# Environment and Natural Resources Trust Fund

2023 Request for Proposal

## General Information

**Proposal ID:** 2023-130

**Proposal Title:** Capturing Carbon Dioxide as Simple Sugars

## Project Manager Information

**Name:** Brett Barney

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

**Office Telephone:** (612) 626-8751

**Email:** bbarney@umn.edu

## Project Basic Information

**Project Summary:** Our project seeks to incentivize the capture of carbon dioxide from industrial or atmospheric sources by converting it into simple sugars that will be transformed into a new crop.

**Funds Requested:** $240,000

**Proposed Project Completion:** June 30, 2025

**LCCMR Funding Category:** Air Quality, Climate Change, and Renewable 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?**

Statewide

**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.**

The increase in carbon dioxide to the atmosphere represents a significant problem that will impact future generations for the foreseeable future. It also represents an opportunity, as nations across the globe recognize that novel processes with the potential to capture carbon must be further investigated. Our laboratory is investigating a small selection of algae that naturally accumulate simple sugars, similar to sucrose, through the natural biological process of photosynthesis. Importantly, these algae concentrate the sugars outside of the algal cell. This means that unlike sugar beet or sugarcane crops, the algal sugars can be continually harvested and the algae reused, without having to grow additional algae. Our laboratory has identified several strains of algae that are well suited for this purpose. Studies will be performed to determine optimal conditions to grow and maintain these cultures while continually harvesting the sugars that they produce, yielding a new product with high value that can be sold to supplement processing costs.

**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.**

We will construct a pilot-scale bioreactor system for the continual culture of sugar secreting algae and the continuous separation and concentration or utilization of the sugars that are generated. While these algae have been demonstrated to accumulate high concentrations of sugar, the ability to culture for extended periods of time, or concentrate and recycle the algae while harvesting the sugar requires further investigation and development. These opportunities will be investigated through a series of iterative design and testing stages to determine the economic and technological hurdles that must be overcome to scale-up this technology.

**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?**

Carbon generation and accumulation in the atmosphere through anthropogenic processes represents the single largest atmospheric pollutant generated by humankind. The full potential environmental and economic impacts to Minnesota and the entire planet remain unknown. Algae have been hailed as a potential solution to mitigate these atmospheric carbon levels and capture carbon in various forms. Barriers to successful application of algal technologies include costs associated with harvest and extraction of various products, including fuels. Our project will protect, preserve and enhance this natural resource by converting carbon dioxide into sugars that can be sold as a new cash crop.

## Activities and Milestones

### Activity 1: Continual Culture of Algae and Separation of Simple Sugars

**Activity Budget:** $240,000

**Activity Description:**

Our primary activity for this project is the design, operation and testing of a pilot bioreactor system for the continual capture of carbon in the form of simple sugars. Our laboratory builds custom algal bioreactors that can be operated autonomously for many months with minimal intervention required. We will incorporate additional technologies into these reactor systems to grow them under natural sunlight. Methods to separate the algae from the media using ultrafiltration membranes or centrifugal separation will be tested, and technologies to further concentrate the sugars and recycle the water will include reverse osmosis. Additional technologies to minimize required energy inputs to operate the reactors will also be explored.

**Activity Milestones:**

| Description | Completion Date |
|---|---|
| Construct 100 Liter Continuous Algal Culture System for Outdoor Testing. | June 30, 2024 |
| Incorporate Algal Cell Recycle and Separation for Sugar Rich Culture Media. | December 31, 2024 |
| Incorporate Additional System Enhancements to Minimize Operational Energy Costs.. | June 30, 2025 |

## 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?**

This project is based on research related to a small, and highly understudied group of algae that accumulate simple sugars as part of a natural symbiosis with other microbes and potentially, with certain ocean and freshwater corals. Much work has been accomplished related to proof of concept for this area of study, but the next step is to demonstrate that additional hurdles to accumulate and process the sugars obtained from these algae can be overcome. Successful demonstration of this technology will entice additional private and industrial partners to invest in further improvement and implementation.

## Other ENRTF Appropriations Awarded in the Last Six Years

| Name | Appropriation | Amount Awarded |
|---|---|---|
| Transformation of Plastic Waste into Valued Resource | M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04j | $225,000 |

## Project Manager and Organization Qualifications

**Project Manager Name:** Brett Barney

**Job Title:** Associate Professor and Director

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

Dr. Brett Barney (Project Manager) received his PhD in 2003. He spent six years in the medical device manufacturing sector, and another six years as a postdoctoral fellow and project manager. He has been a professor with the Department of Bioproducts and Biosystems Engineering and a member of the Biotechnology Institute at the University of Minnesota since 2009. He has been the Director of the Microbial and Plant Genomics Institute since 2020. The Bioproducts and Biosystems Engineering Department serves as a core department combining Agricultural Engineering, Biological Engineering and Environmental and Ecological Engineering. The University of Minnesota provides a range of facilities and sufficient laboratory space to perform each of the activities described in this proposal. Additionally, controlled environments including greenhouse space sufficient for this work is conveniently located in close proximity to Dr. Barney's laboratory space.

Dr. Barney's laboratory is focused on minimizing the environmental impacts associated with biofuels and agriculture, and finding innovative methods to remove airborne contaminants from the atmosphere, including novel ways to trap carbon and convert it into a valuable resource. Dr. Barney has 30 years of experience in both basic and applied research in both academia and industry, including experience managing projects and laboratories in a range of settings. Previous research funding has come from the National Science Foundation (NSF), the United States Department of Agriculture (USDA), the United States Department of Energy (DOE), the Defense Advanced Research Projects Agency (DARPA), the Legislative-Citizen Commission on Minnesota Resources (LCCMR), Minnesota's Discover, Research and InnoVation Economy (MnDRIVE) and the Initiative for Renewable Energy and the Environment (IREE).

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

**Organization Description:**

The University of Minnesota (UMN) was founded in 1851, and is the state's primary research university. UMN is the land-grant university in Minnesota, with strong ties to agriculture, medicine, science, engineering and the arts. UMN has

a strong tradition of education and public service, with faculty of national and international reputation. UMN is an R1 Research Institution, and ranks among the nations top 10 public research universities, as assessed by the National Science Foundation's Higher Education Research and Development survey (HERD). The UMN Sponsored Projects Administration (SPA) is the entity authorized by the Board of Regents to manage project agreements with the LCCMR program.

## Budget Summary

| Category / Name | Subcategory or Type | Description | Purpose | Gen. Ineligible | % Benefits | # FTE | Classified Staff? | $ Amount |
|---|---|---|---|---|---|---|---|---|
| **Personnel** | | | | | | | | |
| Brett Barney | | Principal Investigator, one week of summer support for two years of the project duration. | | | 33.5% | 0.04 | | $15,000 |
| Graduate Research Assistant | | Research Assistant, Performing Laboratory Experiments and Data Analysis, supervised by the project manager | | | 23.6% | 1 | | $107,000 |
| Undergraduate Research Assistants | | Research Assistants for Laboratory Experiment and Bioreactor Data Collection, supervised by the project manager and graduate student. | | | 0% | 1 | | $61,000 |
| | | | | | | | **Sub Total** | **$183,000** |
| **Contracts and Services** | | | | | | | | |
| | | | | | | | **Sub Total** | - |
| **Equipment, Tools, and Supplies** | | | | | | | | |
| | Tools and Supplies | Non-Capitalized Lab Scientific or Field Supplies | Laboratory Supplies: General Laboratory Chemicals, Media, Reagents and Safety Materials for Students, including Gloves ($400 per month) and Kits for Performing Routine Molecular Biology ($100 per kit), Analytical Reagents ($300 per month), Liquid Nitrogen for Strain Storage ($400 per year). | | | | | $24,000 |
| | Tools and Supplies | Non-Capitalized Lab Scientific or Field Equip | Bioreactor components and parts to operate continuous reactor system (Fabricated components, culture vessel, Reactor components, air and water pumps, monitoring equipment, microprocessors). | | | | | $30,000 |
| | | | | | | | **Sub Total** | **$54,000** |
| **Capital Expenditures** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Sub Total** | **-** |
| **Acquisitions and Stewardship** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Travel In Minnesota** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Travel Outside Minnesota** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Printing and Publication** | | | | | | | | |
| | Publication | Publications of two papers in Scientific and Engineering Journals | Many engineering journals have charges associated with publications, generally around $1500 per journal. | | | | | $3,000 |
| | | | | | | | **Sub Total** | **$3,000** |
| **Other Expenses** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| | | | | | | | **Grand Total** | **$240,000** |

## Classified Staff or Generally Ineligible Expenses

| Category/Name | Subcategory or Type | Description | Justification Ineligible Expense or Classified Staff Request |
|---|---|---|---|

## Non ENRTF Funds

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

## Attachments

### Required Attachments

*Visual Component*

File: 38c62eb4-89c.pdf

*Alternate Text for Visual Component*

Novel Algae Accumulate Simple Sugars when provided with Carbon Dioxide and Sunlight....

### Optional Attachments

*Support Letter or Other*

| Title | File |
|---|---|
| Audited Financial Statements | 0496a4fe-8ab.pdf |
| Institutional Approval for Submission | d8b535d0-99e.pdf |

## Administrative Use

**Does your project include restoration or acquisition of land rights?**

No

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

Yes

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

Yes

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

No

**Does your project include original, hypothesis-driven research?**

Yes

**Does the organization have a fiscal agent for this project?**

No

# Capturing Carbon Dioxide as Simple Sugars