MINNEHAHA CREEK WATERSHED DISTRICT
QUALITY OF WATER QUALITY OF LIFE

MEMORANDUM

To: MCWD Board of Managers

From: Tiffany Schaufler

Date: March 21, 2016

Re: LCCMR Grant Request Follow-up: Haying Research Proposal

Purpose:

Provide additional information as requested at the March 10, 2016 Board Meeting regarding the request to apply for a LCCMR grant to research haying at the Six Mile Marsh Prairie Restoration site.

Background:

At the March 10, 2016 Board Workshop, staff presented Resolution 16-020 which sought authorization to submit a partnership proposal with Great River Greening (GRG) to apply for a LCCMR grant. GRG had approach the District about applying for an LCCMR grant to investigate the role of haying to remove nitrogen and promote plant diversity and pollinator diversity in grassland ecosystems. The Six Mile Marsh Prairie Restoration site is proposed to represent a pilot project to test the impacts of haying on soil nitrogen and plant-pollinator diversity. The Board of Managers approved the grant proposal at the March 10, 2016 Board Workshop but had some questions on the proposal. Attached is the GRG proposal which will be submitted to the LCCMR on March 21, 2016. Staff also provided answers to specific questions in a March 17, 2016 email to the Board of Managers.

Attachment:

Six Mile Marsh Prairie Urban Haying Research Project Proposal

If there are questions in advance of the meeting, please contact Tiffany Schaufler at 952-641-4513 or at tschaufler@minnehahacreek.org.

Subject: Minnehaha Creek Watershed District / Great River Greening Partnership
To: Tiffany Schaufler Project & Land Program Manager
Prepared by: Stephen Thomforde, Project Manager Ecologist, Great River Greening

Project Name: Six Mile Marsh Prairie Urban Haying Research Project

Some of the most biological diverse terrestrial ecosystems on earth are found in traditional European hayfields (Dahlström et al. 2012).

Vision: The Six Mile Marsh Prairie grassland-savanna restoration project is managed through traditional haying practices that maximize biological diversity, nutrient regulation, provides cost off-sets to sustain management into perpetuity, and provides data to help inform BWSR guidelines for grassland savanna management.

Outcomes:

- Restore the keystone intermediate disturbance (Figure 1) regime (biomass harvest) which is critical for reinforcing grassland – savanna community configuration and ecosystem function
  - Strongly regulate nutrient flows
  - Reset mechanism for preventing successional trends towards climax
- Create patches of short vegetation and tall vegetation
  - Maximize habitat types
  - Maximize biological diversity
- Facilitate the emergence and maintenance of a robust cool season plant community
  - Maximize biological diversity
  - Provide nectar-pollen sources for cool season pollinators
- Decrease soil nitrogen levels
  - Decrease invasibility
  - Maximize plant diversity
- Off-set long-term management
- Create a robust and resilient plant community that can be advanced to restoring the second trophic level and a grazing regime

Project Background:
Six Mile Marsh Prairie was historically covered with grassland - savanna vegetation. This vegetation represents the most advanced, functional, and productive terrestrial ecosystem ever. This vegetation emerged, most significantly over the past 24 million years with massive herds of grazing endothermic mammals. The vegetation became highly edible during this period, <u>and biomass harvest by herbivores became the default disturbance regime for maintaining grassland – savanna ecosystems</u>. The synergy between plant and beast represents the grandest coevolutionary event on earth ever, whereby each became obligate to the other. This relationship continued to evolve and refine itself into the Pleistocene when humans showed up and employed fire to maximize grassland – savanna, grazing, and therefore biomass harvest. This relationship continued well into the Holocene until 400 years ago when the massive herbivore capacity for biomass harvest was significantly diminished, and the high quality (Figure 2) native plant communities began to unravel.

The cause of herbivore disappearance is complex but it probably began when early European explorers introduced a novel virus community to North America. These virus rapidly spread through aboriginal populations, in a process known as virgin soil epidemics, which killed up towards 99% of the native population. The use of fire by Amerindians ceased, and woody vegetation began to expand. The woody vegetation offered a poorer forage for the advanced grazers, and so herbivore populations decreased which in turn allowed for a more rapid expansion of woody vegetation, a classic example of a positive feedback cycle.

The second blow to the grassland - savanna ecosystem followed directly on the heels of the virgin soil epidemics, as the fur trade literally destroyed the vast herbivore populations of our region 350 years ago. Beavers were trapped to the brink of extinction and elk and deer were killed to feed the fur trade industry. Likewise, Amerindians received new technologies including the horse and firearms, and the killing of herbivores became immense, in fact so immense that the lack of game forced Amerindians onto reservations for subsistence on government rations. By the time the public land survey reached Minnesota the vegetation was in a drastic state of flux, and the subsequent Marschner Map captures a transitional vegetation rather than the original vegetation.

One reason any grassland – savanna survived to recent times is farmers grazed their livestock in the "groves" or on land too steep or rugged to plow. Hay, to sustain livestock through winter, was procured from seasonal wetlands. This hay was called "marsh hay". Haying occurred during the dry month of August. Horses pulled hay mowers and rakes. Hay was stacked and cured along the marsh edges. In the winter, hay was hauled on sleds to the barnyard and awaiting livestock

Haying marshes maintained a high biological diversity as noted by Aldo Leopold in his classic Marsh Land Elegy, "There was a time when all marsh dwellers lived in harmony…, and the marsh could have gone on forever producing hay, cranes, grouse, and deer, but the new overloads thought differently and drained the marsh….". There's also much attention to the traditional hay fields in Europe as being the most biologically diverse terrestrial ecosystems on earth (Dahlström *et al.* 2012).

Traditional farming practices maintained the native pastures and hayfields with fire to prevent leaf-fall and senesced vegetation from smothering the ground layer vegetation, and thus settler farmers mimicked the ways of the Native Americans. Many of these pastures and hayfields were very diverse and we could have gone on indefinitely, producing butter and buttercups (anemones), but in the 1960s, university extension agents declared pasturing and haying marshes as an inefficient means to produce milk and meat. Soon, free roaming livestock were incarcerated in barns and feed lots and fed a steady diet of grain instead of fresh and cured native vegetation. Plowable pastures and hayfields were plowed for corn, and non-plowable lands were abandoned. The vegetation, for the first time in 24 million years was left alone, without it's symbiont organism herbivore, without humans managing native pastures with fire to make better native pasture, and the vegetation unraveled into the current mess of infested, non-edible low quality vegetation we see today.

In summary, biomass harvest by herbivores was the primary disturbance regime that maintained earths' highly advanced grass – savanna ecosystems. The herbivores acted as a control over vegetation configurations, and when the controls were lost, the vegetation crashed into the dysfunctional mess that inhabits so much of earth's abandon land.

What Happens when Biomass Harvest is Lost: Two ecosystem parameters shift in absence of biomass harvest. The first shift is an increase in shade intensity and the second shift is an increase in soil nitrogen (N) levels. The shift in shade intensity and nitrogen levels are at first slow and barely detectable, but like any complex system, thresholds are reached, system behavior goes non-linear, and rapid transformations occurs in community structure and configuration.

Shade: Increases in shade causes the vegetation to reallocate resources from lateral to vertical development. The contraction in lateral growth creates open patches of soil, or gaps in niche space, that offers colonization opportunities to more shade tolerant species. Likewise, unharvested vegetation creates dense thatch layers, which further increases shade intensity, especially at the soil surface. Eventually seedlings of the original vegetation perish in darkness and the original vegetation fails to regenerate itself. Soon more shade tolerant species begin to replace the grassland – savanna heliophilic vegetation.

Nitrogen: Decomposition of the dense thatch layer releases nitrogen and soil nitrogen levels begin to increase. Excess nitrogen fuels rapid, taller and weedier growth, which in turn creates more shade and more detritus. The weedier species tend to be non-edible and non-flammable making biomass harvest by herbivore or fire less likely, and of course the hay is of no value either. Nitrogen deposition from the falling tangle of non-edible, non-flammable, and labile species rapidly increases until the soils become hypereutrophic. High nitrogen soils favor nitrophilic plant species (Curtis 1959) that come to dominate community configuration.

Catastrophic Regime Shift (Scheffer *et al.* 2001): The combination of unharvested vegetation and increases in soil nitrogen create a classic positive feedback loop. At a certain shade-nitrogen threshold, linear incremental increases are subsumed by nonlinear increases that radically transform community structure and ecosystem function. This sequence of events follows the general principles associated with the Catastrophic Regime Shift (CRS) framework used to describe state transitions from highly functional to dysfunctional ecosystems.

General Principles: The Catastrophic Regime Shift of the grassland – savanna ecosystem follows the exact set of principles for lake eutrophication whereby excess nutrients fuel a weedy growth that shades out the high quality macrophyte community. Many of these lakes entered into the dysfunctional state following the demise of the principle waterfowl herbivore, the canvasback duck, which was functionally hunted into extinction 110 years ago. The loss of biomass harvest by the canvasback allowed for excessive nitrogen and phosphorus increases until a threshold was crossed and the lake became hypereutrophic.

Many grassland – savanna ecosystems are in the same hypereutrophic dysfunctional state. Historically, vegetation harvested by herbivores shuttled nitrogen into animal tissue. For example, historic beaver, bison and elk populations combined offered a 28-billion-pound reservoir of N in animal tissue instead of soil. When biomass harvest ceased, the soils became eutrophic which in turn facilitated a rapid transformation in vegetation from high to low quality.

Invasive Species or Invasible Landscape: The previous logic, based on eutrophication and shade, calls into question the current paradigm based on the "invasive species" concept. Do species really invade or has something in the environment changed and the landscape has instead become invasiblie? The current invasive species paradigm forces a management targets the species instead of the cause. Tactical deployments targeting the species use a variety of chemical, physical, and biological treatments, often again and again at the same site, with questionable returns on investment. Haying offers us a strategic opportunity to target the cause for why the landscape became invasible.

Restoration: Without some form of biomass harvest imposed upon grassland-savanna vegetation, ecosystem integrity will decline. On sites that are prone to excessive nutrient loading, such as lowlands (nitrogen is water soluble), poorly drained soils, sites with a history of heavy composting, mulching, and fertilizing, and areas subject to heavy nitrogen inputs from agriculture and nitric-oxides from burning fossil fuels, biomass harvest on these sites may need to be frequent and intense for several years. On better drained soils and uplands, biomass harvest may be regulated to every other or every third year, often in accordance with the burn cycle.

Market Based Incentives: An additional benefit of this project seeks to develop market based incentives for maintenance of ecological restorations. Maintenance regimes based on conservation grazing or haying may achieve both ecological and economic benefits. More importantly, this type of restoration may conjoin emerging markets for locally produced foods and fibers, that in turn will inspire more land managed as native pastures, just as the Amerindians did so before Eurovasion. If we can achieve increases in ecological integrity in ways that provide us high quality foods and fibers, while supporting a variety of jobs in restoration, pasturing, livestock husbandry, processing quality foods and fibers, why wouldn't we?

Project Summary and the Importance of Biomass Harvest:
This project seeks to test the impacts of biomass harvest on soil nitrogen and subsequent feedbacks between plant community configuration. The theory behind the assumptions are strong. But this work needs field testing.

<u>A**ssumptions:**</u>

- Nitrogen pollution from atmospheric deposition and agricultural runoff has increased soil nitrogen in excess of 3xs since 1860 (Galloway *et al.* 2004).
- Moderate to poorly drained soils tend to saturate with excess nitrogen, causing the soils to become hypereutrophic.
- Excessive soil nitrogen favors a low quality non-diverse vegetation composed of nitrophilic
- Nitrophilic plants are non-edible, non-flammable, non-nutrient regulating, and offer few if any benefits
- Haying can effectively mine nitrogen from the soils, removing from 100 - 150 pounds of N per acre per season (2014 Native Prairie Hay Meadows)
- Decreases in soil N will decrease invasibility (Davis *et al*. 1998)
- Lower soil N favors higher plant diversity (Tilman 1988), but more importantly, low soil N favors high quality symbiotic species
- Higher quality vegetation will increase the quality of the hay creating cost off-setting management incentives to continue haying (reinforcing feed backs)
- Higher quality vegetation will attract a greater number and diversity of pollinators
- Managed haying over time will allow land managers to structure different plant communities types
    a. Mid-summer haying will release a spring and fall cool season flora. This type of vegetation, once common is currently lacking, which is a threat to cool season pollinators.
    b. Spring haying will decrease cool season weedy species such as reed canary grass while releasing a native summer and fall flora.
- Managed haying will allow both warm season and cool season plant communities on the same site

- Robust cool and warm season plant communities will increase habitat types for many organisms.

<u>Null hypothesis</u>: "Biomass harvest will have no impact on total soil nitrogen or on floristic and pollinator quality & diversity." (<u>We want to reject the null hypothesis</u>)

<u>Design:</u>

- There are (16) plots on (90) acres.
- Plot sizes are approximately 5.6 acres in size.
- There are 8 treatment and 8 control plots.
- One third (1/3) of each plot is over-seeded with a "diversity booster mix" that contains cool season short stature and warm season tall stature species.
    - The diversity booster mix is designed to test the impacts of "multiple seed rains) to promote highly diverse plantings
    - The diversity booster mix is designed to test the capacity of haying to facilitate recruitment of cool season short stature species that are critical for cool season pollinators.
- Pretreatment (haying) vegetation, nitrogen, and pollinator data collection will occur summer 2017.
- Post treatment (haying) vegetation, nitrogen, and pollinator data collection will occur in 2020.
    - Vegetation sampling is conducted using 1 meter quadrats along 100 meter transects, for % cover by species, % bloom by species, and total diversity by species.
    - Nitrogen soils samples will be collected in early spring 2017 and 2020
    - Pollinator data will be collected 3 to 4 weeks from May 1st to September 31st during the first baseline season (2017) and the last season (2020).
        - Surveys will consist of timed visual transect walks using sweep nets to collect all pollinating insects in flight or on vegetation/flowers in designated survey areas of control and test plots.
        - All flower associations will be recorded.
- Haying will occur 2017, 2018, 2019, 2020.
- Haying will be performed by a local farmer.
- Hay mowers will be set at a minimum of 3 inches above the ground to ensure no damage to meristems
- Collect post treatment data following 3-4 haying events over3- 4 years
- Analyze data and develop reports for dissemination

Logistics:

In the Metro Conservation Corridor
Innovative techniques to incentivize restoration maintenance through haying and grazing.

G**oals/tasks**

- Design a haying plan
- Design and implement research protocols
- Collect baseline data on soil nitrogen, vegetation, and pollinator diversity
- Design a "Booster Seed Mix" 30 acres
- Over seed 1/3 the plots with a diversity booster mix
- Identify haying cooperator

- Develop awareness through presentations, social media, and other sources
- Identify potential sources for prairie hay, possibly grass-fed industry
- Analyze data and develop reports, and disseminate information

- **Budget with research:**
- MCWD $25,000
- GRG $105,000
- **Total: 130,000**

Six Mile Marsh Grazing Proposal

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Figure 1: Intermediate Disturbance Theory. No disturbance equates to low diversity climax communities. High disturbance equates to communities dominated by ruderal species (e.g. annuals). In theory there is a sweet spot between no disturbance and constant disturbance that maximizes diversity and ecosystem function.

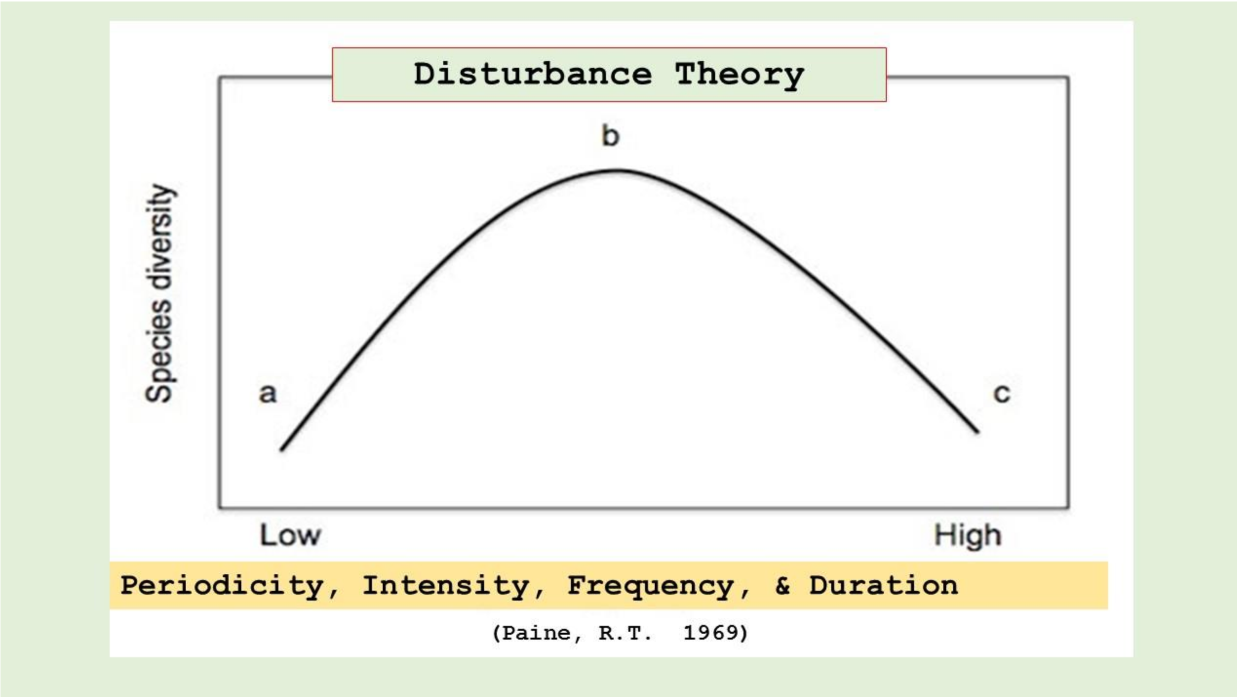

Figure 2: Attributes associated with high and low quality vegetation.

Attributes	**Low Quality Vegetation**	**High Quality Vegetation**
Life Span	Short	Long
Life Strategy	Quantity – Competitive	Quality – Symbiotic
Nutrient Regulation	Low	High
Edibility	Poor	Excellent
Ecosystem Services	Few	Many

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