Environment and Natural Resources Trust Fund
2010 Request for Proposals (RFP)

LCCMR ID: 048-B1

Project Title:

Sustainable Biofuels: Impacts of Climate Change and Management

LCCMR 2010 Funding Priority:

B. Renewable Energy Related to Climate Change

Total Project Budget: $ $264,000

Proposed Project Time Period for the Funding Requested: 3 years, 2010 - 2013

Other Non-State Funds: $ $0

Summary:

Determine how climate change, fertilization and irrigation impact yields of grass monoculture and high-diversity prairie biofuel crops, their storage of soil carbon, and susceptibility to invasion by exotic species.

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Sponsoring Organization: Cedar Creek Ecosystem Science Reserve

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Location:

Region: Regional

County Name: Anoka, Isanti

City / Township: East Bethel

_____ Knowledge Base _____ Broad App. _____ Innovation

_____ Leverage _____ Outcomes

_____ Partnerships _____ Urgency _____ TOTAL

MAIN PROPOSAL

PROJECT TITLE: Sustainable Biofuels: Impacts of Climate Change and Management

I. PROJECT STATEMENT

1) We propose to measure variables that are critical for understanding the sustainability, carbon and nitrogen dynamics, and susceptibility to invasion of grassland biofuel ecosystems. Little is known about how global warming (Fig 1), fertilization and irrigation might affect the yields and sustainability of potential native and non-native biofuel crops. Using a warming experiment and a fertilization-irrigation experiment (Figs 2 & 3), we will determine how these factors impact biofuel crops, including monoculture grass crops and high-diversity prairie, and the ecosystem services they provide. We focus on:

- **Biofuel sustainability—**How do warming, irrigation and fertilization impact the yields and sustainability of various grass monocultures and high-diversity prairie mixtures?
- **Carbon sequestration—**Although soils are the largest storehouse of carbon in Minnesota, the net effects that warming, fertilization and irrigation have on soil carbon storage by perennial grassland biofuel crops have not been tested. We will determine these relationships by studying the balance between plant growth and decomposition.
- **Restoration—**If biofuels could make restoring CRP land to diverse prairie profitable, more than a million acres of Minnesota could be so restored. However, it is unclear how the functioning of these prairies might be impacted by the anticipated warming (Fig 1), or by management practices that use intensive fertilization or irrigation.
- **Invasion potential—**We will investigate the as-yet untested concern that climate change or high rates of fertilization or irrigation may increase invasion of biofuel prairies by exotic species. We will also see if *Miscathus*, a non-native species proposed as a biofuel crop, might itself have the potential to invade prairie.

2) We propose to answer these questions by using two well-replicated field experiments – a warming experiment and a fertilization-irrigation experiment – at the Cedar Creek Ecosystem Science Reserve in Anoka and Isanti counties, Minnesota.

Warming: Thirty-eight plots of prairie vegetation containing 1, 4, 16 or 32 plant species (including biofuel species like switchgrass) are each subdivided into three sections and subjected to our actual climate or two levels of warming via infrared heat lamps (+1ºC or +3ºC) for a total of 114 experimental units (Fig 3).

Fertilization-Irrigation: Ninety-six plots will be planted to one of four perennial grassland biofuel crops: switchgrass, *Miscanthus*, diverse prairie (8 species), and highly diverse prairie (32 species). All four crops are under active consideration as biofuels. Plots will receive either no inputs, fertilization, irrigation, or fertilization and irrigation, with 6 replicates of each combination.

3) The fertilization-irrigation experiment builds on current work by interspersing new plots in the same grid as our warming experiment and earlier biofuel work. For the warming experiment, requested funds would expand our ongoing research to include in-depth studies of carbon sequestration, invasion, and sustainability.

II. DESCRIPTION OF PROJECT RESULTS

Result 1: *Effects of Warming and Agricultural Inputs on Biomass Production and Sustainability.* **Budget:** $ 74,000

By comparing biomass yields among our various treatments, we will determine how yield depends on plant diversity (number of planted species), on plant composition (which species are present), on temperature, on fertilization and on irrigation. We will discover if yields of certain species or combinations are harmed or helped by warming, and how diversity is impacted by fertilization and irrigation.

Deliverables
1. Determine the effects of warming on biofuel yields. (July 1, 2013+)
2. Measure of how fertilization and irrigation impact sustainability and plant diversity in high-diversity restored prairie used for biofuel biomass production. (July 1, 2013+)

Result 2: *Warming and Input Effects on Invasions by Exotic Species* **Budget:** $54,500
We will observe which species invade our experimental plots each year to determine how warming, plant diversity, plant composition, fertilization and irrigation impact invasion. In addition, we will study the invasion potential of specific non-native invasive plant species, including *Miscanthus*, by adding seed and seedlings of these species to each plot, and measuring their growth and spread.
Deliverables
1. Find out the effects of warming on invasion, and its dependence on diversity and species composition. (July 1, 2013+)
2. Determine how low- versus high-input biofuel production methods influence the dynamics of invasive species. (July 1, 2013+)

Result 3: *Effects of Warming and Inputs on Soil Carbon* **Budget:** $92,500
The amount of soil carbon stored in or lost from soils depends on the balance between the carbon sequestered through plant growth and the carbon lost through microbial decomposition in the soil. We will determine how warming and low versus high agricultural inputs impacts this balance.
Deliverables
1. Quantify how warming, fertilization and irrigation interact with various single plant species crops or with multispecies mixtures to control carbon soil storage (July 1, 2013+)
2. Communicate these results and their relevance to Minnesota biofuels (July 1, 2013+)

Results 4: *Sustainable Restoration Practices* **Budget:** $43,000
All of these results will be synthesized to find the optimal ways to combine biofuel production, carbon storage, and habitat restoration.

III. PROJECT STRATEGY

A. Project Team/Partners
Dr. David Tilman (Regents' Professor and Director of Cedar Creek Ecosystem Science Reserve, U of M) will lead the research on sustainability and on effects of warming and inputs on invasion by exotic plant species. Dr. Jennifer Powers (Assistant Professor, U of M) will lead work on soil carbon and nitrogen dynamics and will supervise a graduate student and interns. Dr. Clarence Lehman (Adjunct Faculty, U of M) will lead the synthesis of biofuel and restoration sustainability.

B. Timeline Requirements
2008-Spring 2009—Establish infrastructure and begin treatments in 2009.
2010-2013—During the period for which we request funds, we will make field measurements and write scientific manuscripts that report our findings.

C. Long-Term Strategy
The infrastructure of the warming experiment, including buried wiring, circuit boxes, and heat lamps, was established in 2008 with about $120,000 in grant funds from the National Science Foundation. Support from NSF will maintain warming treatments and sampling plant species abundances. The funds requested here are essential to allow the project to study the sustainability, carbon and nitrogen dynamics, and susceptibility to invasion of these grassland biofuel ecosystems.

Project Budget

IV. TOTAL PROJECT REQUEST BUDGET (3 years)

BUDGET ITEM	AMOUNT
Personnel: 2 full-time graduate student research assistants per summer to conduct research under the guidance of PIs. Projected expenses for graduate student will average $8125 ($6500 salary plus $1625 fringe benefits) per student per summer.	$ 49,000
Personnel: 8 full-time undergraduate summer research interns per summer to collect soil samples, harvest and sort plant biomass, maintain experiment, etc. Projected expenses for interns will average $5005 ($4580 salary plus $425 fringe benefits) per intern per summer.	$ 120,000
Personnel: 1 adjunct faculty member (Clarence Lehman) to participate on a part-time basis. Expenses for the research associate are projected to average $9260 ($7000 salary plus $2260 fringe benefits) per year.	$ 28,000
Equipment/Tools/Supplies: Decagon ECH2O Water & Temperature EC-TM Sensors (120)- $140 each Decagon Data Logger Em50R 900 Mz (38)- $675 each (collects sensor data on site) Decagon Collection Base Station DataStation 900 Mz (1)- $650 (compiles logger data) Decagon ECH2O DataTrac, Single License- $300 (software for above)	$ 43,000
Additional Budget Items: Soil C:N analyses- $6720 Plant C:N analyses- $5040 Soil NO3-NH4 analyses- $9510 Soil nitrogen mineralization analyses- $2730	$ 24,000
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$ 264,000

Figure 1) Air temperature trends for Cedar Creek Ecosystem Science. Data show a statistically significant increase in temperature during the past 65 years.

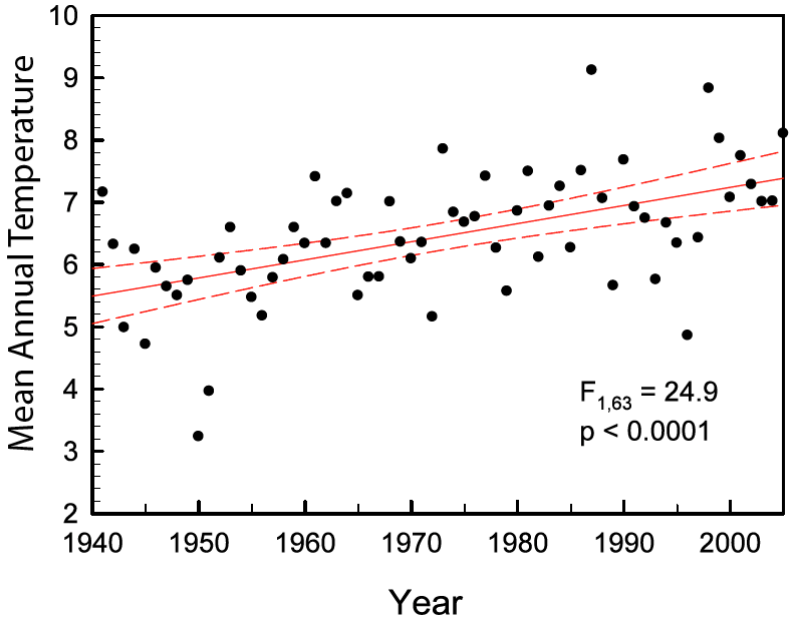
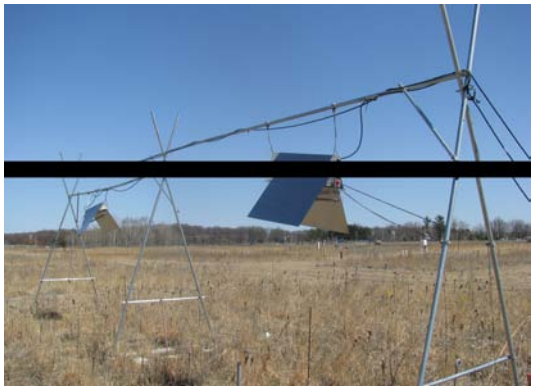


Figure 2) Layout of the existing plots of the warming experiment ("W" shows location of each plot) and of new plots that will be planted to created the new fertilization-irrigation experiment ("M" shows locations that will be used for these "managed" plots) at CCESR.

Figure 3) Warming experiment plot with infrared heat lamps.



Project Manager Qualifications

David Tilman is the Director of the University of Minnesota's Cedar Creek Ecosystem Science Reserve (CCESR). CCESR is a 5400 acre site donated to the University of Minnesota as a place for environmental research. On a typical summer day, more than 100 people, including undergraduate student research interns, graduate students, faculty, and staff, perform their research at CCESR. This research, which focuses on how our habitats and ecosystems are changing under human-caused pressures, is supported by approximately $1.5 million in federal and private foundation grants each year.

After receiving a Ph.D. at the University of Michigan in 1976, David Tilman joined the faculty of the University of Minnesota, where he is now Regents Professor and holds the McKnight University Presidential Chair in Ecology. David Tilman is the lead scientist directing the Long-Term Ecological Research Program at CCESR. He has written two books, edited three others, and published more than 220 scientific papers.

David Tilman is deeply interested in the interface of science, society, ethics and policy. Much of his current work is dedicated to the synthesis and public communication of environmental science. In 1996 he founded the publication *Issues in Ecology* to foster communication among ecologists, the public, and governmental decision makers. He has given over 250 invited talks to both public and academic audiences, and numerous radio, newspaper, magazine, and television interviews. Among other activities, he has served on a White House science advisory panel (the Biodiversity and Ecosystems Panel of the President's Committee of Advisors on Science and Technology – 1997-1998), as a science advisor to Public Radio International (1997-1998), and as an editor for eight different scientific journals. He is currently serving on the National Academy of Sciences' *Nominating Committee*. His honors include Guggenheim Fellow (1984), Pew Scholar in Conservation Biology (1995), the Ecological Society of America's Cooper Award (1989) and MacArthur Award (1996), membership in the National Academy of Science (2002), and the International Prize for Biology from the Japan Society for the Promotion of Science (2008). The Institute for Scientific Information designated him the most widely-read environmental scientist of the past decade (1998-2008).

Organization Description

Cedar Creek Ecosystem Science Reserve is a research station, managed by and funded through the College of Biological Sciences of the University of Minnesota. CCESR's mission is to understand our planet's ecosystems and how they are changing under human pressures.