Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-375

Proposal Title: Water Efficient Perennial Biofuel Grasses for Climate Resiliency

Project Manager Information

Name: Walid Sadok

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Office Telephone: (612) 625-8291

Email: msadok@umn.edu

Project Basic Information

Project Summary: Biofuel crops can boost Minnesota energy independence while protecting natural resources. We will quantify the biofuel potential of four perennial grasses relative to their water, nitrogen requirements and climate resiliency.

ENRTF Funds Requested: $298,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Small Projects (G)
Secondary Category: Energy (E)

Project Location

What is the best scale for describing where your work will take place?
Region(s): Metro

What is the best scale to describe the area impacted by your work?
Region(s): Central, Metro, NE, NW, SE, SW,

When will the work impact occur?
During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Minnesota has long been a leader in bioenergy production. New economic incentives and private investment indicate that sustainable aviation fuel (SAF) production will expand significantly in the next decade in Minnesota and spur promising economic growth. The greenhouse gas reductions from SAF production are largely driven by the types of feedstocks used to create the biofuel. Previous research has shown that perennial grass feedstocks are especially effective at lowering the carbon intensity score of biofuels because they grow at a fast rate, require fewer inputs (nitrogen fertilizer and irrigation) and their roots can sequester carbon in the soil. A new SAF plant is being planned to enter production in Minnesota by 2030 and such infrastructure, along with others, will need local, sustainably produced and climate-resilient feedstock. While perennial grasses offer a unique, versatile and reliable source of feedstock, there are currently no clear options for industry stakeholders in terms of identifying the best MN-adapted perennial grass species that satisfy productivity needs while maximizing environmental protection, and climate resiliency. Our project aims at addressing this challenge by evaluating contrasting but promising perennial grasses in terms of their potential for biofuel production, protecting natural resources (water) and promoting climate mitigation and resiliency.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

To this end, we will evaluate four different perennial grass species: switchgrass (warm-season), big blue stem (warm-season), Canada wild rye (cool season) and intermediate wheatgrass (Kernza®), a naturalized cool-season grass with dual-use potential as a grain crop. This diverse set of species were selected because they are Minnesota-adapted while presenting different physiologies and therefore, distinct potentials for climate resiliency. Furthermore, these species present a spectrum of uses (forage, grain production, ecological restoration) that can add to their bioenergy potential. From an environmental standpoint, each species present numerous ecosystemic services such as soil conservation, nitrogen retention, and improved soil health, in addition to presenting extensive root systems that can act as large carbon sinks.

Our goal is to evaluate these four species for their ability to maximize biomass-biofuel productivity, while minimizing water and nitrogen needs, and maximizing the potential for climate mitigation (carbon capture by roots) and resiliency (adaptation to future simulated climates). An educational goal is to leverage these experiments to provide evidence-based, hands-on, and engaging educational experiences about energy, agriculture and climate change to MN high schoolers. This will be done by hosting training and educational sessions in partnership with the Minnesota Association of Agricultural Educators (MAAE).

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

We expect several positive outcomes from this project. By focusing on biofuel crops, this project seeks boosting the state's reliance on a renewable source of energy.
Furthermore, perennial grasses will be selected to maximize climate change mitigation (biomass production, root carbon sequestration) and resiliency (tolerance to future climate change scenarios) while protecting water resources, by maximizing water use efficiency and minimizing nitrogen needs. Finally, the proposal has a strong educational component by involving future citizens, i.e. high school students, and their educators, in evidence-based, hands-on learning experience on sustainable plant production and climate resiliency, by leveraging the planned experiments.

Activities and Milestones

Activity 1: Comparing seasonal water use efficiency, carbon capture, and SAF biofuel potential as a function of nitrogen application across perennial grasses

Activity Budget: $150,330

Activity Description:
Our goal is to evaluate the seasonal water use efficiency (WUE) and potential for SAF production as a function of nitrogen application of the four bioenergy perennial grasses over the recommended cultivation window (3years). To this end, we will conduct a 3-year experiment in large 80-L wheeled lysimetric bins (mesocosms), in an open-air, outdoor nursery located at the University of Minnesota. Each species will be seeded in 4 replications subjected to three well-watered nitrogen levels (0, 80 and 120 kg/ha equivalent). For each mesocosm, evapotranspiration will be quantified every 2 weeks over the growing season of each year, using a crane system and a high-resolution digital balance available in the Sadok lab (Figure 1). The canopies' ability to fix CO2 will be tracked at the same frequency using a gas exchange system (Figure 2). At the end of each season, aboveground biomass will be harvested, its nitrogen content determined and WUE will be computed as biomass/total water consumed. SAF production will be estimated through NIR-based equations. At the end of the third season, below-ground biomass and its nitrogen content will be quantified destructively to evaluate the carbon and nitrogen sequestration of the root systems of the 4 species.

Activity Milestones:

Description	Approximate Completion Date
Measure seasonal WUE, carbon capture and nitrogen uptake of the four perennial grass species	November 30, 2028
Estimate SAF production from the four perennial grass species	January 31, 2029
Determine nitrogen rate effect on WUE, carbon fixation, and SAF potential of the four grasses	March 31, 2029

Activity 2: Evaluating physiological tolerance, SAF biofuel potential and carbon capture of the four perennial grassess under a simulated climate change scenario

Activity Budget: $123,765

Activity Description:
Our goal is to estimate the climate resiliency of the four species during the three production years. Plants will be grown under a climate scenario predicted to occur across Minnesota's agricultural landscapes over the time horizon of 2050. We will focus on the representative concentration pathway scenario (RCP) 8.5 which projects an average atmospheric CO2 concentration of 541 ppm, while simulating two water availability regimes: 50% field capacity and well-watered. Plants will be grown for 3 years in pots placed in a growth chamber, with a growing season simulated under target temperature, atmospheric CO2 and watering regimes. A parallel experiment will be conducted on the same species with the same water availability regimes but under current CO2 concentrations as a control. During these experiments, whole-plant water use, stomatal conductance, photosynthesis, respiration, canopy temperature, and leaf water potential will be tracked. Changes in cell wall composition and plant anatomy will be quantified using the laser ablation tomography technique. At the end of each year, productivity parameters will include biomass, its potential for SAF production and seasonal WUE. Data analysis will evaluate physiological tolerance and productivity under the imposed climate change scenario for each species relative to the control treatments.

Activity Milestones:

Description	Approximate Completion Date
Determine the physiological tolerance of the four grass species vis-à-vis the simulated climate scenario	May 31, 2029

Determine the effect of simulated climate scenario on biomass and SAF potential for all species	June 30, 2029

Activity 3: Educate Minnesota high schoolers though hands-on science lab on the biology, cultivation and environmental benefits of perennial grasses

Activity Budget: $23,905

Activity Description:

The project offers unique educational opportunities to expose young students to scientific approaches needed to address societal challenges at the nexus of renewable energy, climate resiliency and environmental stewardship. We will work with high school agricultural teachers across Minnesota to design a science lab addressing these questions. We will host a one-day training session at the annual MAAE summer conference during the second week of July at the U of MN's St. Paul Campus (see letter of support). We will prepare lab "kits" that teachers can take to their classrooms. These will contain information needed to run labs which will consist of planting clones of the perennial grass species being investigated and growing them under the outside conditions of their schools for two seasons. At the end of each season (2027 & 2028), students will harvest the plants to measure total aboveground biomass and gather environmental and observational data about plant performance. Data from all high schools will be aggregated and used to create a map of biomass response to climate gradients and discuss what these results mean from a climate resiliency and productivity perspectives. We will also collect student and teacher feedback to evaluate student performance against learning outcomes.

Activity Milestones:

Description	Approximate Completion Date
Host Minnesota Association of Agriculture Educator (MAAE) summer meeting workshop on Saint Paul campus	July 31, 2028
High school teachers launch the lab activity in classrooms across Minnesota	September 30, 2028
Classroom data is collected, analyzed, and shared with all participants and learning outcomes evaluated	January 31, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jacob	Jungers	Co-PI Dr. Jacob Jungers is an Associate Professor of Cropping Systems at the University of Minnesota. His research aims at improving the environmental sustainability of cropping systems using perennial crops. He will provide support/expertise on nitrogen and SAF analyses (Activities 1 and 2), and the outreach effort (Activity 3).	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

We are submitting this proposal as a "small grant" to initiate the first phase of a more comprehensive future study. Based on the findings from this Phase I, we envision Phase II as a multi-year -location field investigation, where biomass/bioenergy productivity, water use efficiency, nitrogen requirements and climate resiliency will be evaluated on larger geographic, precipitation and soil gradients. Phase II will involve bioenergy stakeholders, farmers and ranchers to further identify the best varieties/ecotypes within the top species identified in this investigation. Funding will be requested from federal agencies (e.g. DOE, NSF, USDA) and future LCCMR calls.

Project Manager and Organization Qualifications

Project Manager Name: Walid Sadok

Job Title: Associate Professor

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Walid Sadok is an Associate Professor of Plant Physiology at the Department of Agronomy and Plant Genetics at the University of Minnesota. His core research interest focuses on 1) understanding plant and crop adaptation to abiotic stresses such as drought, heat and freezing and 2) identifying traits leading to improving plant productivity and sustainability under these stresses. His research combines experiments conducted under a range of environmental scenarios imposed in different experimental settings, from the growth chamber to the field. Traits and physiological mechanisms are investigated at a continuum of scales ranging from the plant tissue to the plant population. His research also leverages modeling techniques to understand and predict plant productivity at the landscape/regional/continental levels under current and future environmental scenarios.

Dr. Sadok's research covers a wide variety of plants including aquatic grasses (reeds), perennial grain grasses (e.g., intermediate wheatgrass), forage crops, turfgrass species, and annual crops such as wheat, barley, oats, soybean and corn. His work led to developing high-throughput lysimetric screening methods, identifying key stress tolerance traits, and superior genotypes/ ecotypes that are currently being used in various breeding and management programs across the globe. Dr. Sadok has published extensively on these topics in 57 scientific peer-reviewed scientific papers.

Dr. Sadok is involved in teaching and educational outreach, as an instructor to two plant physiology courses and a coordinator of the Plant Science Major and the Sustainable Agriculture Minor. In this project, Dr. Sadok will leverage the above skills and expertise to oversee the three proposed activities, particularly the outdoor mesocosm lysimetric experiment (Activity 1), the climate simulator experiment with manipulated water and CO_2 conditions (Activity 2) and provide teaching/outreach expertise for the educational part of the project (Activity 3). He will also co-supervise a graduate student and help acquire physiological data.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:

The project will be conducted in the premises of the College of Food, Agricultural and Natural Resource Sciences (CFANS), at the Saint Paul campus of the University of Minnesota. The college's mission is to "advance Minnesota as a global leader in food, agriculture, and natural resources through extraordinary education, science-based solutions, and dynamic public engagement that nourishes people and enhances the environment in which we live". The proposed project is part of a large, college-wide initiative rooted in the above-stated mission with the goals of 1) creating science-based solutions, 2) grow Minnesota's economy, and 3) teach tomorrow's leaders, all of which are captured in the three proposed activities. The two investigators are also part of the Department of Agronomy and Plant Genetics, a unit of the college with a core mission of producing food/feed/bioenergy sustainably while protecting the environment. The department is a leader in develping new perennial crops that promote the energy independence of the state while protecting its water, soil and other natural resources.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Principal investigator summer salary and fringe		PI Sadok will oversee the project, supervise the graduate student, provide plant physiology expertise in Activities 1 and 2, help conduct physiology measurements and provide teaching expertise in Activity 3.			36.6%	0.24		$49,277
Co-principal investigator summer salary and fringe		Co-PI Jungers will co-supervise the graduate student and technician, provide expertise on nitrogen and SAF analyses (Activities 1 and 2), and teaching expertise in Activity 3.			36.6%	0.06		$13,005
Graduate research assistant salary and fringe		The graduate research assistant will lead the experiments of Activities 1 and 2 and provide support for Activity 3. The student will conduct measurements, analyze the data and draft reports and papers.			23.2%	1.5		$120,622
Research technician salary and fringe		Technician (Jungers Lab) will manage plant harvests and processing to determine dry mass and nitrogen content of plant samples at the end of each season for Activities 1 and 2.			32.3%	0.21		$18,892
Undergraduate student salary and fringe		The student will assist the graduate student in setting up experiments, planting, watering, plant husbandry, assisting with crane system use for lysimetric measurements, gas exchange measurements, and collecting environmental data.			7.4%	0.24		$10,234
Graduate research assistant tuition		The graduate research assistant will lead the experiments of Activities 1 and 2 and provide support for Activity 3. The student will conduct measurements, analyze the data and draft reports and papers.			0%	1.5		$48,108
							Sub Total	**$260,138**
Contracts and Services								
Jungers lab	Internal services or fees (uncommon)	Above- and below-ground sample drying, grinding and NIR measurements costs (Activities 1 and 2). 80 above-ground samples/year and 80 below-ground samples at termination in year 3.				0.06		$6,800

Penn State University's Laser Ablation Tomography Facility	Service Contract	Plant samples (96) will be processed by the laser ablation tomography facility in order to quantitfy changes in cell wall composition and anatomy of plant tissues under current and simulated future climate (Activity 2).				0.03		$2,304
Minnesota Agricultural Experiment Station (MAES)	Internal services or fees (uncommon)	1 acre of MAES space rental fee where mesocosms will be placed (Activity 1).				0.03		$825
University of Minnesota Plant Growth Facilities	Internal services or fees (uncommon)	Rental fees of two adjacent growth chambers where plants will be grown under current and future climate scenarios each year (Activity 2).				0.09		$14,400
							Sub Total	**$24,329**
Equipment, Tools, and Supplies								
	Tools and Supplies	NIR bulbs, bags, grinder materials, dusk masks, safety glasses, gloves, gas exchange system supplies (desiccant, capillaries, CO2 cartridges), custom-made PVC pots.	Consumables needed for operating equipment, for storing/ processing samples, planting, and for protection.					$2,500
	Tools and Supplies	CO2 enrichment kit: tank, CO2 regulator, CO2 monitor and controller, tubing.	This kit is needed to ensure CO2 treatments are imposed correctly in the growth chamber.					$2,633
	Tools and Supplies	CO2 gas supply.	Continuous CO2 supply over the growing season is needed for conducting the climate simulation studies in the growth chamber.					$4,500
							Sub Total	**$9,633**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								

	Miles/ Meals/ Lodging	Four trips to high schools for 2-3 people.	Visit with high schools to discuss their findings in labs associated with Activity 3					$400
							Sub Total	**$400**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	One trip to attend a 4 or 5 day US-based conference for the graduate student. Costs include airfare, conference lodging, conference registration, and per-diem.	Travel costs to present research findings in a US conference (Crop Science Society of America or American Society of Plant Biologists Annual Meetings). Presentation is guaranteed in each one of these conferences, at minimum as a poster, otherwise as a talk.	X				$2,500
							Sub Total	**$2,500**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Costs of hosting a 1-day workshop to be attended by attendees from the Minnesota Association of Agriculture Educators summer conference in years 2 and 3.	Costs will cover beverages, snacks and meals over the course of the day.					$1,000
							Sub Total	**$1,000**
							Grand Total	**$298,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	One trip to attend a 4 or 5 day US-based conference for the graduate student. Costs include airfare, conference lodging, conference registration, and per-diem.	This expense is to attend major US-based conferences that typically host large (several thousand) attendees from across the globe. These conferences are unique platforms for disseminating our results to the widest audience possible. Presentation is guaranteed in each one of these conferences, at minimum as a poster, otherwise as a talk. These conferences also present unique opporunities for networking to generate collbarations for future grant proposals.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $298,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: e675185e-b6a.pdf

Alternate Text for Visual Component

Images depicting the lysimetric system developed to quantify seasonal water use of perennial grasses (Fig .1, Activity 1) and the gas exchange system that will be used to measure non-destructively gas exchange parameters (photosynthesis,stomatal conductance, transpiration, respiration) on the four perennial grasses (Fig. 2, Activities 1 and 2)....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
U of MN Board Resolution Letter	978b9f6c-524.pdf
Support Letter and Figures	22409c15-b9a.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care,

treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Kelsey Grachek, Senior Grants and Contracts Officer, U of MN Sponsored Projects Administration

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Yes, I understand