Friends of Cullen Nature Preserve and Bird Sanctuary

Restoring the Cullen Nature Preserve to its Historic Oak Savanna Habitat

Cullen Nature Preserve – A Family Gift and Legacy

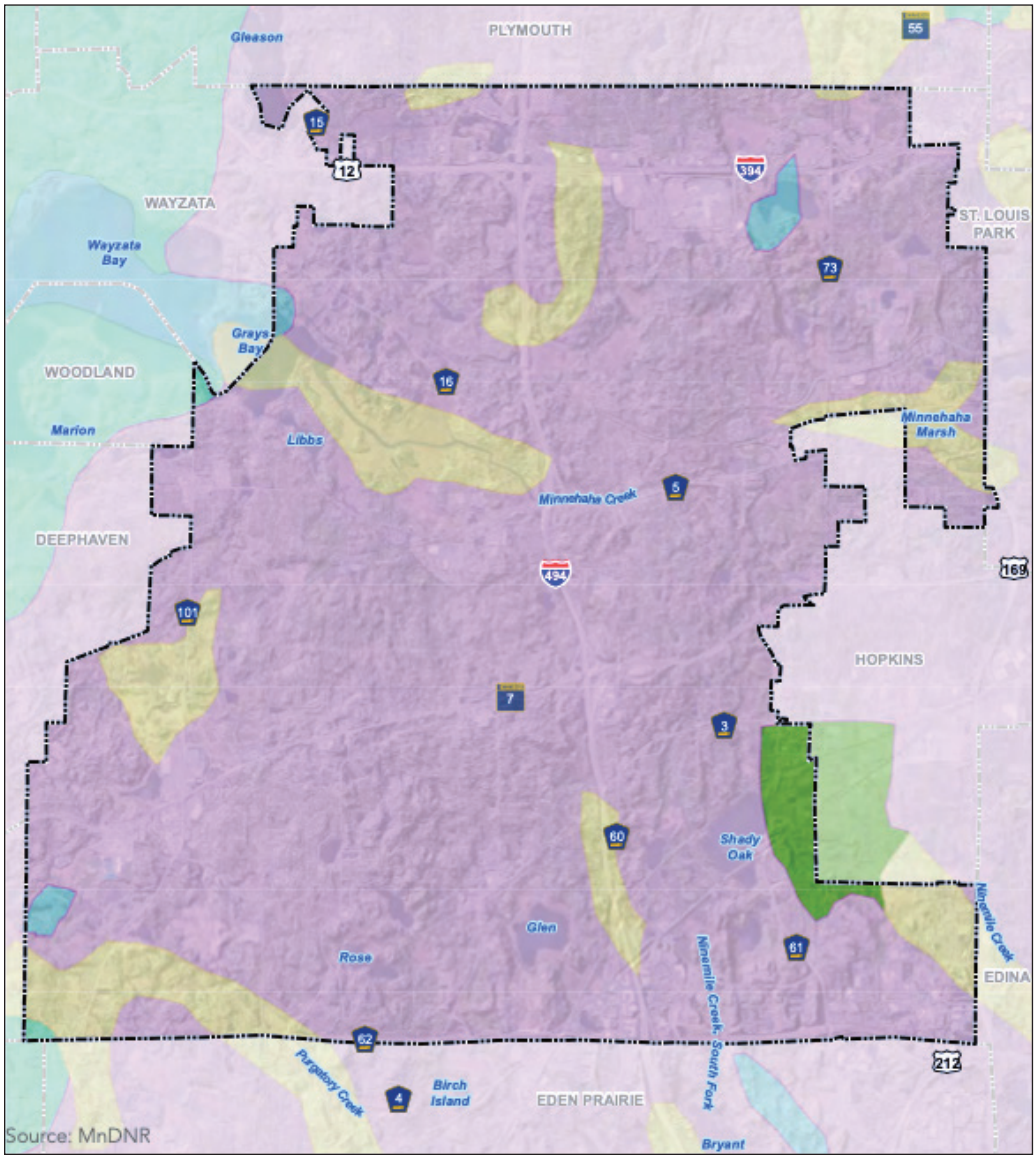
The Cullen Nature Preserve is a City-owned property protected in perpetuity under a Minnesota Land Trust Conservation Easement. Ann Cullen Smith and her husband William Cullen purchased the 30-acre property in Minnetonka in 1935. After the couple built a house and moved to the property in 1937, Ann continued to live in the home for 77 years until 2014. Ann and William often discussed their desire to have the property remain in its natural state so it could be appreciated and enjoyed by the public. After working with the Minnesota Land Trust to develop a conservation easement for the property, Ann approached the City of Minnetonka and arranged to sell the property to the City for half its value. After Ann passed away in 2015 at the age of 105, the property was transferred to the City of Minnetonka.

Ann Cullen's vision for the property, detailed in the conservation easement, includes the protection of the property with a goal of preserving its key conservation values. These values are to preserve and restore the open and natural character of the property, create natural habitat for wildlife and plants, and provide an opportunity for public education and passive use such as nature observation, study, and reflection.

Minnetonka's Historic Ecological Landscape

Minnetonka lies in the tension zone where prairies, oak savannas, oak woodlands, and big woods (late successional, maple-dominated closed canopy forests) historically converged. In Minnetonka, prairies and oak ecosystems (oak savannas and oak woodlands) were once the prevalent plant communities prior to Euro-American settlement. Just west of Minnetonka in communities such as Excelsior or Wayzata, big woods was the primary plant community.

The Cullen Nature Preserve likely was a transition zone between oak savanna and oak woodland, as evidenced by the age of the white and bur oaks as opposed to the much younger fire-intolerant trees on the property.



Map of Pre-European Settlement Plant Communities in Minnetonka.

The area colored light purple was oak savanna. Source: MN DNR and City of Minnetonka, 2021 Natural Resources Master Plan

Cultural Uses of the Land in Minnetonka
A Timeline of Ecological Change

When Ann and William Cullen purchased the land in the 1930s, profound ecological changes had already taken place in Minnetonka and the surrounding region. By 1930, seventy years had passed since treaties were signed by local Native American tribes that resulted in the tribes being driven from their ancestral land they had managed for thousands of years.

Euro-American settlers began to convert these managed prairies and oak ecosystems for agricultural use, log the oaks for lumber and fuel, and ultimately played a primary role in extirpating grazing animals and their predators from the area. The open, oak savannas and oak woodlands became degraded from overgrazing by introduced cattle or lost for other uses as more settlers arrived and continued to convert land for cultivation. Fire suppression by Euro-American settlers led to a significant change in the oak ecosystems; the areas not in cultivation soon became invaded by shade tolerant, fire-intolerant trees. Fire suppression created cool, moist conditions where evaporation decreased, promoting succession toward forests.

By the mid-1960s, shade-tolerant mesophytic tree species such as ironwood, basswood, elm, maple, black cherry, and red oak had fully invaded these white and bur oak ecosystems. At Cullen Nature Preserve, several of the large harvested specimens of these mesophytic trees were assessed for age, and most were between 45 and 55 years old. In other words, the white and bur oak ecosystems at Cullen began to transition to closed canopy forests in the mid-1960s. Many of these fast-growing canopy trees were similar in size to the white oaks; however, the white oak and bur oaks at the Preserve are much older.

Around the same decade, the seeds of invasive plant species such as European buckthorn were being spread from homeowner yards to natural areas by birds. The damp, shaded closed-canopy conditions provided the ideal welcome mat for European buckthorn to become established, furthering the decline in diversity of the ground layer vegetation, resulting in even more shaded conditions, and ultimately a self-reinforcing feedback loop.

Damp, shaded conditions provide the ideal welcome mat for European buckthorn to become established.

Oaks and Oak Ecosystems

Oak Savanna - A Disappearing and Rare Landscape

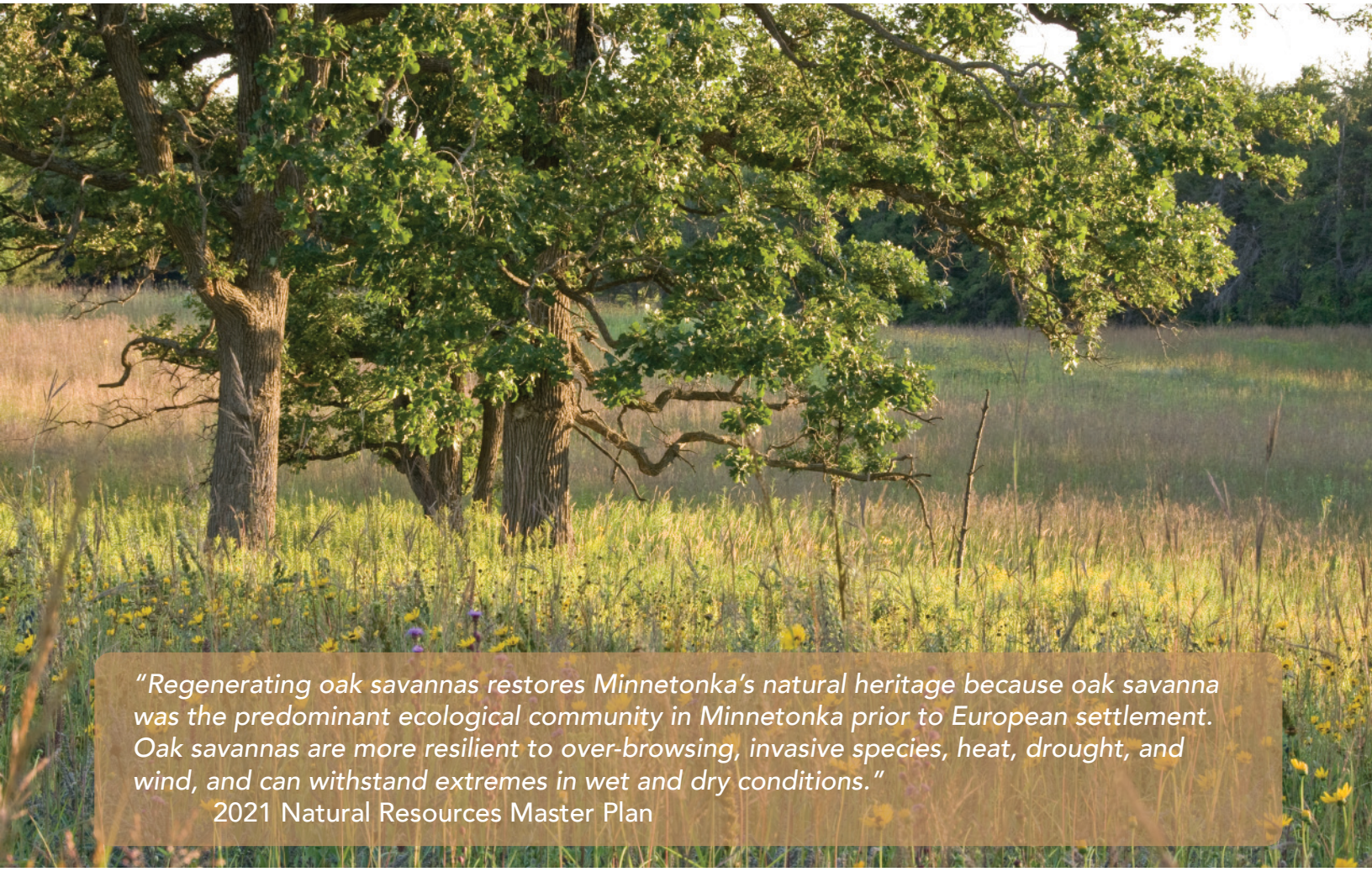
Currently in Minnesota and throughout the Midwest, oak savannas are an extremely rare plant community with less than 0.5% remaining. **Globally, oak savannas in northern latitudes (temperate zone) are one of the world's most endangered ecosystems.** Prior to European settlement, much of the land in Minnetonka was managed and maintained as oak savanna. Native Americans played an integral role, managing these open landscapes to provide grazing animals forage and ultimately nutritious food sources (game, fruit, and seed) that sustained the Native American community.

What is an Oak Savanna?

An oak savanna is an extremely diverse plant communities hosting prairie and woodland flowering plants, grasses, and sedges, in addition to unique plants that grow only in savannas. These landscapes were historically maintained as open grasslands through human-facilitated means including fire, and natural disturbances such as grazing by bison and elk. The 12-acre oak savanna restoration at Cullen Nature Preserve will provide the community with the first present-day model, and foster an appreciation for Minnetonka's natural heritage.

Oak savannas provide unique habitat for rare and declining bird species such as the red-headed woodpecker. Return of the red-headed woodpecker, a species near threatened, is a special target for the restoration efforts; Bill Cullen, son of Ann Cullen, recalls that the red-headed woodpecker was once common on the property.


Red-headed Woodpecker



"Regenerating oak savannas restores Minnetonka's natural heritage because oak savanna was the predominant ecological community in Minnetonka prior to European settlement. Oak savannas are more resilient to over-browsing, invasive species, heat, drought, and wind, and can withstand extremes in wet and dry conditions."
2021 Natural Resources Master Plan

How Do Oak Savannas Differ From Forests?

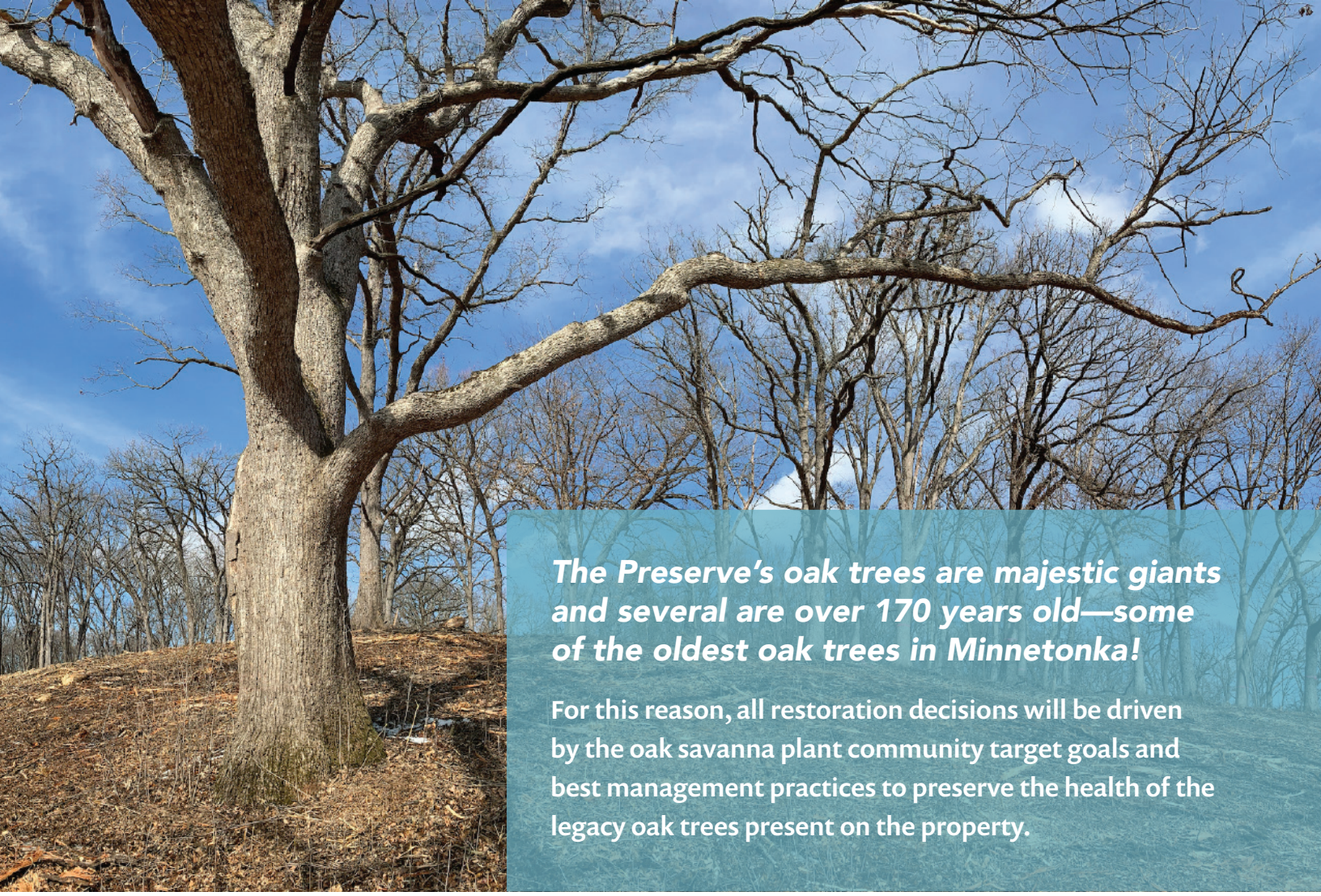
Tree canopy cover in oak savannas can range from sparse (5% tree cover) to more tightly spaced pockets with intermittent canopy openings (50% tree cover). Even at 50% tree cover, the canopy openings still allow enough sunlight to reach the ground to foster the growth of prairie-like vegetation. This dense prairie-like vegetation is a critical component of an oak savanna because it:

- stabilizes soil to reduce erosion,
- facilitates the infiltration of rainwater,
- provides habitat for pollinators, birds, and wildlife,
- competes with invasive plants for light and nutrients, helping to reduce the invasibility of the site, and
- historically, provided forage for grazing animals such as bison or elk.

Oaks: A Keystone Species of Oak Savannas and Woodlands

In Minnetonka, white and bur oaks are the backbone of oak ecosystems. If you drive through the community today, you don't have to look very hard to find legacy oak trees growing in homeowner yards or parks and open space. These oaks (genus Quercus) are keystone species and not only define oak ecosystems, but support a high diversity of other organisms through food web and habitat interactions. If you remove a keystone species from a system, the structure of the system will quickly fall apart. Without oak regeneration or management to remove invading trees affecting white and bur oak health, the legacy oak trees will eventually die and become extirpated from the system.

Oaks are very long lived and adaptable, surviving fluctuating temperatures and periods of droughts. These majestic trees can live to seven hundred years or more and throughout their lifespan support a multitude of butterfly and moth larvae (caterpillars), that in turn provide food for songbirds and their hungry chicks. Acorns are highly sought after as a food source, and oak trees provide cavities for a variety of songbirds and predatory birds such as owls.



The Preserve's oak trees are majestic giants and several are over 170 years old—some of the oldest oak trees in Minnetonka!

For this reason, all restoration decisions will be driven by the oak savanna plant community target goals and best management practices to preserve the health of the legacy oak trees present on the property.

Saving the Legacy Bur and White Oaks

No ecological restoration management has occurred at the Cullen Nature Preserve for over 150 years. With the absence of fire and grazing animals maintaining an open landscape and facilitating the growth of prairie-like vegetation, the Preserve (and all of Minnetonka's remaining savannas) have become severely degraded. Degradation of savannas can result from a combination of factors including:

- the removal of key natural inputs (fire and grazing),
- the establishment and growth of non-oak native trees creating a closed canopy forest,
- the loss of dense ground layer prairie-like vegetation from tree canopy shading, and
- the invasion by invasive plants.

All of these factors contribute to the decline in health of the Preserve's majestic oaks. The non-oak trees and invasive species ultimately compete with the oaks for light, nutrients, and water. The closed canopy conditions also increase the oaks' susceptibility to disease due of reduced air flow, increase in moisture, and lack of adequate amount of sunlight.

Do Red Oaks Belong in an Oak Savanna or Oak Woodland?

Shade-tolerant oaks such as red oak (Quercus rubra) also invade the bur and white oak ecosystems. Historically, red oaks made up a small percentage of the total number of trees in white and bur oak ecosystems. Red oak acorns were the primary food source of passenger pigeons. When fire was excluded from landscapes and passenger pigeons extirpated, red oak began to increase in abundance in the bur and white oak ecosystems.

Diseased Red Oaks Growing in a Former White and Bur Oak Ecosystem Marked for Removal

Red oak is more shade tolerant than bur and white oaks, and is less fire tolerant than bur and white oaks. Red oak is also very susceptible to, and is the primary host of, oak wilt disease. This fungal disease can spread by vectors such as insects and wind, but can also spread in overstocked oak ecosystems from red oak to white and bur oak through their connected root systems. In an oak savanna, single oak trees are typically widely spaced apart or grow in small groves or groupings, limiting the root system connections and exchange of nutrients (and diseases).

Oak Ecosystem Invasion by Fire-intolerant Native Trees
Mesophication

In upland terrain, bur and white oak trees were once the most abundant tree species in Minnetonka's oak savannas and oak woodlands. Today, with widespread fire exclusion, the remaining and highly degraded oak ecosystems lack the former diversity of plants, insects, birds, and mammals. Many still host legacy oak trees, but they have largely become densely forested by invasive plants and invading native, shade-tolerant and fire-intolerant tree species. This process of invasion by fire-intolerant trees when fire exclusion occurs is termed **mesophication**.

For example, ironwood, elm, ash, black cherry, maple, and basswood now grow in these former oak savannas and oak woodlands. With the invasion and growth of these fire-intolerant tree species, the oak ecosystems are radically altered, becoming overstocked with trees, and if left unmanaged and without the frequent input of fire, become cool, moist, densely shaded, and highly susceptible to invasion by invasive species.

A Former Oak Savanna Now Invaded by Mesophytic Trees (and Buckthorn)

Climate Resiliency

Using Historical Oak Savannas as a Model for the Future Climate of Minnetonka

Prairies and oak ecosystems are more resilient to extreme heat, droughts, and fluctuating temperatures than cool, damp closed canopy forests. The deep-rooted prairie-like vegetation creates a vast network of fibrous roots that help build soil organic matter, and are the conduit between the plant and soil microorganisms and fungi that help facilitate the exchange of sugar, water, and nutrients. With projections of the future Minnetonka climate becoming similar to the state of Kansas in terms of average precipitation and temperature, oak savannas will be more tolerant to extremes in heat and drought than forests, and likely easier to manage and maintain due to the adaptability of these ecosystems to withstand stress.

Carbon Sequestration

These grassland systems have been shown to sequester more tons of carbon per acre than forests, storing the majority of carbon permanently in the soil, rather than in aboveground vegetation or trees as would occur in a forest. This aboveground storage in trees is temporary; when the tree dies and starts to decompose, the stored carbon is re-released into the atmosphere.

There are two primary ways in which prairies and oak ecosystems store carbon in the soil.

1) Sixty to eighty percent of the biomass of grassland plants occurs belowground and about one-third of the extensive belowground root system dies every year. The carbon in this plant tissue remains belowground, sequestered in the soil.

2) During photosynthesis, plants use energy from the sun to convert atmospheric carbon dioxide and water (atmospheric and soil) into carbohydrates (sugars) and oxygen. Excess sugars are secreted from the plant roots into the soil which feed soil microorganisms that, in return, provide the plants minerals and water.

Soil Conservation

Soil disturbance and erosion can result in the oxidation of soil carbon and its release back into the atmosphere. The dense ground layer vegetation of prairies and oak ecosystems not only builds soil organic carbon but it also helps prevent soil erosion. In contrast, dense, shaded forests have very low ground layer plant diversity and the leaf litter is readily consumed by non-native earthworms. This can result in large areas of bare soil that are susceptible to soil erosion.

Oak ecosystems that become invaded by fire-intolerant trees are also more susceptible to invasion by invasive plant species. When a full invasion occurs, the system deviates from its stable state and shifts to an unstable state. This deviation continues to compound, resulting in a self-reinforcing feedback loop.

Biodiversity, Ecosystem Stability, and Resiliency

Oak savannas (plant communities with scattered bur and white oak trees and a prairie-like ground layer vegetation) are some of the most biodiverse ecosystems, hosting a significant number of plant, animal, bird, and insect species. This diversity helps ensure that the plant community remains adaptable if a disturbance occurs, or as the climate continues to get warmer. In contrast, the mixed, closed canopy forests one observes in Minnetonka's parks or open spaces today, may be high in tree diversity, but are low in overall plant diversity (and biodiversity).

Consequently, oak ecosystems that become invaded by fire-intolerant trees are also more susceptible to invasion by invasive plants such as European buckthorn and garlic mustard. When this occurs, the system deviates from its stable state and the resulting shift to instability compounds and becomes a self-reinforcing feedback loop. With the use of fire and other restoration management tools, oak ecosystems can sustain a fluctuating (prairie to oak woodland continuum) but stable state, and the system is inherently more resilient.

The Restoration

Restoration Goals

Oak ecosystems are diverse because the dense matrix of ground layer perennial vegetation, comprised of grasses, sedges, and flowering plants, amounts to hundreds of plant species. This plant diversity and the multitude of insects that rely on this plant diversity, in turn provide habitat and food for birds and mammals, leading to robust, interconnected food webs.

The oak savanna and oak woodland restoration at Cullen Nature Preserve is designed to:

- enhance the health of the legacy oak trees,
- reestablish and increase plant diversity,
- foster the regeneration of oaks to produce different age classes,
- provide a restored, living model to showcase to the public, and
- increase the awareness of the need for ecological restoration and appreciation of these rare ecosystems.

Restoration Methods - *A New Approach*

This 12-acre restoration will look very different from the forests that one might observe while visiting a Minnetonka park. The Cullen Nature Preserve restoration will include the implementation of new restoration approaches that are not currently or regularly employed in the management of our parks' natural resources including:

- extensive harvesting of undesirable woody biomass,
- seeding to establish diverse native ground layer vegetation, and
- regular use of prescribed fire.

The overarching restoration goal for the Preserve is to save the majestic oak trees and shift the plant community back to its former stable and climate resilient state — **an oak savanna**.

A Shock to the System

The former savanna at the Cullen Nature Preserve is now an altered and unstable system. The legacy oaks are on life support. If no intervention were to occur, the community would lose this rare savanna ecosystem and the majestic oaks that provide the critical backbone of the plant community. To reverse the trend of degradation, bold restoration management actions are required, actions that will 'shock' the system back to its former stable and resilient state.

To achieve these oak savanna tree cover targets at Cullen Nature Preserve, harvesting of all invasive plants and many non-oak trees will occur to create openings in the canopy. This will produce a park-like visitor experience with extensive and scenic views through the understory of the oaks, and outstanding bird and pollinator habitat.

What to Expect – Restoration Activities

Invasive Plant Removal and Opening of the Tree Canopy

During the winter months and while the ground is frozen, large tree harvesting and invasive plant management equipment will be used to remove the undesirable plants and open the tree canopy.

Prairie and Savanna Grass Seed

Next, native prairie and savanna grass seed mixes will be sown on the bare ground to start establishing the prairie-like vegetation.

Invasive Plant Management

After establishing native grasses, and allowing existing plants to respond to the increase in sunlight, contractors will monitor and manage any undesirable plants. This may include mowing down the vegetation in summer and returning in autumn to herbicide any remaining invasive plants such as buckthorn regrowth.

Flowering Plant Seed

After the prescribed burn and while the ground is still bare, native flowering plants will be sown. This will complete the two-part process to establish diverse prairie-like ground layer vegetation.

Source: City of Minnetonka 2021 Natural Resources Master Plan

Prescribed Fire
A Primary Management Tool of Prairies and Oak Ecosystems

Once dense vegetation is established that can provide enough fuel, the restoration area will be burned. Burning will help control small invasive plant seedlings and temporarily provide bare ground for sowing more seed.

Historically, prairies, oak savannas, and oak woodlands were managed and maintained by natural and human disturbances. Grazing animals such as bison and elk played an important role in sustaining the open character and dense ground layer vegetation of these ecosystems. The most important human management tool was the regular use of fire. In Minnesota, Native Americans used fire for various purposes such as:

- providing nutritious forage (fresh grass) for grazing animals (game),
- improving the nutritional quality and seed or fruit set of foraged plants, and
- reducing underbrush to improve the ease of travel and enhance hunting sightlines.

Fire Frequency Influence on Prairies and Oak Ecosystems

Historical evidence including written accounts by early Euro-American explorers and settlers, and burn scars on oak trees, demonstrates that oak ecosystems and prairies were burned with relative frequency. The frequency and intensity of the fires would result in an ever changing but stable oscillation between prairie, oak savanna, and oak woodland. For example, a ten or twenty year fire interval would allow oak seedlings to become large enough, and develop thick enough bark to withstand the next fire and likely result in an oak savanna. Historically, more frequent fires such as every two or three years, would sustain a prairie.

Fire, Leaf Litter, and Fuel

Like grazing, historically, fire was an important component of the oak savanna ecosystem that prevented the savanna from transitioning to a closed-canopy forest. Bur and white oaks have evolved with fire and are, therefore, well adapted to survive fire due to thick insulating bark. Oak seedlings even have adaptations that help to assist with survival during fire, callusing over and resprouting using reserves from their extensive taproot. Oak leaf litter, as opposed to the leaf litter of mesophytic tree species, is an excellent fuel source for fires. Oak leaves tend to be larger, drier, thicker, and more resistant to decay. When oak leaves dry, they curl, are held uncompressed off the ground, and form gaps of air, providing an oxygen source for the fire to move across the landscape more effectively.

Mesophytic tree leaf litter is thin, decomposes quickly or is quickly consumed by non-native earthworms, and mats to the ground and holds moisture longer than oak leaf litter making it a poor fuel for carrying fire through the landscape. By harvesting mesophytic trees and restoring a part of Cullen Nature Preserve to oak savanna, fire can again be introduced as a management tool to effectively maintain the site, and help prevent the recurring invasion of mesophytic trees and invasive plant species.

The dense, shaded conditions of a sugar maple 'Big Woods' forest. These low diversity forests lack the dense ground layer vegetation of oak ecosystems. In addition, maple leaf litter decomposes quickly or is readily consumed by non-native earthworms, resulting in bare ground that is susceptible to erosion as shown in the photo above.

Looking Forward Toward a Resilient Future

After Cullen Nature Preserve and Bird Sanctuary receives restoration actions including large tree harvesting, prescribed burning, and seeding to reestablish ground layer vegetation, this "shock to the system" will reverse the more than one hundred and fifty years of degradation and mesophication, and begin transitioning the site into a resilient and biodiverse oak savanna.

Management of the site will be ongoing and we will continue to perform restoration actions in response to invasive species pressure and ensure plant species richness and diversity. In the coming years and decades, and with continued monitoring, these rich and diverse plant communities will gradually become more resilient and stable, and ultimately serve as a refuge for rare and common birds, mammals, and pollinators. We envision that Preserve visitors will have awe-inspiring experiences and will revel in the beauty of these rare plant communities.

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