Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2017 LCCMR Work Plan

Date of Submission: September 14, 2016

Date of Next Status Update Report: January 1, 2018

Date of Work Plan Approval:

Project Completion Date: June 30, 2020

Does this submission include an amendment request? No

PROJECT TITLE: Evaluating the Use of Bison to Restore and Preserve Savanna Habitat

Project Manager: David Tilman

Organization: Cedar Creek Ecosystem Science Reserve, University of Minnesota

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Location: Anoka and Isanti Counties, MN

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$388,000**
	Amount Spent:	**$0**
	Balance:	**$388,000**

Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 08c

Appropriation Language:
$388,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota, Cedar Creek Ecosystem Science Reserve, to research combined bison grazing and fire management strategies to restore Minnesota's oak savanna ecosystems. This appropriation is available until June 30, 2020, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Restoring and Preserving Savanna Using Bison

II. PROJECT STATEMENT:

Oak savanna is Minnesota's most threatened ecosystem, and fire, alone, is not restoring and preserving it. At the time of settlement, a broad swath of savanna stretched from the south to north across the middle of Minnesota, but by the early 1900's most had become cropland and pasture. And now, after a century without fire and bison, less than 0.1% remains as savanna, and most remnants have lost their prairie grasses and wildflowers as they became dominated by trees that invaded when fire stopped.

Efforts to restore savanna have been insufficient. Our savanna restoration research started in 1965 in what had once been native savanna at Cedar Creek Ecosystem Science Reserve (henceforth "Cedar Creek"). It has shown that burning about 2 of every 3 years eliminates shrubs and non-savanna tree species and restores prairie grassland species. However, our 50 years of research is also showing that these frequent fires are preventing oaks from regenerating. Although our efforts to date have "restored" the second largest stand of oak savanna in Minnesota, it is now clear that **fire, by itself, is leading to the slow demise of this savanna because oaks are not replacing themselves before they die.** It remains unclear how oak savanna can be both restored and preserved.

We propose that bison are essential for savanna restoration and preservation because bison preferentially graze the most abundant native prairie grasses. When not grazed, these grasses can outcompete oak seedlings for soil nutrients and, when these ungrazed grasses burn, their high abundance causes intense fires that kill oak seedlings. **Fire is also likely essential** since frequent fires eliminate shrubs and most trees except oaks, thus allowing prairie species and oaks to persist.

Our **GOALS are to experimentally test whether and how bison grazing and fire can jointly restore and preserve oak savanna.** Because neither cattle nor deer nor elk preferentially eat the most abundant native grasses, we believe that bison grazing, in particular, may be of central importance to maintaining oaks in savanna ecosystems. This research on bison is essential since the role and usefulness of bison in savanna restoration and maintenance remain completely unknown.

The **OUTCOMES** we plan to achieve are to:

(1) Discover better restoration and preservation practices for savanna remnants;
(2) Determine how these practices impact the full range of savanna biodiversity; and
(3) Educate Minnesotans about the ecological heritage of their state, including the roles that bison, fire and biodiversity play in the functioning of savannas and other Minnesota ecosystems.

Background:

Before the 1800's, the North American Great Plains were home to approximately 30 to 60 million bison. By the late 1800's, bison populations had been almost completely exterminated by human hunting and conversion of their habitat to croplands and rangelands for livestock, leaving only a few thousand individuals remaining. Populations have since recovered to more than one hundred thousand individuals, mostly due to ranching and conservation efforts.

Bison are now known to be a keystone species for restoring and preserving grasslands, but their potential roles in savanna restoration and preservation remain unknown. Many decades ago, it was realized that restoration of grassland biodiversity and ecosystem functioning required not only sowing of the plant community, but also reinstating natural disturbance processes, such as fire. Prescribed burning is now commonly used as a restoration practice in grasslands, savannas, and other ecosystems that historically experienced this disturbance. More recently, it has become appreciated that grassland restoration success can also be enhanced by restoring major herbivores, such as bison. Bison are now commonly used by federal and state agencies, including the US Fish and Wildlife Service (e.g., Neal Smith National Wildlife Refuge) and the Minnesota Department of Natural Resources (e.g., Blue Mounds State Park), and by private conservation organizations, such The Nature Conservancy (e.g., Broken Kettle Grasslands), to restore and preserve grasslands.

Prescribed fire is commonly used in both grassland and savanna restoration projects, but bison grazing has not yet been explored as a potential management tool in savannas.

Bison preferentially graze the dominant warm season grasses that would otherwise outcompete wildflowers, thereby promoting plant coexistence and enhancing plant diversity in grasslands. By promoting grassland plant diversity, bison grazing also helps maintain ecosystem processes and the diversity of many animal species, both of which directly depend on plant diversity. We expect bison grazing will similarly promote the diversity of herbaceous (non-woody) plants in savannas, but the impacts of bison grazing on the oak trees, which dominate savannas, remains unknown.

We hypothesize that bison grazing will promote the growth and survivorship of oak seedlings in burned savannas by reducing grass fuel for fires and by knocking back dominant grass competitors; however, our proposed experiment will also test whether bison might instead disfavor oak regeneration by browsing oak seedlings. Given that bison preferentially graze warm season grasses, which are the primary fuel for fires, and which are known to outcompete oak seedlings at Cedar Creek, we expect that bison grazing will promote oak regeneration by reducing the intensity of fires and the ability of grasses to outcompete oak seedlings. Alternatively, if bison substantially browse oak seedlings, then they might instead reduce oak regeneration. If so, then bison grazing would be recommended as a strategy for restoring and preserving grasslands, but not savannas.

Because Cedar Creek is so data-rich, it provides an ideal location to study the potential role of bison grazing in maintaining savanna biodiversity and ecosystem functioning. We have collected 20-30 years of data from dozens of long-term studies that provide a detailed description of plant community structure and ecosystem function in the absence of bison. These data come from literally thousands of experimental and observational plots distributed across our 21 km^2 landscape. The new measurements we will collect in this project will further advance understanding of the patterns and processes driving the structure and functioning of savannas. Our results will be informed by past research, and will inform future research, at Cedar Creek.

Hypotheses:

We will investigate the following questions:

1. Does bison grazing promote oak regeneration by reducing fire intensity?
2. Does bison grazing increase promote oak regeneration, herbaceous plant diversity, and plant species that are poor competitors for soil nutrients by decreasing the ability of grasses to outcompete oak seedlings and wildflowers?

We will test the following hypotheses:

The **fire-grazing interaction hypothesis** predicts that bison grazing will promote the growth and survivorship of oak seedlings by reducing fire intensity. There would be evidence for this hypothesis if we find an interactive effect of our fire and grazing treatments on oak seedling growth and survivorship, with oak regeneration disfavored by fire, except in the presence of grazing, and if grazing reduces fire temperature in burned plots.

The **resource-apparent competition tradeoff hypothesis** predicts that plants coexist by a tradeoff between relative competitive ability for exploiting soil nutrients (resource competition) and ability to resist consumption by natural enemies, such as herbivores (apparent competition). In other words, if grasses, which are known to be superior competitors for soil nutrients at Cedar Creek, are less able to resist herbivory by bison than are oak seedlings or wildflowers, then bison grazing could promote oak regeneration and plant coexistence and diversity. There would be evidence for this hypothesis if bison increases plant diversity, decreases dominance of warm season grasses, increases oak seedling growth and survivorship, and increases dominance of wildflowers in both burned and unburned treatments.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of January 1, 2018:

Project Status as of July 1, 2018:

Project Status as of January 1, 2019:

Project Status as of July 1, 2019:

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: ***Restore bison grazing to 200 acres of oak savanna***
Description:

We will restore bison grazing to a 200-acre-site on the southwest edge of Cedar Creek that is a mosaic of restored oak savanna (that lacks oak regeneration) and remnant oak savanna (that is now low-diversity forest). In 2017, we will install bison fencing around this parcel, watering facilities, and a bison corral. Then, starting in late spring of 2018 and each subsequent year, a project partner, Northstar Bison, will deliver and release bison, periodically visit throughout the growing season to provide any needed veterinary services, collect any bison that might escape, mend fences, and round-up bison each year in October. A similar seasonal bison grazing partnership between Northstar Bison and Belwin Conservancy has successfully restored prairie grassland with minimal ongoing costs for Belwin. We cannot afford to purchase, or to maintain all year for many years, a herd of 100% genetically pure bison for this research and, fortunately, do not need to do so since Northstar's bison preferentially graze abundant native grasses just as do genetically pure bison.

Restoration goals include promoting oak regeneration, enhancing the biodiversity of plants and animals, and maintaining ecosystem functioning and stability. The experiment in Activity 2, described below, will be used to assess whether these restoration goals are achieved. We will control the intensity and timing of bison grazing with adaptive management to achieve restoration goals.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 99,300
Amount Spent: $ 0
Balance: $ 99,300

Outcome	Completion Date
1. *Perimeter fences and bison corrals constructed and watering facilities established*	November 2017
2. *About 40 bison grazing in 200 acres of current and remnant savanna*	June 2018
3. *About 40 bison grazing in 200 acres of current and remnant savanna*	June 2019
4. *About 40 bison grazing in 200 acres of current and remnant savanna*	June 2020

Activity 1 Status as of January 1, 2018:

Activity 1 Status as of July 1, 2018:

Activity 1 Status as of January 1, 2019:

Activity 1 Status as of July 1, 2019:

Activity 1 Status as of January 1, 2020:

Final Report Summary:

ACTIVITY 2: ***Experimental tests of savanna restoration using bison***
Description:

Within the 200-acre bison enclosure we will create a well-replicated experiment to determine how bison grazing and fire frequency impact the restoration and preservation of oak savanna ecosystems. Using 54 plots, each 7 m x 21 m in size, we will determine the impacts of all combinations of 3 fire frequencies crossed with either bison grazing or no bison grazing. Half of the plots would be fenced to exclude bison. Survivorship and growth of transplanted oak seedlings, and of prairie species, light availability, fire temperature, and soil moisture and chemistry would be measured each summer to determine the impacts of bison and fire frequency. Pre-treatment measurements of plants and soils will occur during 2017, before the bison are introduced during 2018. This experiment will have the statistical power needed to test our hypotheses and determine the roles of bison and fire in savanna restoration and preservation.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 268,300
Amount Spent: $ 0
Balance: $ 268,3000

Outcome	Completion Date
1. *Experimental fences constructed*	November 2017
2. *Pre-treatment plant and soil sampling completed*	October 2017
3. *Oak seedlings transplanted both inside and outside bison grazing exclosures*	May 2018
4. *Plant and soil sampling completed*	August 2018
5. *Plant and soil sampling completed*	August 2019
6. *Plant and soil data analyzed and results submitted for publication*	May 2020

Activity 2 Status as of January 1, 2018:

Activity 2 Status as of July 1, 2018:

Activity 2 Status as of January 1, 2019:

Activity 2 Status as of July 1, 2019:

Activity 2 Status as of January 1, 2020:

Final Report Summary:

ACTIVITY 3: ***Disseminate results to K-12 students and visitors***
Description:

We propose to inform and educate Minnesotans about the ecological heritage of their state, including the roles that bison, fires and biodiversity play in the functioning of savannas and other Minnesota ecosystems, by providing educational programming for the thousands of K-12 students and other visitors who come to Cedar Creek each year and by creating an accessible viewing area (slightly-elevated wooden deck with insect screening) with educational signs and handouts that is open to the public whenever bison are on-site.

Education programs will be developed to correspond with state and national academic standards, and will incorporate both observational and inquiry-based activities. Observational programs will involve groups

learning about bison adaptations, behavior and diet from trained naturalists, in conjunction with time spent in the viewing area watching the bison move through the landscape. Inquiry-based programs, also led by trained naturalists, will require students to generate hypotheses about the impact of fire and grazing on plant communities, and then either collect data (e.g. measure tree diameter, measure light penetration, estimate tree vs. grass cover) or analyze data previously collected by Cedar Creek scientists that support or reject their hypotheses. All programs will also include information and hands-on activities highlighting the role of large herbivores on the landscape, the historical range and impact of bison in Minnesota, and the importance of bison and fire to indigenous Minnesotans and to land managers working to understand savanna dynamics.

During the months that bison are on site, public outreach programs will also take place. These will involve 'open-house' style events at the viewing platform, where visitors can drop by to observe the bison and interact with trained interpreters, as well as organized tours and activities focused on bison adaptations, impact and historical importance in Minnesota. Results from ongoing research into fire, grazing and oak savannas will be disseminated at these events.

Summary Budget Information for Activity 3:

ENRTF Budget: $ 20,400
Amount Spent: $ 0
Balance: $ 20,400

Outcome	Completion Date
1. *Viewing platform constructed and educational signs displayed*	November 2017
2. *At least 10,000 K-12 students and visitors benefit from educational programming*	May 2020

Activity 3 Status as of January 1, 2018:

Activity 3 Status as of July 1, 2018:

Activity 3 Status as of January 1, 2019:

Activity 3 Status as of July 1, 2019:

Activity 3 Status as of January 1, 2020:

Final Report Summary:

V. DISSEMINATION:
Description:
We will communicate results to the scientific community by submitting approximately two peer-reviewed scientific journal articles for publication. We will communicate findings to the general public by offering education and outreach programs on site. Data will be archived and disseminated via the Cedar Creek website. We will share our publications with land managers at federal and state agencies, including the US Fish and Wildlife Service and the Minnesota Department of Natural Resources, and with private conservation organizations, including The Nature Conservancy.

Status as of January 1, 2018:

Status as of July 1, 2018:

Status as of January 1, 2019:

Status as of July 1, 2019:

Status as of January 1, 2020:

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:
A. Preliminary ENRTF Budget Overview:
***This section represents an overview of the preliminary budget at the start of the project. It will be reconciled with actual expenditures at the time of the final report.**

Budget Category	$ Amount	Overview Explanation
Personnel:	$265,000	1 postdoctoral scholar at 100% FTE for 2 years to lead field data collection and analysis efforts and publish papers ($109,000). 3 undergraduate research assistants during year 1 and 5 undergraduate research assistants during years 2 and 3, each at 25% FTE, to assist with sampling plants and soils ($99,000). 4 temporary employees at 25% FTE during year 1 to install fences and watering facilities ($57,000).
Equipment/Tools/Supplies:	$110,000	Perimeter and interior fencing ($86,000). Bison education viewing area ($16,000). Experiment supplies ($3,600). Education supplies ($4,400).
Other:	$13,000	Lab analyses for soil samples ($8,000). Equipment rental for digging holes for fence posts ($5,000).
TOTAL ENRTF BUDGET:	**$388,000**	

Explanation of Use of Classified Staff: NA

Explanation of Capital Expenditures Greater Than $5,000: NA

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 6.25

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 0

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
	$0	$0	
State			
Indirect costs associated with this project waived by UMN	$207,000	$0	
TOTAL OTHER FUNDS:	**$207,000**	**$0**	

VII. PROJECT STRATEGY:
A. Project Partners:
Partners receiving ENRTF funding
None

Partners NOT receiving ENRTF funding

Dr. David Tilman, Director, Cedar Creek Ecosystem Science Reserve, Regents Professor, University of Minnesota, Project Manager, oversee project

Dr. Forest Isbell, Associate Director, Cedar Creek Ecosystem Science Reserve and Adjunct Assistant Professor, University of Minnesota, Project Manager, supervise work on-site at Cedar Creek Ecosystem Science Reserve

Dr. Caitlin Barale Potter, Education and Outreach Coordinator, Cedar Creek Ecosystem Science Reserve, University of Minnesota, Collaborator, co-lead Activity 3

B. Project Impact and Long-term Strategy:

Our results will guide efforts by state and federal agencies and conservation organizations to restore oak savanna across the state. To maximize what is learned from reintroducing bison to Cedar Creek, we aim to maintain bison grazing as long as possible. The partnership with Northstar Bison makes this financially feasible since they provide and care for the bison each year at no cost to Cedar Creek, thus allowing the project to continue potentially indefinitely. Moreover, we have successfully attracted major federal research funding to Cedar Creek for more than three decades and will seek such funding to continue sampling the bison experiment at the end of the proposed 3 years of LCCMR support.

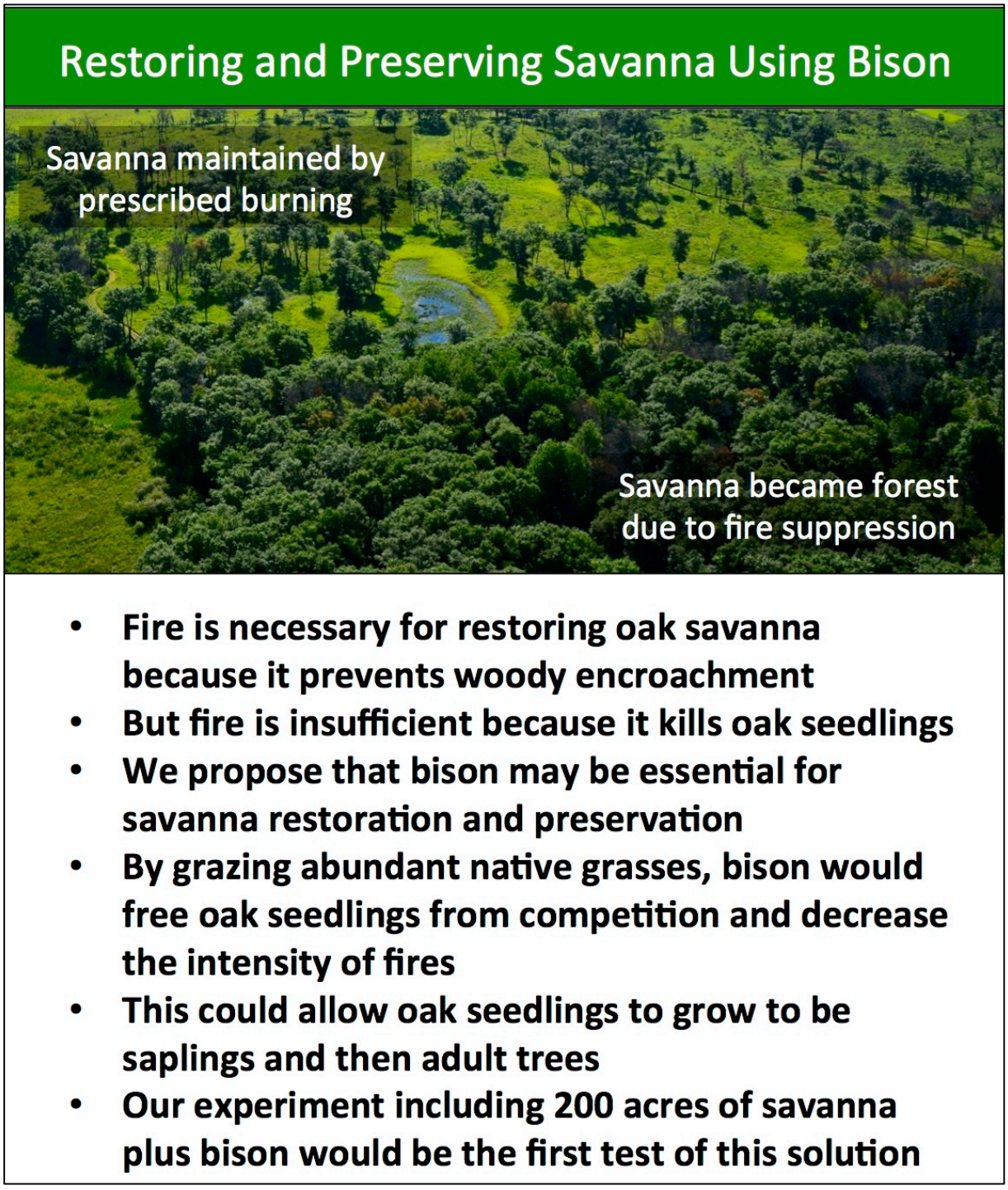
C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	$ Amount
National Fish and Wildlife Foundation- Project ID 99908.05.017860: Grant of cash for savanna restoration	7/2005-7/2008	$55,895
Minnesota Environmental and Natural Resource Trust Fund- ML 2005, first Special Session, Chapt. 1, Art. 2, Sec. 11, Subd. 11(b): Appropriation of cash funds used for savanna restoration	7/2006-6/2008	$141,638

VIII. REPORTING REQUIREMENTS:

- **The project is for 3 years, will begin on 07/01/2017, and end on 06/30/2020.**
- **Periodic project status update reports will be submitted** *July 1* **and** *January 1* **of each year.**
- **A final report and associated products will be submitted between June 30 and August 15, 2020**.

IX. VISUAL COMPONENT or MAP(S):



X. FEE TITLE ACQUISITION/CONSERVATION EASEMENT/RESTORATION REQUIREMENTS: None

Environment and Natural Resources Trust Fund
M.L. 2017 Project Budget

Project Title: Evaluating the Use of Bison to Restore and Preserve Savanna Habitat

Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 08c

Project Manager: David Tilman

Organization: Cedar Creek Ecosystem Science Reserve, University of Minnesota

M.L. 2017 ENRTF Appropriation: $388,000

Project Length and Completion Date: 3 Years, June 30, 2020

Date of Report: September 14, 2016

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	***Restore bison grazing to oak savanna***			***Experimental tests of bison grazing***			***Disseminate results***				
Personnel (Wages and Benefits)	$38,000	$0	$38,000	$227,000	$0	$227,000	$0	$0	$0	$265,000	$265,000
Postdoctoral Scholar, $109,000 (82% salary, 18% benefits), 1(FTE each year for 2 years											
3 Undergraduate Student Summer Field and Lab Assistants during year one and 5 Undergraduate Student Summer Field and Lab Assistants during years two and three, each at 25% FTE, $99,000 (100% salary, 0% benefits)											
4 Temporary and Casual Field Assistant $57,000 (93% salary, benefits), 25% FTE during year one											
Equipment/Tools/Supplies	$58,000	$0	$58,000	$31,600	$0	$31,600	$20,400	$0	$20,400	$110,000	$110,000
Perimeter fencing ($58,000)											
Experimental exclosure fencing ($28,000)											
Experimental supplies ($3,600)											
Bison education viewing area ($16,000)											
Education supplies ($4,400)											
Other	$3,333	$0	$3,333	$9,667	$0	$9,667				$13,000	$13,000
Soil sample lab analyses for total N and C, nitrate, ammonium ($8,000)											
Equipment rental for adding fence posts ($5,000)											
COLUMN TOTAL	**$99,333**	**$0**	**$99,333**	**$268,267**	**$0**	**$268,267**	**$20,400**	**$0**	**$20,400**	$388,000	$388,000