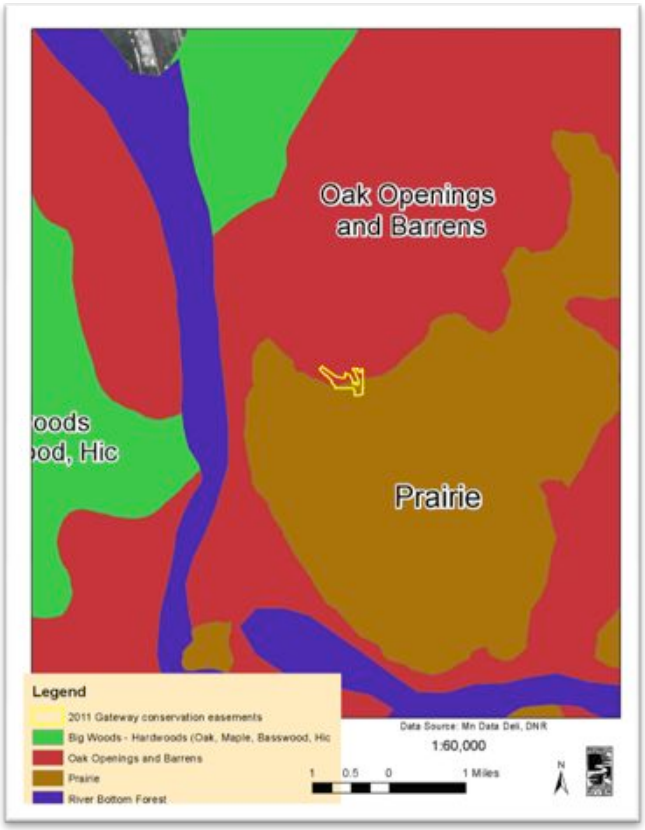


Figure 5. Pre-settlement Vegetation.

The only historical aerial photo that could be found was from 1947 (**Figure 6**). This photo is slightly skewed to the northeast, so that the property boundary should be moved slightly down to the southwest compared to the photo. Nevertheless, the photo shows that the GNOS site was open on the bluff slopes and completely covered with canopy in the woodlands. There were, however, some large rectangles that represent areas that were cleared for agricultural fields, one on the western flank and a couple on the eastern flank. These fields were presumably on fairly level ground. The western one lines up with part of what today is the pipeline easement. One of the eastern ones lines up with what is today a trail/gravel road, and the other one lines up with the southern half of the far eastern

slope—an area that is relatively degraded today. This helps explain why these areas today are disturbed/degraded.

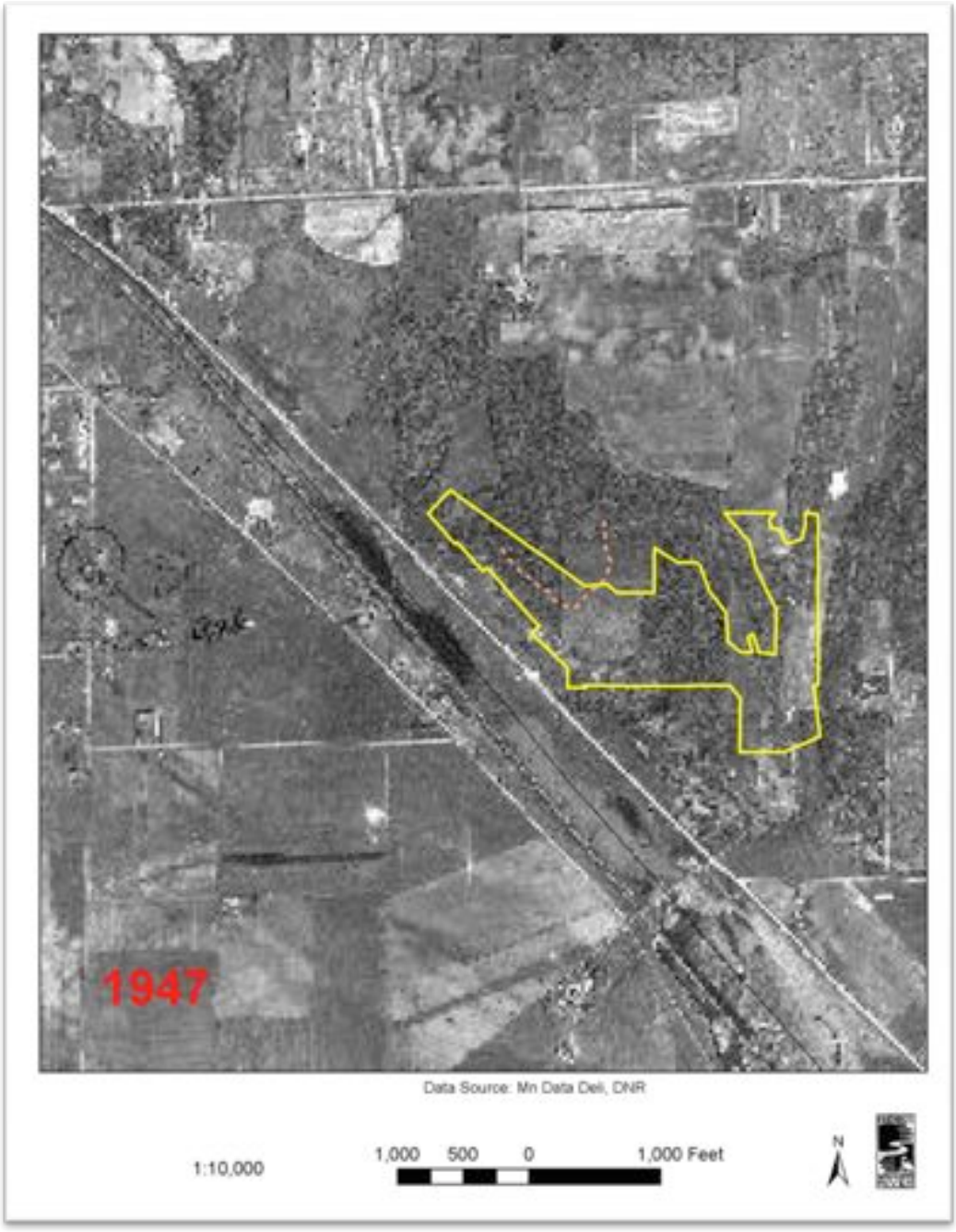


Figure 6. Historical aerial photo from 1947.

It is hard to tell how many fires would have occurred or been suppressed in the 70 to 100 years since European settlement that led up to 1947, the year of the historical aerial photo, but it is likely that many were suppressed. Often times fires were started from sparks caused by railroads, and this may have been the case with the Camel's Humps site, since the rail line is so close at the bottom of the bluff, but its hard to determine for sure. If fire suppression did occur, the woodlands would have had ample time to fill in with woody vegetation. From the photo it appears that the undisturbed ridge tops and wooded ravines of the site were fairly densely wooded. Although the bluff slope was still quite open, it appears to be slowly starting to fill in with brush.

Two other historical photos were supplied by the City of Cottage Grove (**Figure 7**). One depicted several wagons from the late 1800's (exact date unknown) with the Camels Humps in the background. This photo was taken from the Belden farm, across the current location of State Highway 61 looking towards the site from the southwest. It certainly is close enough to get a fairly good view of what this area looked like in the late 1800's. This is a priceless photo, for it actually shows conditions on the ground. It is evident that the steep bluff slopes were very open, with grasslands completely covering them except for a few redcedar. It also shows the ridge tops were filled with trees. The trees cannot be identified, but they look like oaks and other deciduous oak woodland associates. It is possible that even by the time this photo was taken, the oak woodland on top may have been filling in, as opposed to perhaps 50 or 100 years prior.

Figure 7. Historical ground photo from across the curent location of State Highway 61 **from the GNOS property taken at the Belden Farm sometime in the late 1800's. Note the "Camels Humps" in the background of the photo just above the Standard Oil Company wagon and horses. Photo courtesy of City of Cottage Grove, MN.**

Another historical photo is of a street sweeper on Hadley, looking northwest (**Figure 8**), from sometime in the 1960's (1969?). Again, the Camels Humps can be seen in the background of this photo. Note that the bluff slopes are still mainly open, but several red cedars and shrubs have moved in. Also, the ridge tops are not nearly as wooded as they were in the photo from the late 1800's. This is an interesting comparison between the two photos and today's condition.

Figure 8. Historical photo of a street sweeper near Highway 61 on Hadley sometime in the 1960's. Note the "Camels Humps" in the background on the right side of the photo. Although not nearly as brushy as today, note that the bluff slopes are already fairly heavily filled in with shrubs, small deciduous trees, and redcedars, especially on the east side of the slope (right side in this photo). It is hard to tell from this photo whether buckthorn had invaded yet, but it probably had started by this time. Also note the sparse tree cover on the ridge top—only a few trees compared to the late-1800's photo in Figure 6. Photo courtesy of City of Cottage Grove, MN.

HISTORIC AND EXISTING LAND USE

As far as can be determined, historically, portions of this site were used for agriculture, as can be seen from the fields on the aerial photo of 1947. The fields may have been used for pasture or for crops, it is unknown. Today, the ridge top and much of the bluff slope in the bluff prairie are covered with smooth brome (*Bromus inermis*), an introduced cool-season

grass used for forage for livestock. These slopes could not have been too heavily grazed, however, since many pockets of native bluff prairie vegetation still exist.

Currently, the land is used as a passive city park. No changes have been made in the park, in terms of trails, benches, overlooks, signage, etc. Access is through the trail to the north of the site, from the dead end of Bur Oak Street.

WATER RESOURCES

There are no surface water resources (wetlands, lakes, streams, ponds, etc.) on the property, per se. There are several ravines that drain spring meltwater and rainwater, but water does not pond, pool, or collect anywhere—it infiltrates into the soil and drains off the site. There were two small patches of reed canary grass (*Phalaris arundinacea*) on the bluff top in the Oak Woodland forest cover unit, which may indicate localized seeps. Reed canary grass is a non-native wetland grass, but it can occupy uplands as well. If seeps are there, they may come from groundwater that is forced out due to underlying confining soils or rock layers. More investigation of these areas is needed to determine the conditions at there.

Groundwater Recharge or Infiltration Areas

There are no wetlands, which are typically recharge areas to groundwater, on this site. It must be assumed, however, that since this site was rated as "high" for sensitivity of the Prairie du Chien-Jordan aquifer to pollution (Balaban and Hobbs, 1990), then potentially anywhere on this site could be a recharge or infiltration area. There are many areas of groundwater recharge, including the ravines, depressional areas on slopes, flat or level areas on ridge tops, gradual slopes, etc.—basically anywhere water is directed or can slow down to infiltrate through cracks in the rock or through soil. In the bluff prairie unit, there is precious little soil material covering the bedrock, and thus very little protection to the aquifer below. When at all possible, do not use chemicals. If chemicals must be used, extreme caution must be exhibited when handling and applying chemicals during restoration activities. Spilling of chemicals could be very detrimental to the aquifer. No mixing of chemicals or pouring of containers should be allowed on site. All mixing and pouring should be done ahead of time and containers hauled into or out of the site.

Stormwater Management Issues

There is significant erosion potential, with highly erodible soils and steep slopes over much of the site. On the steep bedrock bluffs there were several small to medium gullies that had formed. One of the largest of these was near the cave in the bluff prairie unit. Rainwater runs off of the exposed sandstone and has formed a small gully at the base of the cave area.

Although the large ravines on the property have the potential to erode, there were only a few erosion gullies that had formed recently, and nothing too urgent. Most of them were in a stable condition when evaluated in the fall of 2011, with three exceptions:

1) The northeast part of the property has a ravine with an actively eroding slope. This is presumably due to the nearby (to the north) residences that have increased runoff to this ravine because of an increase in impervious surfaces from driveways, roofs, etc. This ravine is also starting to form a deep channel at its bottom. Controlling runoff at its source (the residential neighborhood) would help this problem.
2) The bottom of the large ravine in the middle of the property (between OF-1 and OF-2, at the south end) had some slumping of the ravine banks
3) At the far south end of the property by the trail on a steeper south-facing slope.

Ecological Threats

The bluff prairie was mostly covered by fine-rooted vegetation (graminoids and forbs), but much of it was being invaded and converted to woody vegetation (shrubs and small trees). It is well known that the fine roots of herbaceous vegetation is the primary factor that holds fine soil particles in place, especially on steep slopes. Thus, a lack of graminoids and forbs may likely lead to a situation of increased erosion and sedimentation at the bases of steep slopes. In light of this, the fact that these slopes were covered by grasses and wildflowers is quite a remarkable benefit. Restoration efforts on steep slopes are typically very difficult, since seed tends to wash away. The sooner restoration of these slopes occurs, the better, since over time, more and more woody vegetation will invade and make it that much harder to establish native prairie.

The same may be said for the rest of the site, since steep slopes and erodible soils occur on roughly two-thirds of the property. Throughout the site, at the bases of some of the steeper slopes, there were very small areas of sediment accumulation and on portions of the steeper slopes there were areas of surface erosion as evidenced by exposed root crowns of trees. This is a chronic phenomenon that can be again attributed to the simple fact that there is a lack of fine-rooted vegetation on these slopes. A denser vegetation layer would act to break the impact of the raindrop and dissipate the energy of stormwater running on these slopes. Also, fine-rooted plants, such as grasses, sedges, ferns, etc., help hold onto fine soil particles better than do coarser-rooted plants like trees and shrubs.

The forest floor throughout the GNOS property did not have a very thick duff layer, having a thin organic surface horizon and accumulation of only one year's leaf litter; much bare soil abounded. This is primarily due to exotic earthworm invasion. No species of earthworms were native to the northern part of the U.S., since the last glaciation, over 10,000 years ago (Frelich and Holdsworth, 2002). During the last century, epigeic (litter dwelling), endogeic (soil dwelling), and anecic (deep burrowing) species of earthworms (Frelich and Holdsworth, 2002) have been introduced (primarily as cast-off bait from anglers). Since then, they have become established and are very invasive in our native woodlands and forests. These species move into new areas in waves, one species following another, with ultimately the largest worms, night-crawlers (*Lumbricus terrestris)*, invading and establishing. Where soils/systems have evolved without them, these earthworm species, contrary to popular opinion, are not good for the soil—tunneling into the top layers of soil and ravenously consuming large amounts of leaf litter. The result of their

activities is a net soil compaction and a marked increase in the duff layer turnover rate (the time it takes for the litter layer to be decomposed and turn into humus). Thus, where there used to be several inches of light, fluffy duff layer in our native forests and woodlands, now there is only a trace or often none at all, with compacted, bare soil prevalent. This situation can then lead to detrimental impacts on surface water, due to increased erosion and nutrient runoff from affected areas into nearby 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 provide thick, fluffy duff layers. Thin duff layers have another important repercussion: common buckthorn seeds and other non-native species such as garlic mustard, readily germinate in bare soil and in a thin layer of duff. Once buckthorn is introduced to an area that has been "wormed", it, which spells yet greater degradation to the woodland ecosystem. Once a few large seed-producing trees take hold in an area, a virtual carpet of buckthorn seedlings will radiate outward from each "mother plant", thus displacing or preventing native plants from re-establishing these areas. The berries of buckthorn (and exotic honeysuckles) are dispersed by birds throughout the woodland. Trees that offer perches for birds are typically choked with buckthorn plants growing under their crowns. Hence, buckthorn can rapidly come to dominate a vulnerable woodland or forest, in a matter of 30 to 50 years (a "blink of an eye" in terms of ecological time scales).

Another factor of the woodland decline is over-browsing/over-grazing. Areas that were pastured by cattle or sheep received heavy grazing pressure that was unknown previously. Native grazers would move around often and not concentrate on one plot of land for long periods of time. This allowed for a very diverse forb layer to thrive. With the advent of cattle, introduced by Euro-Americans in the last century and a half, that grazing pattern changed, since cattle will concentrate their grazing much longer and their impacts are much greater. Many of the native forbs simply could not endure this new pressure.

Today, browsing, not grazing, probably has a greater impact on our woodlands, since the major browsers are deer. Deer populations have greatly increased over the last century due to both direct and indirect causes. Indirectly, due to the vast amounts of agricultural land that have been created at the expense of native forest, woodland, savanna, and prairie. Directly, due to the active management for deer hunting by wildlife managers. It is well known that deer prefer "edge" habitat: areas of land with large amounts of long, linear forest/woodland edge, so they can use both the open areas to feed and the wooded areas for cover. Fragmentation of forests and managing for large gaps and lots with linear woodlands have greatly increased the "edge effect" in Minnesota. This, plus the destruction of wolf populations, has resulted in an explosion in the deer population within the last 75 years. Deer, although they will eat them, do not prefer buckthorn or exotic honeysuckle—if given the choice they prefer many of the native forbs, shrubs, and tree seedlings. Therefore, this greatly increases the browsing pressure on the few natives that can survive earthworm and buckthorn invasions. One result of this is the lack of oak regeneration, typical of such woodlands.

Lastly, the lack of fire due to fire suppression, over the course of the last century and a half, has also negatively impacted the ecosystems of our native woodlands and savannas. Fire acts to kill small woody seedlings that might otherwise grow into mature trees and shrubs, thus keeping the understory of woodland and the ground layer of savannas open. Because of this, wildflowers, grasses, sedges, and ferns can thrive. When fires were allowed (and encouraged, by native Americans), a very diverse and varied herbaceous ground layer flourished under our woodlands and savannas, with hundreds of species occurring. Today, because of a lack of fire, woodlands have succeeded to forests and savannas to woodlands. Adding in the other three factors, earthworms, buckthorn, and deer, results in a degraded, vulnerable ecosystem, with only a few species remaining that can survive the onslaught.

In summary, due to several factors over the last 150 years, our woodlands and forests in Minnesota have undergone a transformation of vulnerability, degradation, and decline. The woodlands and savannas of the GNOS property are typical of this situation. Some areas are worse than others, however. The large ravine west of the new housing development has a relatively low level of buckthorn invasion—the buckthorn plants are not too large and not too many mature, berry producing "mother plants" were found. There is still time to save this area before it is totally choked by buckthorn. The eastern ravine and slopes are much more advanced in the invasion process—they have taller and denser buckthorn and more large, berry-producing plants. Thus, these eastern ravines and slopes are a lesser priority than the ones to the west side of the property. They have been invaded by earthworms, invaded by buckthorn, and over-browsed by deer. They have also been transformed by fire suppression. The bare soil and sedimentation accumulations are just one effect of this situation, which has developed over the course of the past150 years, and will not be easily reversed. However, with proper, well-timed management, restoration of the GNOS property woodlands is possible and likely (see Management Recommendations section below).

ADJACENT LAND USE

The GNOS property is surrounded and tightly bounded by urban land use (**Figure 9**). To the south and west is Highway 61 and abutted by two large buildings to the south. Beyond Highway 61 the landuse is low-density single family residential. To the west is Hardwood Avenue, and beyond that is a parcel of forested open space with a couple of rural residential houses on the north side of it. To the north is low-density residential, on the west side of the north, and on the east side of the north is low-density residential. .

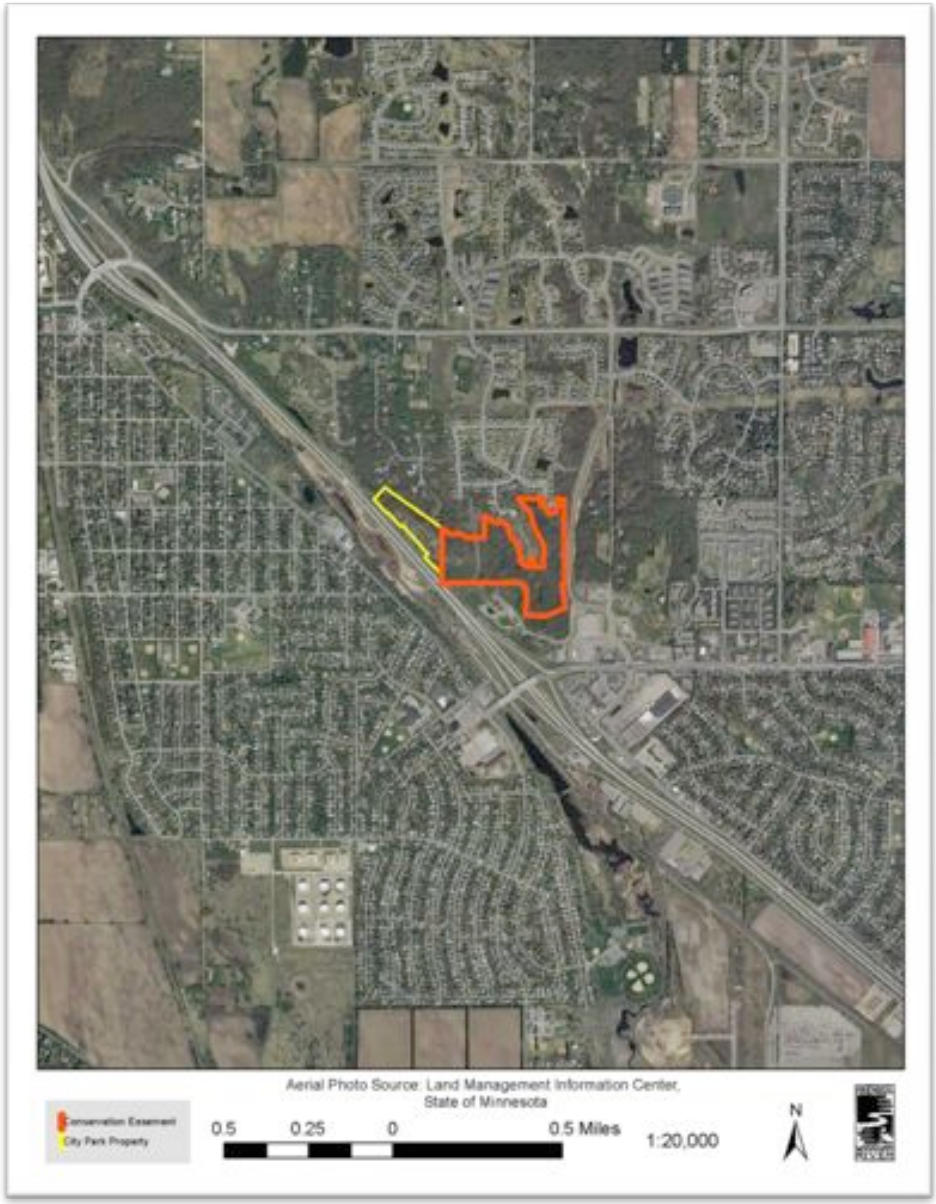


Figure 9. Adjacent Land Use surrounding the GNOS Property. 2010 color aerial photograph.

A large piece of land projects about 1000 feet into the north side, in the middle where the topography is relatively flat, which virtually bisects the GNOS property. Low-density residential housing was being constructed on this projection of land at the time of the field survey. This "peninsula" of non-natural land is a disturbance to the surrounding parkland, and ramifications will affect the surrounding parkland both presently and in the future. There was already evidence of increased erosion of ravine slopes and the beginnings of channelization of the bottoms of some of the ravines close to the disturbance. Zones of cleared vegetation were evident adjacent to the new residential road and houses. Increased stormwater runoff and reduced infiltration will impact the GNOS property

monitoring should be performed often (probably more than annually) to keep a finger on the pulse of the changes to the surrounding parkland.

Not only stormwater issues, but also invasive species issues will be problematic due to this "residential peninsula". Disturbance usually leads to an advent of weed species, both woody and herbaceous. Increased edge effect favors weed growth, too. Increased human traffic in the area will vector (physical introduction of) new species (some potentially invasive) to the adjacent park, creating a sort of a "portal" to the natural plant communities there. Ornamentals that people plant in their yards can potentially escape into adjacent natural areas. Also, disturbance can lead to an increase in the incidence of oak wilt disease (see section below).

Not all of these negative impacts can be prevented, but with education and outreach, they can be ameliorated. The more residents know about their potential impacts, the lesser the impact can be. A greater understanding of the natural communities that surround them and pre-dated their occupation of this site should help reduce the negative impacts, also. Educating through and outreach campaigns and neighborhood meetings, forming local nature clubs or societies, posting interpretive signs, distributing maps, etc., can all help protect the resource.

As was discussed at the beginning of this document, the potential to link the GNOS property with conservation corridors is a vital strategy for promoting the health of wildlife populations here. Since it is virtually surrounded by urban landuses, this will be difficult to accomplish. There is opportunity to connect on the northwest end of the property, going along the highway to the northwest, which leads eventually to a greater corridor that widely arcs around to the area. Connecting to the west, across Hardwood Avenue, into the open space woodland, would be beneficial, but "wildlife bridges" would have to be constructed, which are very expensive.

Salt spray from Highway 61 is potential impact, but there is a buffer between the GNOS property and the highway. However, salt may still impact the plants on the edge. Many of the native dry bluff prairie plants should be resistant to salt damage, whereas trees tend to be heavily impacted (high twig mortality and abundant "witches' brooms"). This should not be a concern, since trees will be removed from the bluff prairie unit here.

Noise pollution from the nearby Highway 61 is a problem. The height of the bluff and slope near the highway will help reduce noise levels from the highway, especially if one is on the back side of the bluff, but the majority of the bluff prairie will be continually exposed to highway noise. Not much can be done about this, unfortunately, short of erecting a wall or sound barrier. Planting trees is not recommended to reduce sound levels, since they are not appropriate in a bluff prairie.

The new White Pines buildings (senior housing) to the south of the GNOS property, on E. Point Douglas Rd S., doesn't really pose any stormwater runoff problems, since it is down-slope from the GNOS property. The native plant community that is to be restored near this building is Oak Savanna, which should be an amenity to the users of this building. One

possible problem could be smoke drifting from the park during controlled burns. Proper planning and notification or building occupants should avert conflicts, however. In fact, all adjacent residents should be notified prior to any controlled burning events at any time, and smoke management should always be part of any burn plan. Burning the bluff prairie should not be problematic for Highway 61, since it is up high enough to have smoke go onto the road. Nevertheless, wind direction from the south would be advisable when burning the bluff prairie. Wind direction from the north would be desirable for woodland burns on the north side of the property. In general, dividing the property up into burn units is recommended, since the property is so large and interfaces with so many urban landuses.

Impacts of the nearby residential and commercial developments are increased stormwater runoff, increased introduction of invasive species (garden plants and ornamentals that may "escape" into the natural areas and become invasive), mowing clippings that accumulate on the border, and clearing of native vegetation. Solutions to these potential problems may be education and outreach of the neighboring residents. FMR may be available to assist with this endeavor.

Oak Wilt

The "peninsula" of land upon which new residential homes are currently being constructed represents a threat to the ecological stability of the GNOS woodlands and forests, since the incidence of tree wounding will most likely increase. When oak trees are wounded they are more susceptible to oak wilt disease since beetles, vectors of the disease (they carry fungal spores on their bodies), are attracted to the scent of fresh wounds. Thus, the incidence of oak wilt in the GNOS will most likely go up. The tree protection measures required in the City Ordinance should be adhered to during construction. Oak wilt is a very serious fungal disease (*Ceratosystis fagacaerum*.) of oak trees that results in tree mortality. Once the oak wilt fungus becomes established in one tree, it can move through common root systems to adjacent trees of the same species—red oaks to other red oaks, and white oaks to other white oaks—thus the formation of an "infection center". Infection centers spread rapidly through red oaks and slowly through white oaks—bur oaks are intermediate in spread rate. **Oak wilt can be controlled primarily through reducing the wounding of trees**.

To slow the underground spread of the fungus root barriers are required. The most cost effective method of installing root barriers is with a vibratory plow—a large, modified backhoe that pulls a vibrating blade through the ground. The blade typically extends five feet deep into the soil, cutting roots as it goes. This procedure can be more or less disturbing to the soil and plant community, so deciding whether or not to root-cut should weigh the pros and cons. Also, vibratory plows will not operate on slopes that are too steep or soils that are too wet or too hard. For instance, vibratory plowing is not recommended on the savanna ridgetop of the bluff prairie, since the bedrock is very close to the surface there. Likewise, it is not recommended on the steep slopes of the site, but rather on relatively broad, flat areas. Access is another issue. Access for the vibratory plow must be allowed, and at least a 10-foot wide lane must be permitted for the machine to pass.

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

Bur Oak Blight

Bur oak blight, or "BOB" is a relatively new fungal disease in Minnesota. BOB is caused by a species of *Tubackia* fungus that was recently discovered (U of MN Forest Resources Extension, 2011). This disease has been confirmed in several counties in Minnesota, including Ramsey and Hennepin, so could potentially occur in Washington County too. This disease is a tree killer, but it moves much more slowly than does Oak Wilt. It only affects bur oaks, which is a concern at the savanna ridge top, as well as other units containing valuable bur oaks on the GNOS site. It seems to be influenced by the frequency of rainfall, with more rainfall resulting in conditions suitable for the disease. Symptoms occur in leaves in July and August, with large, brown, wedge-shaped necrotic lesions forming. Sometimes leaf veins turn brown also. One of the best ways to diagnose the presence of this disease is by examining bur oaks during the winter—if they hold onto their leaves (even just a few), this may indicate that they are infected with BOB. Normal bur oaks drop all of their leaves during the winter. The disease overwinters in leaf petioles and spreads throughout the crown of the tree and potentially into other nearby trees over the span of several years. Mortality can result, but often trees that die are located right next to ones that are unaffected, so the rate of spread is relatively slow. Control of this disease cannot be attained through raking and burning of fallen leaves, since many leaves remain attached to the tree over winter. However, periodic site-wide burning would reduce the spore load, since many fallen leaves will bear fungal spores. Researchers are condoning fungicide injections, since the protection provided by a single injection seems to last for several years.

EXISTING LAND COVER & ECOLOGICAL MANAGEMENT RECOMMENDATIONS

The Department of Natural Resources (DNR) developed a system called the Minnesota Land Cover Classification System (MLCCS), which defines and classifies all types of landcover. This information was used as a basis for the site evaluation, which was conducted by FMR's ecologist in the summer and fall of 2011. Recorded information included a list of plant species and their percent coverage in each vegetation layer (tree, shrub, grass) (**Appendix A**), soil type, slopes, and animal signs. Information also included ecological concerns, such as erosion, exotic species, etc. The classification was modified as needed, based on plant species observed and the resulting landcover types are shown in **Figure 11**. Each of the landcover units is summarized in **Table 3** and described in the paragraphs below.

For determining target plant communities for restoration (**Table 3**), we considered the historic conditions, existing conditions, and relative effort vs. benefits. As a guideline 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 Minnesota Department of Natural Resources 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. There are four ecological provinces in Minnesota (prairie parkland, eastern broadleaf forest, Laurentian mixed forest, and tallgrass aspen parkland), ten sections within the provinces, and 26 subsections **(Fig. 10)**. The GNOS property is classified as follows:

Ecological Province: *Eastern Broadleaf Forest*
Section: *Minnesota and Northeast Iowa Morainal*
Subsection: *St. Paul Baldwin Plains and Moraines*

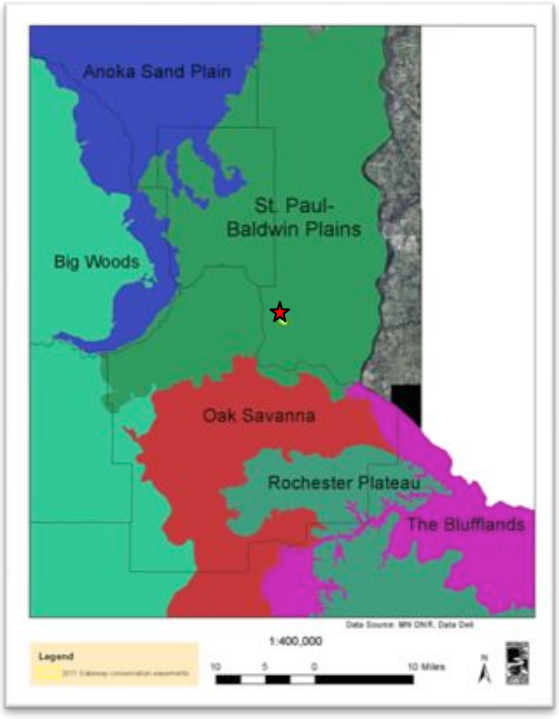


Figure 10. MN DNR Ecological Subsections map for southeastern Minnesota. Red star shows approximate location of GNOS Property.

As stated earlier in the Historic Vegetation section, the vegetation of the GNOS Conservation Easement property, in pre-settlement times was most likely bluff prairie on the bluffs, and oak woodland/savanna on the rest of the property. This is still appropriate for the site, although there has been some succession of communities. Some areas that had been oak savanna have become oak woodland, and areas that were oak woodland are succeeding to dry oak forest. In general, south- and west-facing slopes would now support oak woodland and north- and east-facing slopes would tend to support dry oak forest, without any further management to reverse succession.

The GNOS property was evaluated by an FMR ecologist in late summer and fall of 2011. Recorded information included: primary plant species and their relative coverage; animal signs; land use activities; and ecological concerns such as erosion, exotic species, etc. Each of the land cover units is shown in **Figure 11** and described in the paragraphs below. Photograph numbers refer to the locations, depicted on **Figure 11**. The landcover classifications were based on the Minnesota Land Cover Classification System (MLCCS) developed by the DNR (DNR 2005). The names of the cover types were modified slightly for ease of use.

The following table (**Table 2**) is a list of "notable features" (see **Figure 11** for their locations):

Feature ID	Description
0	Patch of native grasses
1	Cave
2	Native grassland stand
3	Small prairie patch
4	Rock outcrop with prairie node on top
5	Prairie patch, small
6	Mini cave on west end
7	Prairie opening
8	Huge basswood. 45+ inches.
9	Large bur oak
10	Corner post, wooden
11	Equisetum and sedges at base of slope
12	Smooth sumac stand
13	Square, cement structure on ground
14	Large, open grown bur oak
15	American hazelnut shrubs on talus slope
16	Trail head into ravine
17	Bottom of ravine. Side-slope erosional creep.
18	Top of trail.
19	Large, old bur oak. Open grown. Fire scar.
20	Gnarly, branchy bur oaks. Native graminoids.
21	Huge hackberry.
22	Prairie opening
23	Barberry patch. Remove.
24	Aspen grove. High-density buckthorn also.
25	Dugout "artifact". Carpet of knee-high buckthorn.
26	Possible seep (RCG patch)
27	Big toothed aspen stand
28	Massive red oaks
29	Small opening in OW-Br.
30	Large, dead bur oak.
31	3 large red oaks, dead
32	Garlic mustard. Small patch
33	Band of ironwood on slope. 2 to 4 contour lines.
34	Large basswoods.
35	Large green ash, 35"
36	Large green ashes
37	Fallen large red oak at bottom of ravine
38	Interrupted fern. Less buckthorn.
39	Ravine erosion on east slope and channelization at bottom
40	Slope clearing/disturbance from construction

Table 2. List of "Notable Features" from Figure 11.

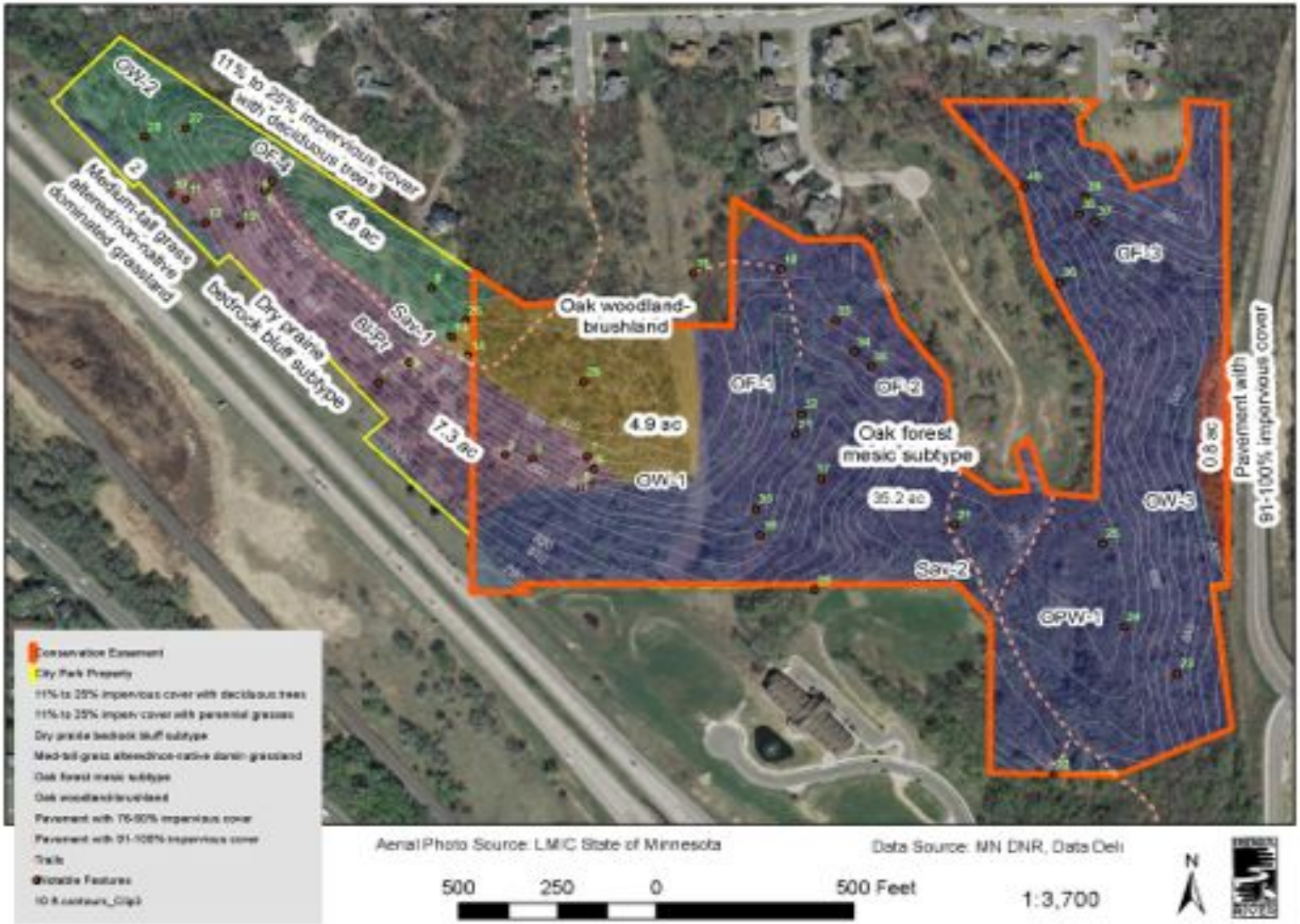


Figure 11. Existing Landcover

The following are descriptions of the various cover types, found on the property. The cover types were described and designated by Minnesota Land Cover Classification System (MLCCS). Some of the cover types were re-designated to a more appropriate type than was designated by MLCCS. They were then arranged in order of size of area, with the largest cover types listed first and the smallest listed last. Cover types may be represented by multiple units of the same cover type (e.g. Oak Woodland represented by OW-1, OW-2, and OW-3). Please refer to **Figure 11** (Landcover) and **Figure 12** (Target Plant Communities) throughout this section.

OAK FOREST, MESIC SUBTYPE (35 ac) (2.4 ac)

This was the largest cover type on the property. There were four units of oak forest on the easement property: OF-1, OF-2, OF-3, and OF-4, which were scattered across the easement. OF-1 (4.8 acres) and OF-2 (7.4 acres) were located in the broad ravine in the middle of the property. OF-3 (6.6 acres) was located in the northeast portion of the property. OF-4 (2.4 acres) was located in the northwest portion of the easement on a north-facing slope.

Photo 1. Old bur oak, in OW-1, with wide-spreading crown.

OF-1, occupying the east-facing slope of the broad ravine in the middle of the easement property, consisted of few very large (20 to 40 inch diameter) oaks (bur and red) scattered in groups across the unit. These oaks occupied about 10 to 15% of the total **canopy tree** cover of the unit. These oaks were typified by very large, spreading crowns (Photo 1). Many of these trees had large callused over branch stubs placed low down on their trunks, indicating that they once had very large branches and the site was more open than it is today (Photo 2). Also, several of these large, old trees were actually dead, having recently died, since their bark was still intact on their trunks (Photo 3). Some of the old oaks had fire scars at their bases, whereas

Photo 2. Old bur oak with large branch stubs low down on trunk.

none of the younger trees did, which indicates that fire had formerly occurred on this site probably 100 years ago or so (Photo 4). Other species constituting the canopy tree layer were a few large to medium-large (10 to 20 inch diameter) hackberry, basswood, bitternut hickory and black cherry. No stumps were observed to indicate that the area had been logged in the past. The dominant tree cover of the unit was the **subcanopy tree layer**, constituting about 65 to 85% of the total canopy cover (Photo 5). 4 to 8 inch diameter basswood and hackberry were most common. Other species occurring in this layer were American elm, bitternut hickory and a few bur and red oaks. The **shrub layer** covered approximately 50 to 65% of the layer and consisted primarily of buckthorn, with a few other species including red elderberry (especially down by the bottom of the ravine), chokecherry, and Missouri gooseberry. Shrubs were generally not very tall, being only about 4 to 6 feet high. The density of buckthorn was not too bad in this unit, yet, with very few large berry-producing individuals present. Managing now for buckthorn control in this unit should be a

Photo 3. Large bur oak that recently died. Note the intact bark on trunk and decay fungi.

Photo 4. Fire scar at bas of old oak in OW-1.

Photo 5. View of OW-1 to the northeast, showing the dense subcanopy layer of this unit.

Photo 6. West-facing slope in OW-2. Note the abundant ironwood.

priority, since it is still at a level and density that can be fairly easily and successfully controlled. The ground layer was not very diverse, with buckthorn (dominant) and a few other species present including Pennsylvania sedge, white and yellow avens, Virginia creeper, sweet cicely, and lopseed. There were a couple of garlic mustard plants near the bottom of the ravine. Eliminating the garlic mustard before it gets spreads should be a priority for this unit also. There were many patches of bare soil, and the leaf litter was very sparse, with just a trace of leaves from the present year on the soil surface. The gully at the bottom of the ravine did not show many signs of erosion, although one reach on the southern end did show signs of some slow erosional creep.

Photo 7. Large basswood in OF-2. Note the upward branch angles indicating a more closed-grown situation.

OF-2, occupying the west-facing slope of the same broad ravine in the middle of the property, was quite different from OF-1. OF-2 contained more large trees in the canopy tree layer and it also contained ironwood in the subcanopy layer, something OF-1 did not have (Photo 6). The canopy tree layer covered about 60 to 85% and consisted of a mix of hardwood tree species including red oak, bur oak, basswood (Photo 7), green ash, hackberry, and bitternut hickory. The subcanopy layer contained abundant ironwood (3 to 8 inch diameter), especially in a 40-foot-wide band stretching across the mid to upper west-facing slope.
Shrub and Ground layers again were dominated by small buckthorn. Leaf litter was sparse and much bare soil was exposed.

Photo 8. Gully forming in bottom of ravine in OF-3.

OF-3, located in the far northeast portion of the property, is similar to OF-1 and OF-2, in that the total canopy was 65 to 90%, but most of the trees were in middle size classes. There were a few large canopy trees, mostly red oak, basswood, and green ash, but most of the canopy consisted of smaller diameter sub-canopy trees. The gully at the bottom of the ravine at the north end showed signs of erosion (Photo 8). The north bank was steeper and was actively eroding in spots. The gully was starting to form a channel, also. The residential development to the north of this unit no doubt contributed to this erosion situation.

OF-4, located in the northwest portion of the property, north of the bluff prairie, lies on a north-facing slope. This unit is really an overgrown woodland that is succeeding to a forest. The tree canopy was rather oddly distributed, in that trees were grouped or clustered, with expanses of open areas between them (Photo 9). The largest canopy trees were a few extremely large basswoods (50+ inch diameter) and several medium-sized red oaks. Other tree species present were Black cherry, American elm, bitternut hickory, and a few bur oaks. Prickly ash was prevalent in the shrub layer. Buckthorn seedlings and saplings (up to 8 feet tall) were also quite dense in the ground layer and in the shrub layer. Not many large buckthorn shrubs were present. Many large to medium sized stumps (Photo 10) were scattered throughout this unit, showing evidence of what had to be a former oak wilt infection center, which also explained the odd clustering distribution of the trees (since many larger red oaks had died from disease, many canopy gaps existed). Oak leaf density on the ground was such that the site could be burned, so restoration to woodland is possible, but not probable, since red oaks cannot be planted due to oak wilt. Oak-Basswood forest (MHs37) is a more likely plant community target here.

Photo 9. View of OF-4. Notice the trees are clustered with lots of open space between them. Also note the abundant buckthorn in the understory, having been "released" by gaps created by dying oaks.

Photo 10. Oak stump. Note the bark still on the stump, indicating a recent cut. Oak wilt presumably was the cause of mortality.

One of the issues in facing the entire Oak Forest cover type was the lack of oak regeneration. High deer-browsing pressure, competition from buckthorn, lack or light to the forest floor, and reduced duff layers all contribute to this problem. Without new oaks coming to replace old and dying ones, the oak component of this forest will be eliminated. Without proper management, this will not be a mesic oak forest for long.

DRY PRAIRIE, BEDROCK BLUFF SUBTYPE (7.2 acres)

The MLCCS designated approximately seven acres on the steep, southwest-facing slope along the north side of Highway 61 as "Dry Prairie, Bedrock Bluff Subtype", or otherwise known as "Bluff Prairie" (Photo on cover page). Not the entire seven acres was actually

bluff prairie, however. There were significant remnants of native bluff prairie scattered throughout the unit, but there were also large tracts that were devoid of native

Photo 11. Smooth brome grass is quite dominant in large portions of the bluff prairie slope.

Photo 12. Prairie node on east end of Bluff Prairie. Note the abundant big bluestem.

groundcover, being dominated by the introduced cool season grass, smooth brome (Photo 11). The largest concentration of bluff prairie was on the far western end of the unit (Photo 9) and one little prairie node at the far eastern end of the unit (Photo 12). Both of these high quality areas were perched over a very shallow layer of soil that mantled the bedrock, which outcropped in several places along the ridge top and along the steeper slopes throughout (Photo 13). The topography of this site was quite steep, with some sheer cliff faces. Much of the slope was covered with loose rock (talus) that had accumulated from the weathering of the sandstone outcrops, and made for treacherous footing (Photo 14). Two caves were present at the western end of the unit, a small one at the far end (Photo 15), which faced west, and a larger, cave complex (Photo 16) at the mid-western end, which faced

Photo 13. Rock outcrop on east end of Bluff Prairie, which underlies the east prairie node from Photo 12.

Photo 14. Talus slope of bluff prairie. Note the profusion of rock flakes accumulated here.

southwest. The vegetation surrounding both of these caves was primarily native herbaceous species including little bluestem, big bluestem, muhly grass, Schweinitz's flatsedge, and thimbleweed, but some woody brush was invading. The eastern prairie node (Photo 12) was dominated by big bluestem and Indian grass, whereas the western end (a larger area) was really not dominated by any one species, although some areas had higher concentrations of little bluestem and needle grass (Photo 17). There was an area at the mid-bottom of the western end slope, where the slope leveled out a little, which contained equisetum, which may be an indicator of a wetter soil; perhaps there was a seep just under the soil surface, emanating from a confining layers of the soil below.

Photo 15. Cave at west end of Bluff Prairie ridge, on west-facing slope.

Photo 16. Larger cave complex on southwest-facing cliff. Note the little bluestem in mid and foreground of photo. Some woody vegetation is encroaching on the left of the photo.

Photo 17. West end of bluff prairie. Note the abundant and diverse native flora.

A band across the lower slope was completely dominated by smooth brome. The natives started to show up only at about halfway up the slope, and then they were patchy in spots. Much of the slope has been invaded by woody vegetation, and it is distributed in patches or groves and scattered single individuals. This woody vegetation consists of both native and non-native species, including common buckthorn, Tartarian honeysuckle, Siberian elm, eastern red cedar, Russian olive, hackberry, American basswood, American elm, bur oak, boxelder, eastern cottonwood, black cherry, smooth sumac, and American hazelnut. Regardless of its nativity, this bluff prairie is quite overgrown with brush, and all of the non-native brush and most of the native brush should be removed (see **Management Recommendations** section). The smooth brome could be controlled using a combination of very carefully targeted chemical applications and late-season burning.

Native prairie plant species found on the steep bluff slope included the following: bur oak, American hazelnut, smooth sumac, a recumbent black raspberry species, eastern red cedar, prairie rose, plains muhly grass, needle grass, wild rye, big bluestem, little bluestem, sideoats grama, hairy grama, Scribner's panic grass, Indian grass, Schweinitz's flatsedge, prairie dropseed, Missouri goldenrod, thimbleweed, stiff goldenrod, columbine, heath aster, wild bergamot, lead plant, and prairie cinquefoil.

There was a large sumac stand on the western end of the bluff prairie slope (Photo 18), and a few others scattered throughout the remaining slope. Generally, going west to east on the slope, the woody vegetation got denser. At a point basically aligned with the eastern rock outcropping and prairie node, the slope rounded a corner and turned more south and east-facing (OW-2, south portion), which resulted in a change in the vegetation cover to more woody vegetation (Photo 19). Here bur oak was dominant and dense enough to suppress the growth of herbaceous ground cover.

Photo 19. Standing at east edge of bluff prairie looking into the adjacent Oak Woodland to the east. Note the abundant bur oaks and denser hardwood vegetation as compared to the bluff prairie.

Photo 18. View of bluff prairie slope from base looking up. Note the stand of smooth sumac on lower slope.

The top of the ridge of the bluff slope was quite level and flat (Photo 20). This area will be restored to **Oak Savanna**. The 1947 aerials show that much of this flat-topped ridge was formerly a field. Scattered large, mature bur oaks abound here, with grassland dominating between the oaks (Photo 21). Quite a few shrubs and small trees have invaded during the last 40 to 50 years, and should be removed and controlled by fire. This flat-topped ridge was also underlain by a more mesic soil type, which would allow the herbaceous and woody vegetation to become large and lush. Bur oaks would be able to grow well here because they have thick corky bark that is heat resistant, whereas other trees would probably not flourish due to the high frequency of fire introduced from the steep bluff prairie to the southwest. The other side of the bluff was a north-facing slope, which would be shadier and moister, and thus have a lower fire frequency, allowing a more mesic plant community to flourish.

Photo 20. The flat-topped ridge of the bluff prairie, looking east. Note the mix of native and non-native grasses. Also note the foot path (darker line in photo).

Photo 21. Oak savanna on ridge. Note the picturesque grove of bur oaks.

The main restoration opportunity for this unit would be to remove woody brush and trees. Trees and shrubs invade a prairie when fire is not frequent enough to kill woody seedlings. On bluff prairies, often wind blown tree seeds establish on precarious ledges, flat mid-slopes, and anywhere soil has had a chance to accumulate and the microclimate is somewhat protected from fire. Once trees start to invade, and a few get established, it gives birds perch sites; seeds are then dropped by the perching birds. Shrubs that spread via seeds/berries are readily spread in this manner. Numerous examples on

Photo 22. Example of a tree (in this case a dead elm) ringed by red cedars.

this site abounded of trees that were completely surrounded by shrubs (red cedar, Tartarian honeysuckle, buckthorn) (Photo 22). Sometimes the trees were dead, as in the case of elms that contracted Dutch elm disease, but they are long-since survived by their complement of surrounding shrubs. Slowly but surely, woody plants have started to transform this once open bluff prairie to a closed brushy shrubland. Given enough time, this transformation would be complete on the entire slope. To reverse this trend and restore prairie on the bluff, it is imperative to 1) remove the larger woody brush and 2) to re-introduce fire into the ecosystem of the bluff prairie. This will not be easy, given the steepness of the slopes and the extent of woody brush encroachment, but it is necessary. After the brush has been removed and several prescribed burns have been performed, prairie should then start to make a comeback.

Another priority of this area is the protection of bur oaks from oak wilt and bur oak blight diseases. (See the section entitled "**Adjacent Landuse**" for a fuller description of the oak wilt disease and control options.) Bur oaks on the savanna ridgetop of the bluff prairie are particularly significant to the landscape and are of high priority to protect. Oak wilt infection centers exist nearby, on the north-facing slope on the other side of the ridge from the bluff prairie (OF-4). This area has shallow soil that is very close to bedrock, and therefore it is not recommended to use vibratory plowing here. It is strongly recommended to monitor for oak wilt every year, and to remove trees that are recently dead or dying from the disease, since this greatly reduced the spore load in the vicinity. Many times oak wilt will start in the reds and move to burs just because the concentration of spores is so high that if a bur oak happens to get injured (in a storm, for example) its likelihood of becoming infected is high. By using sanitation—removing and properly disposing of infected branches and stems—the probability of overland spread of the disease into nearby bur oaks is greatly reduced. Also reducing the wounding of nearby oaks (for instance in nearby development and construction zones) greatly helps reduce overland spread. If burs do contract the disease, probably the best direct control would be chemical injections into individual high-value bur oaks trees. This is expensive, however, and also needs to be done every two years to be effective.

OAK WOODLAND-BRUSHLAND (13.9 acres) (2.5 ac)

This cover type was encountered at three different units on the property, OW-1 (6.6 ac), OW-2 (2.5 ac), and OW-3 (7.3). These units have one thing in common: they are dominated by red and pin oaks, have a large component of aspen, and are desperately in need of fire, since they are quite badly overgrown with brush.

OW-1 was located in the central portion of the property, between the pipeline and the bedrock prairie. It was 6.6 acres in area and lies on flat topography in the north portion and steeper, south-facing slope in the south portion. In the north portion of this unit, it was

Photo 23. OW-1, north portion. Note the rather open character of the woodland and the lack of mature trees.

Photo 24. OW-1, south portion, looking east from the eastern end of the Bluff Prairie. Note the denser, more mature woodland here.

quite open, with only about 10 to 30% tree cover here (Photo 23). This makes sense, since the 1947 aerials show that this was the site of one of the rectangular clearings (old fields) (**Figure 6**). In the south part, on the steeper slopes and at the bases of these slopes, the canopy was much more closed, with many medium-sized bur oaks and large red cedar dominating the canopy (Photo 24). In the north part of the unit, the tree canopy consisted of a mix of primarily young black cherry, basswood (multi-stem trees), boxelder, American elm, eastern red cedar, and red oak. Grading to the north-facing slope (OW-4), a stand of big-toothed aspen occurs. Shrubs cover about 40 to 80% of the north portion and about 20-40% of the south portion of the unit. Shrubs consisted of smooth sumac, prickly ash, buckthorn, black raspberry, red cedar, and grey dogwood. The ground layer varied from 20 to 60% in the northern portion to 10-40% in the south of the unit, and consisted of smooth brome, Kentucky bluegrass, Pennsylvania sedge, moss, reed canary grass for graminoids, and Canada goldenrod, bergamot, thimbleweed for forbs. No native grasses were found in this unit.

OW-2, located at the western end of the property, beyond the bedrock prairie, lies on a west-facing slope that levels out at the bottom of the far west end of the property. This unit was dominated and almost exclusively occupied by large, mature red oaks in the tree canopy which had an approximately 60-80% coverage. A stand of big-toothed aspen also was present on the west-facing slope. The shrub layer and understory layer was quite dense with buckthorn, and the ground layer was nearly absent. Oak leaves abounded on the soil surface, so fire has an excellent chance of being used as a restoration tool here.

OW-3 is located at the opposite end of the property, on the east-facing slope at the far eastern side of the easement. This unit was also on the site of a former clearing, as seen in **Figure 6** (Perhaps this was a large timber harvest, since it would have been too steep for a field.) Nevertheless, this area was definitely quite degraded, with much larger and much denser buckthorn (Photo 25). The canopy dominant was red oak. A large quaking aspen stand was located at the west boundary of this unit, at the flat ridge-top, which blends into the FDs27 unit. The herbaceous ground layer was virtually absent in this OW-3 unit, since the buckthorn was so dense. High quantities of large woody debris were present on the forest floor, thus heavy fuels were much greater here than in other parts of the property, which will have impacts on potential future burning plans (Photo 26).

Photo 25. Dense thicket of buckthorn in understory of OW-3.

Photo 26. Abundant amounts of heavy fuels have accumulated in OW-3.

As in the oak forest, a lack of oak regeneration is a problem in this oak woodland cover type. Without proper management, this woodland will likely succeed to a disturbed mesic forest with no oak component, that will likely dominated by buckthorn. The restoration goal of this community should be Southern Dry-Mesic Oak Woodland (FDs37).

Photo 27. Gnarly bur oak. Note the buckthorn crowding around it.

Approximately four acres of the higher, flatter portion of what was formerly Mesic Oak Forest between OW-3 and the trail and blacktop road in mid-eastern portion of the property is recommended to restore to **Southern Oak-Pine woodland** (FDs27). Present here was a stand of Jack Pine, and the continuation of the large quaking aspen stand, with scattered bur and red oaks. Buckthorn was very dense throughout.

Three acres of what was formerly mesic oak forest at the southern end of the easement, and wrapping around the north side of the

newly constructed building, was an area that had numerous prairie openings and was dominated by large, gnarly bur oak trees (Photo 27). It is recommended to restore this area to **Southern Mesic Savanna** (UPs24). There were several prairie species in the ground layer, including leadplant, thimbleweed, little bluestem, big bluestem, and several sedges. Removing small to medium sized trees and expanding the prairie ground cover into cleared gaps would be recommended for this portion.

MEDIUM-TALL GRASS, ALTERED NON-NATIVE DOMINATED GRASSLAND (2.0 acres)

This unit is located at the base of the slope near Hwy 61 at the far western end of the property, and was re-designated primarily as Oak Woodland (FDs37, OW-2) with a small portion as Bluff Prairie (UPs13c).

GRASSLAND ON PIPELINE RIGHT OF WAY (1.1 Acres)

This unit is designated as "grassland" (Photo 28) (**Figure 12**). The vegetation on this long, narrow strip of land was dominated by Canada goldenrod and rounded out by bergamot,

Photo 28. "Grassland" on pipeline right of way in middle of property. View looking south from the north side of the property.

Photo 29. South end of pipeline right of way. Disturbance on slope and surface repair via erosion control blanketing.

smooth brome, prickly ash, and black raspberry, among others. The very south end of this unit was disturbed and then repaired on the surface using erosion control blankets. It is recommended to monitor this area for erosion and also for establishment of vegetation. It is further recommended that native vegetation be seeded here. So if non-native seed was used, it is recommended to re-do this area using native seed and erosion control blanket. It is assumed that maintenance of this unit will be the responsibility of the pipeline company, who will be responsible for re-seeding disturbed areas, etc.

11 to 25% IMPERVIOUS SURFACES (9.2 Acres)

Portions of the part located north and adjacent to the bluff prairie were considered 11-25% Impervious Surfaces, presumably because of nearby houses. This area is targeted to be oak

savanna (Sav-1), oak woodland (OW-2) and oak forest (OF-4) in this plan (**Figure 12**). See those sections above for a description of these landcovers.

PAVEMENT WITH 91 to 100% IMPERVIOUS COVER (0.8 Acres)

A portion of the far eastern end of the property was occupied by impervious cover. It is targeted to oak woodland (OW-3) in this plan (**Figure 12**).

Figure 12. Target Plant Communities at the Gateway North Open Space Easement

RESTORATION PROCESS

Undertaking a restoration project of this size is a significant task and assistance is available to help landowners with the process. Friends of the Mississippi River and Washington County will continue to work closely with the landowners, if desired, by helping to secure funding and providing project management and oversight. Professional firms that can conduct management tasks are listed in ***Appendix E.***

Management recommendations were developed for each land cover area, with the overall goals for the easement area focused on 1) protecting high quality bluff prairie, 2) restoring oak woodland/forest, and 3) providing wildlife habitat. Overall management practices to achieve those goals are:

- remove non-native, invasive, woody species;
- control non-native invasive herbaceous species, including, reed canary grass, hybrid cattail, Canada thistle, common burdock, and smooth brome grass;
- restore ground layer and shrub layer on steep bluff prairie/woodland/forest slopes;
- conduct periodic prescribed burning to maintain prairei and woodland vegetation and reduce invasive shrubs and overabundant tree seedlings;
- monitor annually for potential erosion and sedimentation, as well as for non-native invasive woody species;
- institute a monitoring plan to track effectiveness of management and restoration activities.

Restoration Goals

The primary objective for this site is to improve the composition of the plant communities throughout the property to better reflect the diversity, composition and structure that would have been present at the time of European settlement and to improve the ecological functions that the historic native plant communities would have 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.

Though degraded by past uses, the existing plant cover retains a good variety of native species and could be readily improved. A healthy and diverse plant community can provide much greater wildlife value than a degraded one, and tends to be much more stable, and less susceptible to disease, invasive species, and other concerns.

Target Plant Communities

The restoration sites on property will consist primarily of a mix of woodland plant communities and native bluff prairie.

The restoration target communities for this property are listed in **Table 3** and mapped in **Figure 13**.

Table 3. Restoration target plant communities for existing landcover.

MLCCS Unit	Re-designated Unit	Acres	Dominant Soil Type(s)	Target Community
OF	OF-1	4.8	Brodale flaggy loam (488F)	Southern Dry-Mesic Oak Forest (MHs37)
OF	OF-2	7.4	Waukegan silt loam (411C)	Southern Dry-Mesic Oak Forest (MHs37)
OF	OF-3	6.6	Brodale flaggy loam (488F) and Chetek sandy loam (155)	Southern Dry-Mesic Oak Forest (MHs37)
OF	OW-1	3.1	Waukegan silt loam (411B)	Southern Dry-Mesic Oak Woodland (FDs37)
OF	OW-3	7.3	Brodale flaggy loam (488F)	Southern Dry-Mesic Oak Woodland (FDs37)
OF	Sav-2	2.9	Waukegan silt loam (411)	Southern Mesic Savanna (UPs24)
OF	Gr-Pipe	1.1	Waukegan (411), Dorerton Rock Outcrop (1819F) and Brodale (488F)	Generic grassland
Bl-Pr	same (Bl-Pr)	7.3	Dorerton Rock Outcrop (1819F)	Dry Bedrock Bluff Prairie (UPs13c)
OW-Br	OW-1	4.9	Waukegan silt loam (411B)	Southern Dry-Mesic Oak Woodland (FDs37)
11-25% Imp	OW-2	2.5	Mahtomedi loamy sand (454D) and Hubbard loamy sand (7B)	Southern Dry-Mesic Oak Woodland (FDs37)
11-25% Imp	OF-4	2.4	Dorerton Rock Outcrop (1819F)	Southern Dry-Mesic Oak Forest (MHs37)
11-25% Imp	Sav-1	4.3	Waukegan silt loam (411B)	Southern Mesic Savanna (UPs24)
Md-tl Gr-Alt	Bl-Pr	2	Dorerton Rock Outcrop (1819F) and Hubbard (7B)	Dry Bedrock Bluff Prairie (UPs13c)
Pave	OW-3	1.1	Mahtomedi (155B)	Southern Dry-Mesic Oak Woodland (FDs37)

As can be seen from **Figure 12** and **Table 3**, the majority of landcover in the GNOS easement property is Oak Forest. This oak forest was named "mesic subtype" by MLCCS and is being called *Southern Dry-Mesic Oak Forest* in this plan, following convention set by MN DNR (DNR, 2005) for native plant communities. Some of what was classified "Oak

Forest, Mesic Subtype" by MLCCS was determined to be overgrown oak woodland, by the FMR ecologist, and therefore this plan is calling for it to be restored to *Southern Dry-Mesic Woodland* (FDs37) and to *Southern Dry-Mesic Oak-Pine Woodland* (FDs27). Note that the Oak Woodland communities will be second highest in area occupied on the GNOS property, following restoration (**Figure 12**). Also, some of the cover unit "11-25% Impervious Cover with Deciduous Trees" is being restored to both Oak Forest (MHs37) and Oak Woodland (FDs37) (**Table 3**). The "Dry Prairie Bedrock Bluff Subtype" cover unit (**Figure 11**) is being called by this plan *Dry Bedrock Bluff Prairie* (UPs13c), and gains two acres along the south border (adjacent to Hwy 61) that was formerly designated as "Medium-Tall Grass, Altered Non-Native Dominated", since it makes sense to manage this along with the larger adjacent bluff prairie unit. Portions of cover types designated as "Oak Forest, Mesic Subtype" and also "11-25% Impervious Cover with Deciduous Trees" are being restored to *Southern Mesic Savanna* (UPs24) (**Figures 11 and 12**) to reflect the existing conditions of the site and the historical vegetation of the site. Lastly, the narrow, long strip of what was part of cover type "Oak Forest, Mesic Subtype" that is currently a pipeline right of way, is being re-classified as "Generic Grassland", since this is not an oak forest but neither is it a native plant community.

Although the plant communities on **Figure 12** are shown as having distinct borders, in actuality they would for the most part have rather fuzzy borders. One community generally grades into another, with community structure being interwoven, with wavy margins separating them—nature tends to have few straight lines. Management of, for example an oak forest unit and an adjacent oak woodland unit, may sometimes mix together, and that is fine. Also, if a unit does not respond to being restored to a specific plant community, then it is reasonable and acceptable to adapt the plan to the situation at hand, sort of going with what the site dictates. This also underscores the importance of annual evaluations performed by ecologists or other natural resource professionals.

Restoration Process

Restoration is a process. It takes time to restore ecosystems to their former functioning, sometimes this can only be approximated. It took many years to degrade the ecosystem and biological communities of the GNOS site, so it will not be restored overnight. Many steps are typically involved in a successful restoration. Even deciding when a restoration is complete/successful can be very difficult. A good guide on how to accomplish restoration is using the concept of *adaptive management.* Adaptive management is a strategy commonly used by land managers and restorationists, and integrates thought and action in the process. It can be described as a strategy that uses evaluation, reflection, communication, and also incorporates learning into planning and management. It is set up like a feedback loop and looks like this: Assess Problem -→ Design -→ Implement -→ Monitor -→ Evaluate -→ Adjust -→ Assess Problem -→ and so forth. Thus, moving forward with restoration, each round of adaptive management refines and hones the process to better fit the conditions of the site and time. This strategy should be used at the GNOS site.

The restoration of the biological communities at the GNOS property will be broken into phases. Each phase will address the restoration of each given target plant community.

Phases will be spread out over a number of years. Restoration will also be prioritized, with the most important resources or vital areas taking precedence. On this site, the Bluff Prairie is the highest priority because this plant community is vulnerable to extirpation in the state of Minnesota, and is quite rare in Washington County (personal communication with staff at Washington Conservation District, January, 2012) and thus will be given preference in this plan. The second priority is restoring the Mesic Savanna units, since savanna is also a vulnerable plant community. The third priority is protecting/restoring the higher quality areas of forest and/or woodland on the property (for example, OF-1 and OF-2). The fourth priority is restoring lower quality areas of forest and/or woodland (e.g., OW-1, OW-2). Last priority is managing the pipeline ROW grassland, since this will be in a continual state of artificiality. **Table 4** is a schedule of proposed management activities and cost estimates, and lists each step in the process.

Site-Wide Invasive Woody Plant Removal/Control

The initial restoration goal will be the eradication of non-native woody species. This can be done in phases, according to priority, with bluff prairie coming first, followed by Oak Savanna, Oak Forest, and Oak Woodland. Restoration of each of the proposed plant community types, following in subsequent phases, as listed, can proceed depending on funding and scheduling. It would be nice to attain this goal all at once for the entire property, a process that typically takes three to five years. However, more closely integrating seeding, following removal, may be necessary, especially on the steep slopes that constitute the greater part of this property. Part of the exotic woody control would be prescribed burns, which will reduce seedlings of exotic species and will help to foster native species.

Restoration Priorities

PRIORITY 1: <u>Restore/Protect Bedrock Bluff Prairie</u>

Woody Plant Removal

The Bluff Prairie is in desperate need of being burned. Burning would not be enough, however, since so many trees and shrubs have invaded over 150 years of fire suppression. Therefore, first almost all trees and shrubs (woody brush) should be removed, and then the site should be burned. Only a few trees should be allowed to remain: a few bur oaks and a few redcedars. There are a few very large cottonwoods at the top of the bluff that could be removed—they are old and declining and may die soon, and don't appear to be regenerating. Detailed woody species removal information is provided in **Appendix D**. Primary species to remove are common buckthorn, Tartarian honeysuckle, redcedar, basswood, hackberry, with some Amur maple, and Siberian elm also. Cut stumps should be treated with Glyphosate (via hand-held spray bottles because they are easy to handle on steep slopes). This should be applied to stumps on a calm day during the growing season when temperatures are above freezing but not above 85 degrees. If not treated, stumps will sprout with multiple stems, thus creating a difficult situation to control, since even more cutting and herbicide will be required on the multiple resprouts. Use of chemicals should be done with extreme care on this site, especially on the bluff prairie, given the high potential for groundwater contamination and the high diversity of native prairie plants. It

is recommended to use Glyphosate. Glyphosate binds to soil particles and is generally not mobile, so it is a better choice than other herbicides that are more mobile.

Working on steep slopes presents a challenge on this property, especially on the talus slopes of the bluff prairie. Hand cutting of all woody brush is recommended for these steep, sensitive slopes. Operating equipment here would be very dangerous. Footing will be treacherous so proceed with caution keeping safety the highest priority. Using trained professionals (city staff or contractors) on the bluff prairie would be recommended. Volunteers can be utilized for areas that are not too steep. Costs for working on the steep slopes will undoubtedly be higher than usual. Brush near the ridge top can be hauled up top. Brush farther down the slope will be easier to haul down to the bottom. Brush pile locations will need to be determined, considering access and proximity to the highway. Burning of brush piles will probably not be an option close to the highway. Brush pile site locations to consider may be 1) on the far west end of the slope, where it flattens out and 2) the far eastern end of the slope near the building. Details will have to be worked out in the field at the time of removal.

Shrub Control

In terms of shrubs, the stands of sumac should be suppressed by mechanical methods ((two or more coppices per growing season) (**Appendix D**)), but not eradicated. There is a patch of American hazelnut on the slope, which can be left alone. Otherwise, all of the other shrubs should be removed. Prickly ash, a native shrub of open woodlands and savannas, can be controlled in areas that it is overabundant in the bluff prairie. Cutting and treating of stumps is recommended to control overabundant populations, but eradication is not recommended. Burning will top-kill prickly ash, but will not kill the root.
Repeated burning will keep populations in check.

Grass Control, Burning and Seeding

Eliminating smooth brome on the steep bluff prairie slopes involves properly timed activities. First attempts should be late season burns. Late season burns are beneficial because they more completely deplete plants of energy reserves by destroying the biomass of the topgrowth. Early season burns can only destroy what little topgrowth that has formed at that early part of the growing season. Late season burns also are more damaging to native forbs, so it is recommended to switch to early season burns in successive years, once smooth brome has been controlled. Two consecutive years of late-season burns should be adequate. Then switch to a regular burning cycle of 2 to 5 years. If late-season burning alone proves to be unsuccessful, then spot treatments of herbicide can be performed. Since native prairie remnants are patchy and their distribution is random on the slope, care should be taken to reduce collateral damage to the native plants (**Appendix D**).

Dry prairies do not require as frequent burning as do mesic ones, since tree and shrub invasion is somewhat inhibited by dry and nutrient poor conditions of the soil (MN DNR, 2005). However, as can be seen from the dense vegetation of this site, they still do require frequent enough fire to keep woody plants from invading. Two years of back-to-back Rx burns are recommended for the bluff prairie, followed by burns every 3 to 5 years from

then on. Also, the bluff prairie could be divided into two or three burn units so that burning could be rotated between units. The site should be evaluated after each burn to see how well plants (and animals) recover.

Before deciding whether or not to seed, monitor and evaluate the bluff prairie after a couple of burns to see if any native come into open gaps. Sometimes a latent seedbed can be released following smooth brome control. If it turns out, after 2 years or so, that no natives are filling in the gaps, then seeding will probably be required. Collect on site seed first, to preserve the integrity of the remnant. Collecting seed in the summer and fall, following a spring burn, is recommended since fecundity and fertility of plants from burned areas improves. It may be best to collect seed after the first year and save it, and add it to the second year's collection, to be broadcast following the second year burn. If not enough seed is available from on site, then purchase seed of local genetic origin (local ecotype origin) that is appropriate to the community. Origin within 100 miles is desirable. Use of erosion control blanket may be needed on steep slopes.

PRIORITY 2: <u>Restore Oak Savanna</u>

Although oak savanna would have constituted a large portion of this site in pre-settlement times, most of the site is too heavily wooded to restore to savanna. Approximately 7 acres are being restored to oak savanna on this property, in two different units, one on the bluff prairie ridge top (Sav-1) and the other along the south boundary (Sav-2) (**Figure 12**). The ridge top savanna will be relatively easy to restore, since it already contains the proper structure (scattered mature bur oaks and a grassland understory), and really only needs to be burned and possibly seeded. The other savanna, "Savanna 2" will be more difficult, since it requires much more tree and shrub (brush) removal. Brush removal can be accomplished in a similar fashion as on the Bluff Prairie, in terms of treatment of stumps. Large bur oaks should be left in this unit, but most of the other trees should be removed.

Woody debris should be gathered and stacked into burn piles, which can be located scattered throughout the property. Protect trees from heat damage by locating piles in forest openings at suitable distances from trees. Piles are best burned in winter when a light snow cover exists (e.g. 3-6 inches); otherwise fall is acceptable, too. Another option is to cut the stems small and scatter them on the ground, but this is undesirable when stems are thick. Stem-scattering would be suitable in woodland areas. It can save on exotic brush removal costs, but can also impede access for future management if cut brush is dense and regrowth occurs through the litter.

Since this site is fairly large, seed will most likely have to be purchased. Try collecting as much as possible, but purchase of local ecotype seed is appropriate here. No erosion control blanket will be necessary due to flatter terrain in this unit.

Burn at a rotation similar to the bluff prairie, about every 3 to 5 years. Savanna-1 unit may be burned in conjunction with the bluff prairie for most years, but juxtaposing it against the bluff prairie burn cycle is recommended for some of the burns.

Scenic Overlook or Council Ring

The City of Cottage Grove expressed a desire to install a Scenic Overlook or Council Ring on the flat-topped ridge at the top of the bluff prairie. Design proposals were evaluated by FMR ecologist, as well as a proposed location. Proposed designs looked appropriate for the site, with some exceptions.

- We recommend not planting any turf or other plants in or around the ring.
- Keep the location of the ring in the area near the concrete rectangular structure (Notable Feature #13, **Figure 11**).
- Use natural materials such as rock, stone, etc. so as to maintain organic unity with the surrounding natural community
- Do not impact the roots of any nearby bur oaks. Stay back from critical root zone at all times.
- Limit construction damage and soil compaction by working and hauling materials during winter or late fall when surface soil is frozen.
- Only one structure is recommended, not an overlook and a council circle, since this will take up too much of the valuable savanna area.

If a trail is installed on the ridge top, we recommend that it be terminated at the overlook, and not extended beyond westward. This should discourage excess foot traffic across the savanna areas (savanna will be in the process of being restored). Wood chips are an appropriate material to use for trail construction in this sensitive area.

PRIORITY 3: Restore/Protect Dry-Mesic Oak Forests and Restore Dry-Mesic Oak Woodlands

For the most part, the Dry-Mesic Oak Forests are less disturbed than the Dry-Mesic Oak Woodlands and actually should require less effort to restore. The Oak Forests have a less dense layer of buckthorn to deal with, compared to the woodlands, and they should not require as frequent burning. Light surface fires should burn Dry-Mesic Oak Forests on a rotation of about once every 20 years. Comparatively, Dry-Mesic Oak Woodlands should be burned on a rotation of about every 7 to 9 years. There was a significant accumulation of heavy fuels in these communities at the time of the field visits in fall of 2011, especially in the woodlands. The first couple of burns will be longer, with hotter fires, until fuels get reduced. It would be advisable to perform a couple of burns in close succession the first couple of times/years, and then drop back to the regular rotation rate, to help consume the abundant fuels.

Buckthorn Control

For buckthorn control in the **forest units**, the least damaging approach would be mechanical cutting (using a shoulder-strapped brush cutter). Stems should be cut over a period of two to three years to reduce the vigor of the shrubs. Buckthorn plants usually die after repeated cutting that occurs at lease twice a year for two to three years in a row. Evaluate the site after two years, and if this method is not working, then perhaps combine it with a late fall foliar or a basal bark application of Glyphosate. The buckthorn plants of the forest landcover units are generally small and, since the ground layer is not that diverse, collateral damage from herbicide spray would most likely be low. Timing is critical, however. Late fall (mid-October) treatments are best because most of the native forest forbs and graminoids have gone dormant. If a one-time cutting is used as a control

method for buckthorn, then each little stump must be treated with herbicide, which is very labor intensive. Basal bark treatments may also be used, but this requires large amounts of herbicide. Basal bark treatments may be done in the winter. All methods, however, should be subject to modification based on field assessments by an ecologist throughout the restoration process.
Buckthorn is large and dense in the **woodland units**, and thus controlling it will require cutting and stump treating with herbicide (**Appendix D**). Again, as in the Savanna units, woody debris should be gathered and stacked into burn piles, which can be located scattered throughout the property. Protect trees from heat damage by locating piles in forest openings at suitable distances from trees. Piles are best burned in winter when a light snow cover exists (e.g. 3-6 inches); otherwise fall is acceptable, too. Another option is to cut the stems small and scatter them on the ground, but this is undesirable when stems are thick. Stem-scattering would be suitable in woodland areas. It can save on exotic brush removal costs, but can also impede access for future management if cut brush is dense and regrowth occurs through the litter.

Seeding and Planting
For restoration of the ground layer, seed will have to be purchased for the forests and woodlands (**Appendix B** is a species list). Forest seed is notoriously slow to germinate, so perhaps it would be best to plant plugs (small transplants) in plots to add diversity to the forest. Because of high deer populations, it may be necessary to protect plantings with fencing surrounding each plot. Seed tends to germinate more readily in woodlands, since they are more open to light. Taking advantage of canopy gaps is recommended for seeding.

Planting of shrubs to add diversity is also recommended (**Appendix B**). Trees do not need to be planted, although planting oaks may be necessary for regeneration of oaks in the forest and woodlands. Oaks require light for growth, so planting in gaps is recommended. Protecting each shrub or oak tree with a wire cage is recommended. Watering during dry spells is also recommended the first year after planting, but logistics on watering in this park will be tricky. It would be best to plant in spring to take advantage of early season soil moisture. Remember to protect shrub plantings from fire for five years, and new seedings for two to three years, lest they be killed before they become established.

Prescribed Burns—More Information
It is recommended to split the entire site up into burn units, for ease of operation and for ecological reasons (impacts on insects and animals, for instance). It is important to leave some areas unburned (refugia) to allow insect and animal populations to recover and repopulate burned areas. Rotate the burning of units from year to year, and try not to burn adjacent units in consecutive years. Prior to a prescribed burn, a burn plan must be devised. The burn contractor can help with the burn plan. Permits must be obtained from the DNR and local fire officials. Initially, burning would be rotated every one or two years, so that each year a different burn unit would be burned. Long-term, burns should occur every 5-9 years in woodlands and 3-5 years in prairies and savannas.

Prior to burning, burn breaks must be created to contain the fire. Burn breaks consist of a mowed swath in grassland areas, typically at least 8 feet wide. In woodland areas, the break line is created by clearing the leaf litter and any other debris to reach mineral soils. Locating breaks on the periphery of the easement is a logical place for them. Also utilizing the trail system and edges of forests would be useful and easier than making them from scratch. The burn contractor can also help with the placement and installation of burn breaks. Allowing fire to run into adjacent different land covers is a good strategy. For example, breaklines in a prairie unit that is adjacent to woodland should be placed a short distance into the woodland, where feasible. This makes for a more natural looking and functioning landscape and helps to prevent the woodland from encroaching into the prairie.

Smoke management is the main concern for burning on this property, since there are a number of nearby residences, buildings, and roads.

Long-Term Monitoring and Maintenance

Monitoring is very important to restoration success. Monitoring, evaluation and assessment should be done at least annually by an ecologist or a restoration professional. More frequent monitoring will be needed in the initial phases of restoration to evaluate the success of the methodology and to inform future strategies. Adapting to issues or factors observed during monitoring and assessment is vital to the restoration process.

Once the primary restoration tasks are completed, the restoration process will convert to a monitoring and adaptive management phase. Long-term maintenance for the woodland areas will consist of burning every 5 to 9 years and monitoring every year and managing for exotic species. Dry-Mesic Oak Forests (those that are very dense and occur on moist soils and north to east-facing slopes) and Lowland Hardwood Forests will require burning once every 20 years. For Prairies, burning should occur every 3 to 5 years.

Restored areas must be regularly monitored to identify ecological issues, such as erosion and sedimentation, invasive species, and disease. Monitoring is also important for detecting human-related issues such as illegal activities (hunting, ATV use, tree harvesting, etc.) Early detection of concerns enables quick responses to address them before they become significant problems.

Monitoring animal as well as plant communities is also helpful for evaluating results of the restoration. A comparison of bird populations before and after restoration, for example, would be a valuable tool for quantifying positive impacts on the land.

RESTORATION SCHEDULE AND COST ESTIMATES

An approximation of restoration/management tasks, priorities, and costs are provided in **Table 4**, below. Project cost estimates are not based on actual contractor bids, but on typical costs for similar projects. Actual project costs could be significantly higher or lower,

depending on multiple factors. Costs could potentially be decreased by, for example, reducing the diversity of prairie seed costs, contracting for the entire project with one contractor, using volunteers or STS (Sentence to Serve) crew for portions of the labor such as hauling brush. Some activities may be carried out by the landowner if they wish, and have the time and equipment to do so. Project tasks and costs may also change over time, as more information is learned about the property and as the site conditions change.

The most important short-term issue to address is exotic woody species control at all the units. Ideally, this should be addressed site-wide prior to any other restoration activities to eliminate seed sources of these exotic species. However, if budget concerns preclude this, woody brush removal may be phased and accomplished over several years time.

Table 4. GNOS Restoration Schedule and Cost Estimates

These tables are rough schedules and approximate costs for restoration and management tasks for the GNOS property. Both the project tasks and costs are likely to change as the project progresses - these tables should be used only as rough guides. Tasks were phased, with 1 being the highest priority. Work units correspond with those shown in **Figure 12**.

Year	Season	Units	Activity	Acres	Cost/ Ac	Cost Est.
PHASE 1. RESTORE AND PROTECT BLUFF PRAIRIE AND ADJACENT UNITS						
0	June	Bl-Pr, Sav-1, OF-4, OW-2	Breeding bird survey before restoration occurs.	15.3		1,200
1	fall, winter, early spring	Bl-Pr	Cut and treat exotic woody brush plants and other undesirable native woody brush on steep slopes of bluff prairie. Haul brush to piles and either remove or burn in winter.	7.2	3,000	21,600
1	fall, winter, early spring	Bl-Pr, Sav-1	Cut and treat large exotic woody brush plants and other undesirable native woody brush on ridge-top (Oak Savanna-1) of bluff prairie.	11.5	1,500	17,250
1	fall, winter, early spring	Sav-1, OF-4, OW-2	Cut and treat large exotic woody brush plants and other undesirable native woody brush throughout remaining savanna-1, oak forest-4, and oak woodland-2.	8.1	1,500	12,150
2	late spring	Bl-Pr, Sav-1, OF-4, OW-2	Conduct prescribed burn on bluff prairie slopes and ridge-top (oak savanna-1), and if possible into nearby oak savanna-1 unit, oak forest-4 unit, and oak woodland-2 unit.	15.3	200	3,060
2	fall	Bl-Pr, Sav-1, OF-4, OW-2	Treat exotic resprouts.	15.3	100	1,530
1	Jul-Aug and Winter	Bl-Pr, Sav-1, OF-4, OW-2	Monitor for bur oaks for Oak Wilt disease (July-Aug) and for Bur Oak Blight (BOB) (July-Aug for leaf necrosis and winter for marcescent leaves (those that do not drop).	15.3		1,000
1	Any	Bl-Pr, Sav-1, OF-4, OW-2	Annual Ecological evaluation and assessment.	15.3		1,050
2	June	Sav-1, OF-4, OW-2	Seed parts of savanna, woodland, and forest with native cover crop and native seed mix following burn.	8.1	600	4,860

1	Summer, Fall	Bl-Pr	Collect seed from native prairie remnants on bluff prairie. Save this seed and combine with Year 2 seed collection to be broadcast following second burn.	7.2		900
1	June	Bl-Pr, Sav-1, OF-4, OW-2	Breeding bird survey, after restoration	15.3		1,200
2	late spring	Bl-Pr, Sav-1, OF-4, OW-2	Conduct second prescribed burn on bluff prairie slopes and ridge-top (oak savanna-1), and if possible into nearby oak savanna-1 unit, oak forest-4 unit, and oak woodland-2 unit.	15.3	200	3,060
2	June	Bl-Pr, Sav-1, OF-4, OW-2	Re-evaluate after burn.	15.3		300
2	fall (1st or 2nd wk of October	Bl-Pr, Sav-1, OF-4, OW-2	If necessary, apply grass-herbicide to non-native grasses (smooth brome, Kentucky bluegrass, reed canary grass) on bluff prairie slopes, ridge-top (oak savanna-1), and throughout open units to be restored to oak savanna.	15.3	100	1,530
2	June	Sav-1, OF-4, OW-2	Purchase native seed and broadcast the seed into parts of savanna, woodland, and forest with native cover crop following burn.	8.1	600	4,860
2	June	Bl-Pr	Broadcast seed onto bluff prairie following second burn. Use seed that was collected from the bluff prairie in years 1 and 2. Do not use purchased seed.	7.2		600
Subtotal				17.3		70,990
PHASE 2. RESTORE AND PROTECT REMAINING OAK SAVANNA and DRY-MESIC OAK FORESTS						
2	fall, winter, early spring	Sav-2	Cut and treat exotic woody brush plants and other undesirable native woody brush throughout remaining savanna (oak savanna-2). Cut and treat stumps. Haul brush to piles and burn in winter.	2.9	1,500	4,350
2	June-July And Sept-Oct	OF-1, OF-2, OF-3	Cut and treat brush plants and other undesirable native woody brush throughout remaining oak forest units (OF-1, OF-2, OF-3). Brush cut whips in June-July and again in Sep-Nov. Allow to resprout. If necessary, foliar or basal bark treat with Glyphosate in Sept/Oct.	18.8	1,500	28,200
3	May-June	Sav-2	In oak savanna, seed with native cover crop seed in spring.	2.9	1,000	2,900
3	June or Oct-Nov	Sav-2, OF-1, OF-2	Conduct prescribed burn on oak savanna-2 unit, and into nearby oak forest-1 and oak forest-2 units.	15.1	200	3,020
3		Sav-2, OF-1, OF-2	Evaluate after the burn.	15.1		300
3	Spring or Fall	Sav-2, OF-1, OF-2	Seed with diverse local ecotype seed mixes, if necessary. Plant shrubs at a low density.	15.1	1,000	15,100
3	Summer and Fall	Sav-2, OF-1, OF-2	Treat exotic resprouts (brush cut whips in summer and fall)	15.1	200	3,020
2	Jul-Aug and Winter	Sav-2, OF-1, OF-2	Monitor for bur oaks for Oak Wilt disease (July-Aug) and for Bur Oak Blight (BOB) (July-Aug for leaf necrosis and winter for marcescent leaves (those that do not drop).	15.1		1,000

2		All	Annual ecological evaluation and assessment	54		1,030
Subtotal				20.2		62,920
PHASE 3. RESTORE DRY-MESIC OAK WOODLANDS						
1 & 2	June	OW-1, OW-3, OPW-1	Breeding bird survey before restoration occurs.	14.5		1,200
3	fall, winter, early spring	OW-1, OW-3, OPW-1	Control large exotic woody brush plants and other undesirable native woody brush throughout oak woodlands. Cut and treat stumps. Haul brush to piles and burn in winter.	14.5	1,500	21,750
4	May-June	OW-1, OW-3, OPW-1	Seed with native cover crop seed in spring.	14.5	600	8,700
4	Summer, fall	OW-1, OW-3, OPW-1	Treat exotic resprouts	14.5	100	1,450
4	Oct-Nov	OW-1, OW-3, OPW-1	Conduct prescribed burn on oak woodland units, and into nearby oak forest-3 unit.	14.5	200	2,900
5	Spring	OW-1, OW-3, OPW-1	Evaluate after the burn.	14.5		300
5	fall or spring	OW-1, OW-3, OPW-1	Seed with a diverse mix of woodland graminoids and forbs.	14.5	1,200	17,400
5	spring or fall	OW-1, OW-3, OPW-1	Conduct a second prescribed burn on oak woodland units. Do not allow fire to run into nearby Oak Forest-3 unit.	14.5	200	2900
5		OW-1, OW-3, OPW-1	Evaluate after the burn.	14.5		300
5 or 6	spring or fall	OW-1, OW-3, OPW-1	If necessary, seed again with a diverse mix of woodland graminoids and forbs. Plant shrubs at a low density. Plant herbaceous plugs in plots	14.5	1000	14,500
3	Jul-Aug and Winter	OW-1, OW-3, OPW-1	Monitor for bur oaks for Oak Wilt disease (July-Aug) and for Bur Oak Blight (BOB) (July-Aug for leaf necrosis and winter for marcescent leaves (those that do not drop).	14.5		1,000
3		All	Annual ecological evaluation and assessment.	54		1,030
Subtotal				16.5		73,430
TOTAL				**54.0**		**207,340**

Long-Term Management

Once initial restoration tasks are completed, then long-term management ensues. Long-term management includes tasks that are required to be done periodically to maintain the plant community. **Table 5** lists these tasks with associated cost estimates.

Table 5. GNOS Long-Term Management Schedule and Cost Estimates

Season	Units	Activity	Acres	Cost/ Ac	Cost Est.
Spring or fall	Bl-Pr	Burn the Bluff Prairie every 2-5 years.	7.2	300	2160
Spring or fall	Sav-1, Sav-2	Burn the Savanna units every 2-5 years.	7.2	200	1440
Fall (spring sometimes)	OW-1, OW-2, OW-3, OPW-1	Burn the oak woodland units every 7-9 years. Divide into burn units and rotate burn cycles to maintain heterogeneity.	13.3	200	2660
July-Aug and Winter	All	Monitor for bur oaks for Oak Wilt disease (July-Aug) and for Bur Oak Blight (BOB) (July-Aug for leaf necrosis and winter for marcescent leaves (those that do not drop).	54		1000
fall, summer, spring	All	Evaluation and assessment by ecologist	54		1030
June	Bl-Pr, Sav-1, OF-4, OW-2, OW-1, OW-3, OPW-1	Breeding bird surveys second year after restoration.	29.6		1200
					$9,490 or more

WORKPLAN

The following tasks and budget are based on known costs and project needs at the time of the restoration agreement. All parties, prior to implementation, will agree upon additional future tasks. Work units are shown on Map in **Figure 12**.

Yr	Season	Activity	Acres	Cost Est.	Wash-ington County	City of Cottage Grove	Other
RESTORE BLUFF PRAIRIE AND ADJACENT UNITS							
1	fall, winter	Control large woody exotic brush and treat resprouts on Bluff Prairie and surrounding units.	26.8	52,600			
1,2	fall, spring	Control exotic grassy vegetation on bluff prairie and surrounding units.	15.3	1,600			
1	late spring	Conduct prescribed burn on Bluff Prairie and surrounding units.		3,000			
2	June	Seed parts of savanna, forest, and woodland adjacent to Bluff Prairie		7,000			
2	late spring	Second burn on bluff prairie and into nearby units	15.3	3,100			
	Summer& Winter	Monitor units for oak tree disease	15.3	1000			
1, 2		Evaluation and assessment	26.8	2,600			
				70,900			
RESTORE REMAINING OAK SAVANNA AND DRY-MESIC OAK FORESTS							
2	fall, winter	Control large woody exotic brush and treat resprouts on Savanna-2	2.9	4,400			
2	June-July; Sept-Oct	Control large woody exotic brush and treat resprouts throughout remaining forest units (OF-1, OF-2, and OF-3).	18.8	28,200			
3	May-June; Spring, Fall	Seed and burn savanna and seed again. Plant Shrubs at low density.	15.1	22,000			
	Summer& Winter	Monitor units for oak tree disease	18.8	1000			
2,3		Evaluate units.	18.8	2,000			
				58,600			
RESTORE DRY-MESIC OAK WOODLANDS							
3, 4	fall, winter, summer	Control exotic brush and other undesirable native brush throughout woodlands. Treat exotic resprouts.	14.5	23,300			
4 & 5	spring, fall	Seed, burn, and seed again.	14.5	29,000			
5	Late spring	Second burn, and seed again if necessary. Plant shrubs at low density.		17,400			
3	Summer& Winter	Monitor and assess all units.		4,600			

0, 1, 3	June	Breeding bird survey in all units, both two years before and two years after restoration.		3,600			
				77,900			

		Long-term management		9,400*			

* This figure is a minimum. More will likely be necessary.

APPENDICES

APPENDIX A Information Sources

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Great Britain Forestry Commission: http://www.forestry.gov.uk/fr/INFD-678DWY
MN Natural Resources (DNR): http://www.dnr.state.mn.us/nr/index.html

Natural history of MN, bibliography (DNR):
http://www.dnr.state.mn.us/snas/naturalhistory_resources.html
Earthworm website: http://www.nrri.umn.edu/worms/

Forest Ecology:
http://cffe.cfans.umn.edu/.

Bur Oak Blight
http://www.myminnesotawoods.umn.edu/2010/09/bur-oak-blight-bob-in-minnesota/

Oak Wilt
http://www.dnr.state.mn.us/treecare/forest_health/oakwilt/index.html

APPENDIX B Plant Species for Restoration at GNOS Property

Dry Bedrock Bluff Prairie (UPs13c)

Genus	Species	Common Name
Shrubs		
Rosa	cmx	Smooth wild rose
Amorpha	*canescens*	Lead-plant
Forbs		
Anemone	*cylindrica*	Long-headed thimbleweed
Antennaria	*spp.*	Pussytoes
Aquilegia	*canadensis*	Columbine
Asclepias	*verticillata*	Whorled milkweed
Asclepias	*tuberosa*	Butterfly-weed
Asclepias	*viridiflora*	Green milkweed
Asclepias	*syriaca*	Common milkweed
Aster	*sericeus*	Silky aster
Aster	*Oolentan-giensis*	Sky-blue aster
Aster	*ericoides*	Heath aster
Aster	*laevis*	Smooth aster
Astragalus	*Crassi-carpus*	Buffalo-bean
Calylophus	*serrulata*	Toothed evening primrose
Campanula	*rotundifolia*	Harebell
Coreopsis	*palmata*	Stiff tickseed
Dalea	*purpurea*	Purple prairie-clover
Dalea	*candida*	White prairie-clover
Delphinium	*carolini-anum*	Prairie larkspur
Desmodium	*illinoense*	Illinois tick-trefoil
Euphorbia	*corollata*	Flowering spurge
Gnaphalium	*Obtuse-folium*	Sweet everlasting
Helianthem um	*bicknellii*	Hoary frostweed
Helianthus	*pauciflorus*	Stiff sunflower
Heuchera	*richardsonii*	Alum-root
Hypericum	*perforatum*	Common St. John's-wort
Kuhnia	*eupato-roides*	False boneset
Lespedeza	*capitata*	Round-headed bush-clover
Liatris	*aspera*	Rough blazing star
Liatris	*punctata*	Dotted blazing star
Liatris	*cylindracea*	Cylindric blazing star
Linum	*sulcatum*	Grooved yellow flax
Lobelia	*spicata*	Rough-spiked Lobelia
Lysimachia	*ciliata*	Fringed loosestrife
Mirabilis	*hirsuta*	Hairy four-o'clock
Monarda	*fistulosa*	Wild bergamot
Oenothera	*biennis*	Common evening-primrose
Oenothera	*clelandii*	Cleland's evening-primrose
Oxalis	*violacea*	Violet wood-sorrel
Pediomelum	*esculentum*	Prairie-turnip
Pediomelum	*argophyllum*	Silvery scurf-pea
Penstemon	*grandiflorus*	Large-flowered beard-tongue
Physalis	*virginiana*	Ground-cherry
Potentilla	*arguta*	Tall cinquefoil
Pycnan-themum	*virginianum*	Virginia mountain-mint
Scutellaria	*leonardi*	Leonard's skullcap
Senecio	*plattensis*	Prairie ragwort
Silene	*antirrhina*	Sleepy catchfly
Sisyrinchium	*campestre*	Field blue-eyed grass
Solidago	*nemoralis*	Gray goldenrod
Solidago	*rigida*	Stiff goldenrod
Solidago	*speciosa*	Showy goldenrod
Tradescantia	*occidentalis*	Western spiderwort
Viola	*pedatifida*	Prairie bird-foot violet
Viola	*pedata*	Bird-foot violet
Zizia	*aptera*	Heart-leaved alexanders

Dry Bedrock Bluff Prairie (UPs13c)—cont'd.

Grasses, Rushes and Sedges		
Andropogon	*gerardii*	Big bluestem
Bouteloua	*curtipendula*	Side-oats grama
Bouteloua	*hirsuta*	Hairy grama
Calamovilfa	*longifolia*	Sand reed-grass
Carex	*pensylvanica*	Sunshine sedge
Cyperus	*schweinitzii*	Schweinitz' cyperus
Cyperus	*lupulinus*	Hop-like cyperus
Elymus	*wiegandii*	Canada wild rye
Eragrostis	*spectabilis*	Purple lovegrass
Muhlenbergia	*cuspidata*	Plains muhly
Panicum	*oligosanthes*	Few-flowered panic grass
Panicum	*wilcoxianum*	Wilcox's panic grass
Panicum	*perlongum*	Long-leaved panic grass
Panicum	*linearifolium*	Linnear-leaved panic grass
Panicum	*leibergii*	Leiberg's panic grass
Schizachyrium	*scoparium*	Little bluestem
Sorghastrum	*nutans*	Indian grass
Sporobolus	*heterolepis*	Prairie dropseed
Sporobolus	*asper*	Rough dropseed
Stipa	*spartea*	Porcupine-grass

Southern Dry-Mesic Oak Forest (MHs37)

Forbs		
Anemone	*quinquefolia*	Wood-anemone
Anemone	*virginiana*	Tall thimbleweed
Apocynum	*androsaemifolium*	Spreading dogbane
Aquilegia	*canadensis*	Columbine
Aralia	*nudicaulis*	Wild sarsaparilla
Aralia	*racemosa*	American spikenard
Arenaria	*lateriflora*	Side-flowering sandwort
Arisaema	*triphyllum*	Jack-in-the-pulpit
Asclepias	*exaltata*	Poke milkweed
Aster	*ciliolatus*	Lindley's aster
Aster	*lateriflorus*	Side-flowering aster
Aster	*macrophyllus*	Large-leaved aster
Aster	*Oolentangiensis*	Sky-blue aster
Aster	*sagittifolius*	Tail-leaved aster
Caulophyllum	*thalictroides*	Blue cohosh
Circaea	*lutetiana*	Canada enchanter's nightshade
Clintonia	*borealis*	Bluebead lily
Cryptotaenia	*canadensis*	Honewort
Desmodium	*glutinosum*	Pointed-leaved tick-trefoil
Dioscorea	*villosa*	Wild yam
Fragaria	*vesca*	Wood strawberry
Fragaria	*virginiana*	Common strawberry
Galium	*aparine*	Cleavers
Galium	*boreale*	Northern bedstraw
Galium	*concinnum*	Elegant bedstraw
Galium	*triflorum*	Three-flowered bedstraw
Geranium	*maculatum*	Wild geranium
Geum	*canadense*	White avens
Geum	*triflorum*	Prairie smoke
Helianthus	*hirsutus*	Woodland sunflower
Helianthus	*strumosus*	Rough-leaf sunflower
Hepatica	*americana*	Round-lobed hepatica
Heuchera	*richardsonii*	Alum-root
Lathyrus	*venosus*	Veiny pea
Maianthemum	*canadense*	Canada mayflower
Maianthemum	*racemosum*	Racemose false Solomon's-seal
Maianthemum	*stellatum*	Starry false Solomon's-seal
Mitchella	*repens*	Partridge-berry
Osmorhiza	*claytonii*	Clayton's sweet cicely
Osmorhiza	*longistylis*	Anise-root
Phryma	*leptostachya*	Lopseed
Physalis	*heterophylla*	Clammy ground-cherry
Polygonatum	*pubescens*	Hairy Solomon's-seal
Polygonatum	*biflorum*	Giant Solomon's-seal

Forbs (cont'd)		
Pyrola	*elliptica*	Common pyrola
Pyrola	*secunda*	One-sided pyrola
Ranunculus	*abortivus*	Kidney-leaf buttercup
Ranunculus	*recurvatus*	Hooked crowfoot
Rubus	*pubescens*	Dwarf raspberry
Sanguinaria	*canadensis*	Bloodroot
Sanicula	*gregaria*	Gregarious black snakeroot
Sanicula	*marilandica*	Maryland black snakeroot
Smilax	*lasionuera*	Carrion-flower
Solidago	*flexicaulis*	Zig-zag goldenrod
Solidago	*hispida*	Hairy goldenrod
Solidago	*uliginosa*	Bog goldenrod
Streptopus	*lanceolatus*	Rosy twisted-stalk
Thalictrum	*dasycarpum*	Tall meadow-rue
Thalictrum	*dioicum*	Early meadow-rue
Thalictrum	*thalictroides*	Rue-anemone
Trientalis	*borealis*	Starflower
Trillium	*cernuum*	Nodding trillium
Trillium	*grandiflorum*	Large-flowered trillium
Uvularia	*grandiflora*	Yellow bellwort
Uvularia	*sessilifolia*	Pale bellwort
Veronicastrum	*virginicum*	Culver's root
Viola	species	Violet (multiple species)
Zizia	*aurea*	Golden alexanders
Grasses, Rushes and Sedges		
Brachyelytrum	*erectum*	Bearded shorthusk
Carex	*blanda*	Charming sedge
Carex	*deweyana*	Dewey's sedge
Carex	*gracillima*	Graceful sedge
Carex	*peckii*	Peck's sedge
Carex	*pedunculata*	Long-stalked sedge
Carex	*pensylvanica*	Pennsylvania sedge
Carex	*tenera*	Marsh-straw sedge
Carex	*radiata*	Stellate sedge
Elymus	*hystrix*	Bottlebrush grass
Festuca	*subverticillata*	Nodding fescue
Oryzopsis	*asperifolia*	Moutain rice-grass
Schizachne	*purpurascens*	False melic grass
Ferns and Fern Allies		
Athyrium	*filix-femina*	Lady-fern
Dryopteris	*intermedia*	Fancy wood fern
Equisetum	*pratense*	Meadow horsetail
Matteuccia	*struthiopteris*	Ostrich-fern
Osmunda	*claytoniana*	Interrupted fern
Pteridium	*aquilinum*	Bracken

Southern Dry-Mesic Oak Forest (MHs37)—cont'd

Genus	Species	Common Name
Canopy Trees & understory trees		
Acer	*negundo*	Box elder
Betula	*papyrifera*	Paper-birch
Carya	*cordiformis*	Bitternut hickory
Celtis	*occidentalis*	Hackberry
Fraxinus	*pennsylvanica*	Green ash
Ostrya	*virginiana*	Ironwood
Populus	*grandidentata*	Big-toothed aspen
Populus	*tremuloides*	Quaking aspen
Prunus	*serotina*	Black cherry
Quercus	*alba*	White oak
Quercus	*ellipsoidalis*	Northern pin oak
Quercus	*macrocarpa*	Bur oak
Quercus	*rubra*	Northern red oak
Tilia	*americana*	Basswood
Ulmus	*americana*	American elm
Ulmus	*rubra*	red elm
Shrubs		
Amelanchier	*interior*	Juneberry
Amelanchier	*laevis*	Smooth juneberry
Cornus	*alternifolia*	Pagoda dogwood
Cornus	*rugosa*	Round-leaved dogwood
Cornus	*racemosa*	Gray dogwood
Corylus	*americana*	American hazelnut
Corylus	*cornuta*	Beaked hazelnut
Crataegus	cmx	Hawthorn
Diervilla	*lonicera*	Bush honeysuckle
Ilex	*verticillata*	Winterberry
Lonicera	*dioica*	Wild Honeysuckle
Prunus	*virginiana*	Chokecherry
Ribes	*cynosbati*	Prickly gooseberry
Ribes	*missouriense*	Missouri gooseberry
Rosa	*arkansana*	Prairie rose
Rosa	*blanda*	Smooth wild rose
Rubus	*occidentalis*	Black raspberry
Rubus	*idaeus*	Red raspberry
Sambucus	*racemosa*	Red-berried Elder
Symphoricarpos	*alba*	Snowberry
Viburnum	*lentago*	Nannyberry
Viburnum	*rafinesquianum*	Downy arrow-wood

Southern Dry-Mesic Oak Woodland (FDs37)

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

Southern Mesic Savanna (UPs24)

Genus	Species	Common Name
Trees		
Quercus	*macrocarpa*	Bur oak
Shrubs		
Amorpha	*canescens*	Lead-plant
Prunus	*virginiana*	Chokecherry
Rosa	*arkansana*	Prairie rose
Salix	*humilis*	Prairie willow
Symphori-carpos	*abla*	Snowberry
Grasses, Rushes and Sedges		
Andropogon	*gerardii*	Big bluestem
Bromus	*kalmii*	Kalm's brome
Carex	*bicknellii*	Bicknell's sedge
Carex	*meadii*	Mead's sedge
Carex	*muhlenbergii*	Muhlenberg's sedge
Elymus	*canadensis*	Canada wild rye
Dicanthelium	*perlongum*	Long-leaved panic grass
Panicum	*virgatum*	Switchgrass
Schizachyrium	*scoparium*	Little bluestem
Sorghastrum	*nutans*	Indian grass
Sporobolus	*heterolepis*	Prairie dropseed
Stipa	*spartea*	Porcupine-grass
Forbs		
Allium	*canadense*	Wild garlic
Allium	*stellatum*	Prairie wild onion
Anemone	*canadensis*	Canada anemone
Anemone	*cylindrica*	Long-headed thimbleweed
Anemone	*virginiana*	Virginia thimbleweed
Antennaria	*species*	Pussytoes
Apocynum	*Androsae-mifolium*	Spreading dogbane
Artemisia	*campestris*	Tall wormwood
Artemisia	*frigida*	Prairie sagewort
Asclepias	*syriaca*	Common milkweed
Asclepias	*tuberosa*	Butterfly-weed
Aster	*ericoides*	Heath aster
Aster	*laevis*	Smooth aster
Aster	*lanceolatus*	Panicled aster
Aster	*novae-angliae*	New England aster
Aster	*oolentangiensis*	Sky-blue aster
Astragalus	*canadensis*	Canada milk-vetch
Campanula	*rotundifolia*	Harebell
Comandra	*umbellata*	Bastard toad-flax
Coreopsis	*palmata*	Stiff tickseed
Dalea	*candida*	White prairie-clover
Dalea	*purpurea*	Purple prairie-clover
Desmodium	*canadense*	Canadian tick-trefoil
Euphorbia	*corollata*	Flowering spurge
Euthamia	*graminifolia*	Grass-lvd goldenrod
Forbs (cont'd)		
Fragaria	*virginiana*	Common strawberry
Galium	*boreale*	Northern bedstraw
Gentiana x	*billingtonii*	Closed gentian
Geum	*triflorum*	Prairie smoke
Helianthus	*maximiliani*	Maximilian's sunflower
Helianthus	*pauciflorus*	Stiff sunflower
Heliopsis	*helianthoides*	Ox-eye
Heterotheca	*villosa*	Prairie golden aster
Heuchera	*richardsonii*	Alum-root
Lathyrus	*venosus*	Veiny pea
Lespedeza	*capitata*	Round-headed bush-clover
Liatris	*aspera*	Rough blazing star
Liatris	*ligulistylis*	Northern plains blazing star
Liatris	*pycnostachya*	Gayfeather
Lilium	*Philadel-phicum*	Wood lily
Lobelia	*spicata*	Rough-spiked Lobelia
Maian-themum	*racemosum*	False Solomon's-seal
Maian-themum	*stellatum*	Starry false Solomon's-seal
Mirabilis	*hirsuta*	Hairy four-o'clock
Monarda	*fistulosa*	Wild bergamot
Oenothera	*biennis*	Common evening-primrose
Pedicularis	*canadensis*	Wood-betony
Phlox	*pilosa*	Prairie phlox
Physalis	*heterophylla*	Clammy ground-cherry
Potentilla	*arguta*	Tall cinquefoil
Pycnan-themum	*virginianum*	Virginia mountain-mint
Ratibida	*pinnata*	Gray-headed coneflower
Rudbeckia	*hirta*	Black-eyed Susan
Sisyrinchium	*campestre*	Field blue-eyed grass
Solidago	*missouriensis*	Missouri goldenrod
Solidago	*nemoralis*	Gray goldenrod
Solidago	*ptarmicoides*	Upland white goldenrod
Solidago	*speciosa*	Showy goldenrod
Thalictrum	*dasycarpum*	Tall meadow-rue
Tradescantia	*bracteata*	Bracted spiderwort
Veroni-castrum	*virginicum*	Culver's root
Viola	*pedatifida*	Prairie bird-foot violet
Zizia	*aurea*	Golden alexanders
Ferns and Fern Allies		
Equisetum	*arvense*	Field horsetail
Equisetum	*hyemale*	Tall scouring-rush
Equisetum	*laevigatum*	Smooth scouring-rush

APPENDIX C Plant Species Recorded at the Gateway North Open Space Property

The following plant species were identified at the site by Friends of the Mississippi River in 2011.

Bedrock Bluff Prairie

Non-Native	Scientific Name	Common Name	Cover	Diameter (inches)	Comments
CANOPY/SUBCANOPY		**12 to 70 ft height**	**Total Cover: 1 to 2**		
	Acer negundo	Boxelder			
	Celtis occidentalis	Hackberry	1	6 to 18	Invading into prairie
	Juniperus virginiana	Eastern redcedar	3	6 to 10	Invading into prairie
	Populus deltoides	Eastern cottonwood	1	30 to 45	Old, declining; not regenerating
	Prunus serotina	Black cherry	+	6 to 10	
	Quercus macrocarpa	Bur oak	+	8 to 18	
	Tilia americana	American basswood	2	6 to 10	Invading into prairie
	Ulmus americana	American elm	1	6 to 10	
x	*Ulmus pumila*	Siberian elm	2	6 to 10	Invading into prairie
UNDERSTORY/SHRUB LAYER		**4 to 12 ft height**	**Total Cover: 2 to 3**		
	Amorpha canescens	Lead plant	+		
	Celtis occidentalis	Hackberry	1		
	Corylus americana	American hazelnut	+		A couple of patches on steep south-facing, mid slope. Not invasive now.
x	*Eleagnus angustifolia*	Russian olive	+		
	Juniperus virginiana	Eastern redcedar	2		Invading into prairie
x	*Lonicera tatarica*	Tartarian honeysuckle	2		Invading into prairie
	Quercus ellipsoidalis	Northern pin oak	+		
	Quercus macrocarpa	Bur oak	1		
	Quercus rubra	Red oak	+		
x	*Rhamnus cathartica*	Common buckthorn	3		Dominant in many parts
	Rhus glabra	Smooth sumac	3		Invading into prairie
	Rubus spp.	Recumbant blackberry	+		One patch on west end
	Tilia americana	American basswood	2		Invading into prairie
	Zanthoxylum americanum	Prickly ash	2		Invading into prairie
GROUND LAYER		**to 4 ft height**	**Total Cover: 3 to 4**		
Graminoids					
	Andropogon gerardii	Big bluestem	1		
	Boutelua curtipendula	Side oats grama	+		
	Boutelua hirsuta	Hairy grama			
x	*Bromus intermis*	Smooth brome	3 to 4		
	Carex schweinitzii	Schweinitz's sedge	+		
	Dicanthelium oligosanthes	Panic grass, cf. Scribner's	+		
	Elymus virginicus	Wild rye	+		
	Muhlenbergia cuspidata	Muhly grass	1		
	Panicum virgatum	Switchgrass	+		
x	*Poa pratensis*	Kentucky bluegrass	+		
	Schizachyrium scoparium	Little bluestem	1		
	Sorghastrum nutans	Indian grass	+		
	Sporobolus heterolepis	Prairie dropseed	+		
	Stipa spartea	Needle grass	1		
Forbs					
	Ambrosia artemisiifolia	Common ragweed	1		
	Anemone cf. *cylindrica*	Thimbleweed	1		
	Aquilegia canadensis	Columbine	+		
	Aster ericoides	Heath aster	+		
	Aster laevis	Smooth aster	+		
	Aster oolentangiensis	Sky blue aster	+		
	Dalea candida	White prairie clover	+		
	Juniperus virginiana	Redcedar	2		Seedlings
	Kuhnia eupatorioides	False boneset	+		
	Lonicera tatarica	Tartarian honeysuckle	1		Seedlings
x	*Melilotus officinalis*	Sweet clover	+		
	Monarda fistulosa	Bergamot	+		
	Potentilla arguta	Prairie cinquefoil	+		
	Quercus macrocarpa	Bur oak	+		Seedlings
	Rhamnus cathartica	Common buckthorn	1		Seedlings
	Rosa arkansana	Prairie rose	+		
	Solidago canadensis	Canada goldenrod	1		
	Solidago nemoralis	Grey goldenrod	+		
	Solidago rigida	Stiff goldenrod	+		
x	*Ulmus pumila*	Siberian elm	1		Seedlings
Vines					
	Vitis riparia	Grape vine	+		

Savanna Remnants

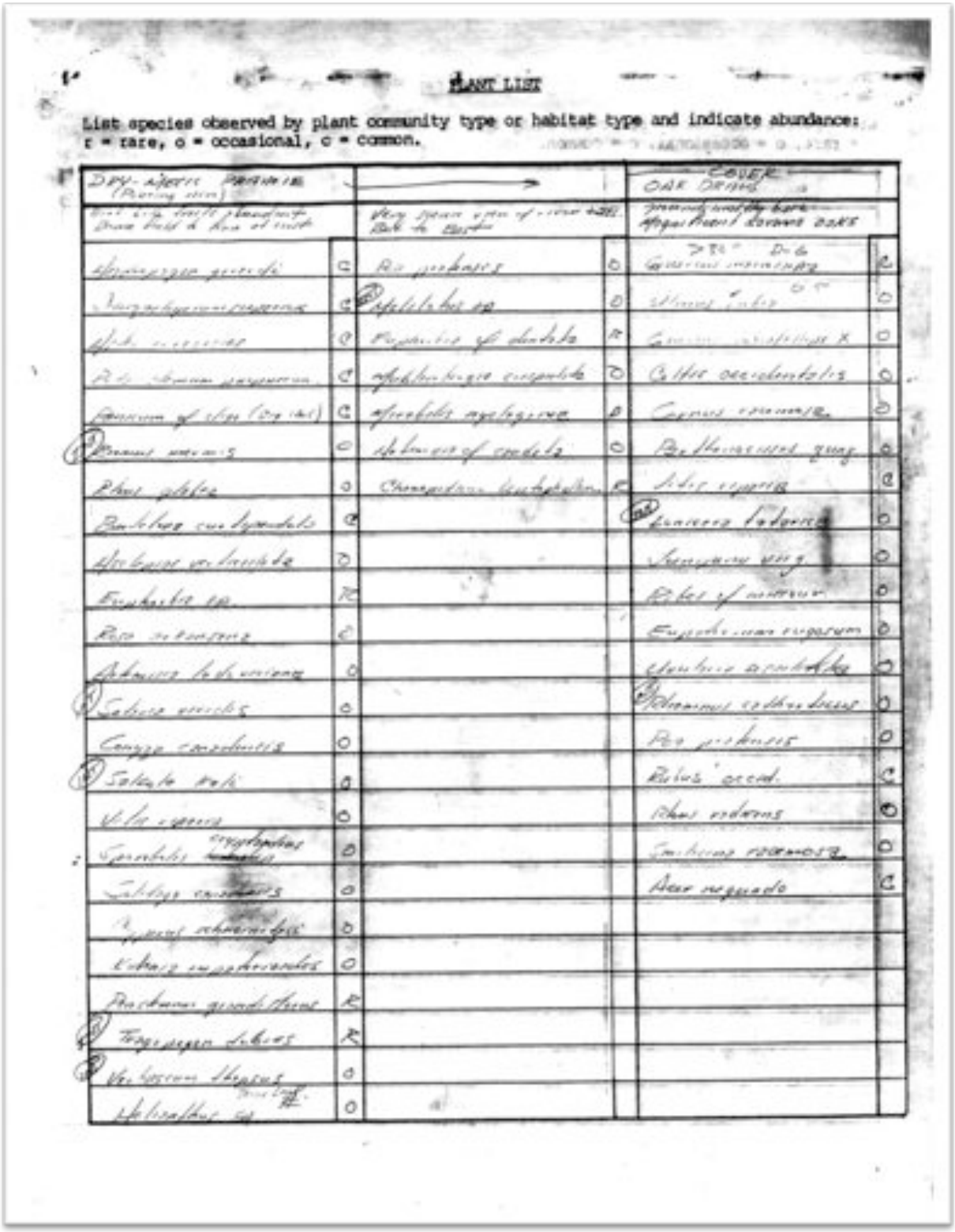
Non-Native	Scientific Name	Common Name	Cover	Diameter (inches)	Comments
CANOPY		**20-40 ft height**	**Total Cover: 2 to 3**		**Denser in Sav-2. Sparse in Sav-1**
	Carya cordiformis	Bitternut hickory	+	10	
	Juniperus virginiana	Redcedar	1	6 to 10	
	Prunus serotina	Black cherry	+	6 to 10	
	Quercus macrocarpa	Bur oak	2	8 to 30	Dominant
	Quercus rubra	Red oak	1	6 to 10	
	Tilia americana	American basswood	2	10 to 35	Abundant. Some very large, multistem.
	Ulmus americana	American elm	+	6 to 12	
x	*Ulmus pumila*	Siberian elm	1	6 to 10	
SUBCANOPY		**12 to 20 ft height**	**Total Cover: 2 to 3**		**Denser in Sav-2. Sparse in Sav-1**
	Juniperus virginiana	Redcedar	1		Invading
	Prunus serotina	Black cherry	+		
	Quercus macrocarpa	Bur oak	+		
	Quercus rubra	Red oak	+		
	Tilia americana	American basswood	1		Invading
	Ulmus americana	American elm	+		
x	*Ulmus pumila*	Siberian elm	1		Invading
UNDERSTORY/SHRUB LAYER 4 to 12 ft height			**Total Cover: 2 to 3**		**Dense in Sav-2. Sparse in Sav-1**
	Juniperus virginiana	Redcedar	2		
	Amorpha canescens	Leadplant	+		
x	*Lonicera tatarica*	Tartarian honeysuckle	1 to 2		
x	*Rhamnus cathartica*	Common buckthorn	1 to 3		
	Rhus glabra	Smooth sumac	1 to 2		
	Tilia americana	American basswood	1		
	Ulmus pumila	Siberian elm	1		
	Zanthoxylum americanum	Prickly ash	2 to 3		
GROUND LAYER		**to 4 ft height**	**Total Cover: 3**		**Dense in Sav-1; Sparse to patchy in Sav-2**
Graminoids					
	Andropogon gerardii	Big bluestem	+		
	Boutelua curtipendula	Side oats grama	+		
	Boutelua hirsuta	Hairy grama			
x	*Bromus intermis*	Smooth brome	3 to 4		
	Bromus kalmii	Prairie brome	+		
	Dicanthelium oligosanthes	Panic grass, cf. Scribner's	+		
	Elymus virginicus	Wild rye	+		
	Panicum virgatum	Switchgrass	+		
x	*Poa pratensis*	Kentucky bluegrass	1		
	Schizachyrium scoparium	Little bluestem	+		
	Sorghastrum nutans	Indian grass	+		
	Sporobolus heterolepis	Prairie dropseed	+		
	Stipa spartea	Needle grass	+		
Forbs					
	Ambrosia artemisiifolia	Common ragweed	1		
	Anemone cf. *cylindrica*	Thimbleweed	+		
	Antennaria plantaginifolia	Plantain-leaved pusseytoes	+		
	Aster ericoides	Heath aster	+		
	Aster oolentangiensis	Sky blue aster	+		
	Gnaphalium obtusifolium	Fragrant cudweed	+		
	Juniperus virginiana	Redcedar	1		Seedlings
x	*Lonicera tatarica*	Tartarian honeysuckle	1		Seedlings
x	*Melilotus officinalis*	Sweet clover	+		
	Monarda fistulosa	Bergamot	+		
	Quercus macrocarpa	Bur oak	+		Seedlings
x	*Rhamnus cathartica*	Common buckthorn			
	Solidago canadensis	Canada goldenrod	1		
	Solidago nemoralis	Grey goldenrod	+		
x	*Ulmus pumila*	Siberian elm	1		Seedlings
Vines					
	Vitis riparia	Grape vine	+		

Dry-Mesic Oak Woodland

Non-Native	Scientific Name	Common Name	Cover	Diameter (inches)	Comments
CANOPY		**20-80 ft height**	**Total Cover: 2 to 3**		**Random spacing: 10, 30, 50 ft**
	Acer negundo	Boxelder	1 to 2	6 to 15	Abundant
	Celtis occidentalis	Hackberry	1	6 to 25	Some large
	Juniperus virginiana	Redcedar	+ to 1	4 to 10	
	Pinus banksiana	Jack pine	+ to 2	6 to 12	On one site, but absent everywhere else
	Populus deltoides	Eastern cottonwood	+	20 to 45	Large, mature.
	Populus grandidentata	Big-toothed aspen	+	8 to 20	Patchy
	Populus tremuloides	Quaking aspen	2	6 to 40	Patchy. Some very large.
	Prunus serotina	Black cherry	2	6 to 20	Dominant in parts
	Quercus macrocarpa	Bur oak	1	6 to 18	
	Quercus rubra	Red oak	2	6 to 25	Dominant in parts
	Tilia americana	American basswood	1 to 2	6 to 25	Multistems predominant
	Ulmus americana	American elm	1	6 to 18	
x	*Ulmus pumila*	Siberian elm	+ to 1	6 to 12	
SUBCANOPY		**12 to 20 ft height**	**Total Cover: 2 to 3**		
	Acer negundo	Boxelder	1 to 2		
	Celtis occidentalis	Hackberry	2		Abundant
	Juniperus virginiana	Redcedar	+ to 1		
	Populus deltoides	Eastern cottonwood	+		
	Populus grandidentata	Big-toothed aspen	+		Patchy
	Populus tremuloides	Quaking aspen	1		Patchy
	Prunus serotina	Black cherry	2		Abundant
	Quercus macrocarpa	Bur oak	1		
	Quercus rubra	Red oak	2		Dominant
	Tilia americana	American basswood	1 to 2		
	Ulmus americana	American elm	1		
x	*Ulmus pumila*	Siberian elm	+ to 1		
UNDERSTORY/SHRUB LAYER		**4 to 12 ft height**	**Total Cover: 4 to 5**		
x	*Berberis thunbergii*	Japanese Barberry	+		Only in one spot. Eradicate it now.
	Cornus racemosa	Grey dogwood	1		Patchy
x	*Lonicera tatarica*	Tartarian honeysuckle	1 to 2		
	Prunus serotina	Black cherry	1		
	Prunus virginiana	Choke cherry	1		
x	*Rhamnus cathartica*	Common Buckthorn	3		Dominant. Not too many large individuals in OW-1. More large ones in OW-2. Many large ones in OW-3.
	Rhus glabra	Smooth sumac	1		Patchy
	Ribes cynosbati	Gooseberry	1 to 2		
	Rubus ideaus cmplx.	Black raspberry	1		
	Zanthoxylum americanum	Prickly ash	2 to 3		Co-dominant with BT througout 80% of unit
GROUND LAYER		**to 4 ft height**	**Total Cover: 3 to 4**		
Graminoids					
	Carex pensylvanica	Pennsylvania sedge	2		
	Carex radiata	Wood sedge	+ to 1		
x	*Phalaris arundinacea*	Reed canary grass	+		patchy
Forbs					
x	*Cirsium arvense*	Canada thistle	+		
	Cirsium discolor	Field thistle	+		
x	*Cirsium vulgare*	Bull thistle	1		
	Eupatorium rugosum	White snake root	2		
x	*Lonicera tatarica*	Tartarian honeysuckle	1 to 2		
	Monarda fistulosa	Bergamot	1		
x	*Rhamnus cathartica*	Common buckthorn	3 to 4		seedlings
	Rubus cf. ideaus	Black raspberry	1		
	Scrophularia lanceolata	Figwort	+		
	Solidago canadensis	Canada goldenrod	1 to 2		
x	*Sonchus arvensis*	Perennial sow thistle	1		
x	*Verbascum thapsis*	Common mullein	1		

Dry-Mesic Oak Forest

Non-Native	Scientific Name	Common Name	Cover	Diameter (inches)	Comments
CANOPY		**20-80 ft height**	**Total Cover: 2 to 3**		
	Carya cordiformins	Bitternut Hickory	2	8 to 16	
	Celtis occidentalis	Hackberry	2	8 to 25	
	Fraxinus pennsylvanica	Green ash	1 to 2	10 to 35	Many large ones on east side of property.
	Prunus serotina	Black Cherry	1	8 to 20	
	Quercus macrocarpa	Bur oak	1	20 to 40	Very large; sparse; many dead or dying; huge spreading crowns.
	Quercus rubra	Red oak, northern	2	10 to 35	
	Tilia americana	Basswood, American	2	8 to 30	
	Ulmus americana	American elm	1 to 2	8 to 14	
SUBCANOPY		**12 to 20 ft height**	**Total Cover: 3 to 4**		
	Acer negundo	Boxelder	1		
	Carya cordiformis	Hickory	2		
	Celtis occidentalis	Hackberry	2		Abundant
	Fraxinus pennsylvanica	Green ash	2		
	Ostrya virginiana	Ironwood	1 to 3		Dominant on west-facing slopes
	Prunus serotina	Black cherry	2		
	Quercus macrocarpa	Bur oak	1 to 2		
	Quercus rubra	Red oak	2		
	Tilia americana	Basswood, American	2		Abundant
	Ulmus americana	American elm	1 to 2		
UNDERSTORY/SHRUB LAYER		**4 to 12 ft height**	**Total Cover: 2 to 3**		
x	*Lonicera tatarica*	Tartarian honeysuckle	1		
	Prunus virginiana	Choke cherry	1		
x	*Rhamnus cathartica*	Common buckthorn	2 to 3		Dominant; 4 to 6 foot tall whips; few large mature ones
	Ribes cynosbati	Gooseberry	1		
	Sambucus pubens	Red berried elder	1		In ravine
GROUND LAYER		**to 4 ft height**	**Total Cover: 3**		
Graminoids					
	Carex blandii	Bland sedge	1		
	Carex pensylvanica	Pennsylvania sedge	2		
Forbs and others					
	Actaea rubra	red baneberry	+		
	Aralia nudicaulis	wild sarsaparilla	+		
	Athyrium felix-femina	lady fern	+		
	Circaea lutetiana	Enchanters nightshade	+		
	Eupatorium rugosum	White snakeroot	1		
	Galium aparine	cleavers	+		
	Oryzopsis asperifolia	mountain rice grass	+		
	Osmorhiza claytonii	clayton's sweet cicely	+		
	Parthenocissus quinquefolia	virginia creeper	+		
	Phryma leptostachya	Lopseed	+		
	Prunus virginiana	chokecherry	1		seedlings
x	*Rhamnus cathartica*	Common buckthorn	2		Seedlings
	Sanicula marilandica	Maryland black snake root	+		
	Vitis riparia	wild grape	1		



PLANT LIST

List species observed by plant community type or habitat type and indicate abundance:
r = rare, o = occasional, c = common.

Figure 13. Scan of the species list for the bluff prairie from the original County Biological Survey of 9/16/1987 by J. C. Almendinger of the Minnesota DNR.

Appendix D. Methods for Controlling Exotic, Invasive Plant Species

TREES AND SHRUBS

Common Buckthorn, Tartarian 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, readily grows, 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.

In non-freezing temperatures, a glyphosate herbicide such as Roundup can be used for most woody species. It is important to obtain the concentrated formula and dilute it with water to achieve 10% glyphosate concentration. Adding a marker dye can help to make treated stumps more visible. In winter months, an herbicide with the active ingredient triclopyr must be used. Garlon 4 is a common brand name and it must be mixed with a penetrating oil, such as diluent blue. Do not use diesel fuel, as it is much more toxic in the environment and for humans.

Brush removal work can be done at any time of year except during spring sap flow, but late fall is often ideal because buckthorn retains its leaves longer than other species and is more readily identified. Cutting can be accomplished with loppers or handsaws in many cases. Larger shrubs may require brush cutters and chainsaws, used only by properly trained professionals.

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.

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. Herbicide can be applied to

the foliage of these plants. Fall is the best time to do this, when desirable native plants are dormant and when the plant is pulling resources from the leaves down into the roots. Glyphosate and Krenite (active ingredient – fosamine ammonium) are the most commonly used herbicides for foliar application. Krenite prevents bud formation so the plants do not grow in the spring. This herbicide can be effective, but results are highly variable. Glyphosate or a triclopyr herbicide such as Garlon can also be used. Glyphosate is non-specific and will kill anything green, while triclopyr targets broadleaf plants and does not harm graminoids. 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. "Weed Wands" or other devices that allow dabbing of the product can be used rather than spraying, especially for stump treatment.

Undesirable trees and shrubs can also be destroyed without cutting them down. Girdling is a method suitable for small numbers of large trees. Bark is removed 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. Girdled trees die slowly over the course of one to two years. Girdling should be done in late spring to mid-summer when sap is flowing and the bark easily peels away from the sapwood. Herbicide can also be used in combination with girdling for a more effective treatment.

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 so that it does not run off. If the herbicide runs off it can kill other plants nearby. More herbicide is needed for effective treatment of plants that are four inches or more in diameter.

Mechanical Control

Three mechanical methods for woody plant removal are hand pulling (only useful on seedlings and only if few in number), weed wrenching (using a weed wrench tool to pull stems of one to two inches diameter), and repeated cutting. Pulling and weed wrenching can be done any time when the soil is moist and not frozen. The disadvantage to both methods is that they are somewhat time-consuming, as the dirt from each stem should be shaken off. Weed wrenching also creates 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 probably best used in areas that have very little desirable native plant cover.

Repeated cutting consists of cutting the plants (by hand or with a brush cutter) at critical stages in its growth cycle. Cutting in mid spring (late May) intercepts the flow of nutrients from the roots to the leaves. Cutting in fall (about mid-October) intercepts the flow of nutrients from the leaves to the roots. Depending on the size of the stem, the plants typically die within three years, with two cuttings per year.

Stems, Seedlings and Resprouts

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.

If burning is not feasible, critical cutting in the spring is also effective, though it can impact desirable herbaceous plants as well. Foliar (leaf) application of a bud-inhibitor herbicide (Krenite) during fall is also effective. This method can also affect non-target species, though most natives will be dormant by that time.

Prickly ash

A native shrub, prickly ash can become excessively abundant, especially in areas that have been disturbed or grazed. Complete eradication may not be necessary, but management may target reducing the extent of a population. Removal is most easily accomplished in the same manner as for buckthorn – cutting shrubs and treating cut stumps with glyphosate herbicide. Cutting can be completed at any time of the year.

Disposal

The easiest and most cost-effective method to handle large amounts of brush is usually to stack it and burn it in winter. 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. Small brush piles can also be left in the woods as wildlife cover. Where there is an abundance of larger trees, cut trees may be hauled and chipped and used for mulch or as a biofuel. Alternatively, the wood can be cut and used for firewood, if a recipient can be found.

FORBS

Canada thistle

While native thistles are not generally problematic, exotics such as Canada thistle are clone-forming perennials that can greatly reduce species diversity in old fields and restoration areas (Hoffman and Kearns 1997). A combination of chemical and mechanical control methods may be needed at the Empire property. Chemical control is most effective when the plants are in the rosette stage and least effective when the plants are flowering. A broadleaf herbicide such as 2,4-D would be appropriate for the south grassland (G1), to minimize damage to native grasses. It is most effective when applied 10-14 days before the flowering stems bolt. It is applied at rate of 2-4 lb/acre using a backpack or tractor-mounted sprayer or in granular form. Dicamba could also be used, with the advantages that it can be applied earlier in the spring at a rate of 1 lb/acre. Plants that do not respond to treatment or that are more widely dispersed could be controlled mechanically.

Mechanical control, involving several cuttings per year for three or four years, can reduce an infestation, if timed correctly. The best time to cut is when the plants are just beginning to bud because food reserves are at their lowest. If plants are cut after flowers have opened, the cut plants should be removed because the seed may be viable. Plants should be cut at least three times throughout the season. Late spring burns can also discourage this

species, but early spring burns can encourage it. Burning may be more effective in an established prairie, where competition from other species is good, than in an old field, where vegetation may not be as dense.

Sweet clover
White and yellow sweet clover are very aggressive annual species that *increase* with fire. Sweet clover was found in the brome field (G2) and would be eliminated by treatment that eliminates the brome if prairie restoration occurs. However, it is a common plant in agricultural areas, so if restoration is implemented, the area should be surveyed for this species on an annual basis. Individual plants or small populations can be removed by hand-pulling. If seed production occurs, prodigious amounts of seed could be spread at the site.

GRASSES

Smooth Brome
Burn two years in a row (late-season burns in June) followed by seeding. This will usually be sufficient to control smooth brome. (Remember to collect seed from on-site first, and if there is not enough, then purchase local ecotype seed from off-site). Evaluate after the two years. If this is not working, perhaps try a cool-season overspray of a grass-specific herbicide either in the spring (April) or in the fall (October). Using glyphosate as a cool-season overspray herbicide application is a last resort, since it kills everything.

Reed canary grass
This species is extremely difficult to eradicate and requires repeated treatment over a period of one to three years. A combination of burning, chemical treatment and mowing can be used, in accessible areas, or chemical treatment alone in inaccessible areas. The combination method starts by burning in late spring to remove dead vegetation and to stimulate new growth. When new sprouts have reached a height of 4 to 6 inches, the site can be sprayed with a 5% solution of a glyphosate herbicide appropriate for wetland habitat (e.g. Rodeo). The site is then mowed in late summer, followed by chemical application after re-growth. This treatment will stimulate new growth and germination to deplete the seed bank. The sequence of chemical treatment and mowing are repeated for at least a second season, and possibly a third until the grass is completely eradicated. Then native grass and forb seed can be broadcast or drilled.

If reed canary is eradicated from an area, future management of the grassland, namely burning, will likely keep the reed canary in check. Monitoring and mapping new individuals or clumps should continue, however, and treated if burning is not adequate. If the plants are small they can be removed by digging out the entire root. Generally though, chemical treatment is more feasible. If plants are clumped, they can be treated by tying them together, cutting the blades, and treat the cut surface with herbicide. Otherwise herbicide should only be applied in native planted areas on very calm days to avoid drift to non-target plants.

Appendix E. Ecological Contractors

Following is a list of contractors to consider for implementing the management plans. While this is not an exhaustive list, it does include firms with ecologists who are very knowledgeable with natural resource management. Unless otherwise noted, all firms do prescribed burning. Many other brush removal companies are listed in the yellow pages (under tree care), but most do not have knowledge or understanding of native plant communities. We recommend hiring firms that can provide ecological expertise. Additional firm listings can be found on the DNR website:
http://www.dnr.state.mn.us/gardens/nativeplants/index.html

Friends of the Mississippi River (FMR) has extensive experience working with landowners to implement natural resource management plans. FMR can assist landowners with obtaining funding for restoration and management projects and providing project management, including contractor negotiations, coordinating restoration and management work, and site monitoring and evaluation.

Applied Ecological Services, Inc.
21938 Mushtown Rd
Prior Lake, MN 55372
952-447-1919
www.appliedeco.com

Bonestroo Natural Resources
2335 West Highway 36
St. Paul, MN 55113
651-604-4812
www.bonestroo.com

Great River Greening
35 West Water St, Suite 201
St. Paul, MN 55107
651-665-9500
www.greatrivergreening.org

Minnesota Native Landscapes, L.L.C. 14088 Highway 95 N.E.
Foley, MN 56329
(320) 968-4222 Phone www.mnnativelandscapes.com

Conservation Corps Minnesota
2715 Upper Afton Road, Suite 100
Maplewood, MN 55119
(651) 209-9900

North American Prairies
111754 Jarvis Ave NW
Annandale, MN 55302
320-274-5316
info@northamericanprairies.com

Prairie Restorations, Inc.
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Cannon Falls, MN 55009
507-663-1091
www.prairieresto.co