



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-141

Proposal Title: Measuring Enhanced Greenhouse Gas Capture by Restored Peatlands

Project Manager Information

Name: Mark Green

Organization: U of MN - Duluth - NRRRI

Office Telephone: (218) 788-2694

Email: mgreen@umn.edu

Project Basic Information

Project Summary: This project would build upon ongoing work to quantify the effect of peatland restoration in northern Minnesota on enhancing greenhouse gas capture by focusing on more heavily degraded peatlands.

ENRTF Funds Requested: \$1,164,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Resiliency (A)

Project Location

What is the best scale for describing where your work will take place?

Region(s): NE

What is the best scale to describe the area impacted by your work?

Region(s): NE

When will the work impact occur?

In the Future

Narrative

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

Minnesota contains over 6 million acres of peatlands - the most extensive in the contiguous United States. These waterlogged ecosystems are globally significant carbon sinks, storing billions of tons of carbon. However, human disturbances, particularly historical ditching and drainage for agricultural conversion, threaten to transition these landscapes into major sources of greenhouse gas (GHG) emissions. Lowering the water table exposes carbon-rich peat to decomposition, driving substantial carbon dioxide and nitrous oxide releases. In Minnesota, drained peatlands are a significant source of GHGs lost to the atmosphere.

Despite this recognized threat, a critical knowledge gap remains regarding the precise magnitude of these emissions across varying states of peatland degradation and hydrology. The complex tradeoff between carbon dioxide emissions from drainage and methane emissions from inundation is poorly constrained for this region. We lack accurate, state-specific emissions factors that account for agricultural impacts and other land uses that impact GHG emissions - and how they can be mitigated with restoration. This data deficit limits the ability of policymakers and land managers to evaluate the true climate costs of land-use change or to strategically prioritize degraded areas for ecological restoration.

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 propose a monitoring and modeling project to isolate the drivers of peatland GHG emissions and generate robust, regionally specific information about GHG capture. Our solution bridges localized, high-frequency field measurements with landscape-level remote sensing.

First, we will establish a comprehensive baseline of GHG fluxes and hydrology. We will utilize six existing eddy covariance towers (field scale) and chamber (plant scale) arrays, paired with a continuous groundwater well network, to monitor GHG fluxes and water table dynamics. This work will build on the three-year record starting in 2023 with the UMN's three established sites with towers at Sax-Zim bog in addition to adding 3 restored peatland sites established by NRRRI in 2025. To directly quantify the impact of contemporary farming practices on these GHG fluxes, we will conduct a controlled agricultural experiment on a targeted peatland site.

To translate these localized measurements into regional tools, we will integrate remote sensing of water table dynamics, enabling us to map spatial variations in hydrology and upscale our site-level understanding, identifying the broad-scale extent of areas amenable to restoration. Finally, we will synthesize these empirical datasets to parameterize models, forecasting GHG capture across varying peatland conditions to aid targeting of restoration activities.

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?

This project directly enhances the conservation and restoration of Minnesota's critical peatland resources. By delivering highly accurate, State-specific information about GHG capture, we will provide State agencies and land managers with the data needed to quantify the climate benefits of peatland preservation and restoration. Furthermore, our upscaled hydrological maps will pinpoint degraded areas with the highest potential for successful restoration. Ultimately, this actionable framework empowers policymakers to strategically prioritize conservation investments, incentivize sustainable land-use practices, and protect these vital ecosystems from further degradation, ensuring long-term climate resilience for the state.

Activities and Milestones

Activity 1: Monitor productivity and greenhouse gas fluxes from degraded peatlands

Activity Budget: \$423,000

Activity Description:

We will monitor carbon dioxide, methane, and nitrous oxide exchange between peatlands and the atmosphere in peatlands of various levels of degradation across northeastern Minnesota. This will leverage equipment purchased through a previous LCCMR study (Lenhart and others, 2023) and by NRRI that makes these measurements with small towers continuously and small chambers for spatially extensive spot measurements. Chamber measurements will be conducted on over one hundred locations that vary in their hydrology, vegetation, peat characteristics, and land use. The continuous measurements from the towers allow us to assess how environmental conditions control greenhouse gas emissions. We will monitor for three years, capturing year-to-year variation so that we can better understand how greenhouse gas fluxes from these peatlands respond to varying precipitation and air temperature. In addition, we will experimentally manipulate plots within a NRRI-owned peatland by conducting small-scale agricultural activities and quantify how agricultural land uses alter greenhouse gas fluxes. The activities will include growing hay or sod and entail fertilizer application.

Activity Milestones:

| Description | Approximate Completion Date |
|---|-----------------------------|
| Measure continuous carbon dioxide and methane fluxes at six peatlands in northern MN | November 30, 2029 |
| Measure the spatial variation of greenhouse gas fluxes to understand land use and environmental controls | November 30, 2029 |
| Characterize vegetation, hydrology, peat characteristics, and land use history at chamber measurement sites | November 30, 2029 |
| Conduct agriculture experiment on a peatland to directly assess the impact on greenhouse gas fluxes | November 30, 2029 |

Activity 2: Monitor the water table at sites where greenhouse gas fluxes are measured with remote sensing

Activity Budget: \$355,000

Activity Description:

We will quantify the variability in the water table across the northern Minnesota study area using a network of groundwater wells equipped with automated, continuous data loggers. Colocated with our six eddy covariance towers and chamber arrays, these loggers will capture high-resolution temporal changes in water table depth. This localized, continuous hydrologic monitoring is critical for establishing the baseline relationship between soil saturation and greenhouse gas fluxes. It will allow us to isolate the impacts of peatland hydrology and on productivity and GHG emissions.

To scale these localized hydrologic measurements to the landscape level, we will integrate synthetic aperture radar (SAR) data from NASA's NISAR mission (launched in 2025) and ESA's Sentinel-1 (launched in 2015). By calibrating The SAR high-resolution observations of surface inundation and soil moisture/water table with our in-situ well network, we can accurately map spatial variations in peatland hydrology. This remote sensing approach enables us to upscale our site-level understanding of greenhouse gas dynamics across northern Minnesota. Ultimately, this spatial extrapolation will be critical for identifying the broad-scale extent of degraded areas that are most amenable to targeted restoration.

This will help inform the optimal water levels for reducing GHG emissions in managed peatlands.

Activity Milestones:

| Description | Approximate Completion Date |
|--|-----------------------------|
| Evaluate water table height dynamics within the flux tower footprints | November 30, 2029 |
| Remotely sense water table variability at GHG monitoring sites, including within tower areas | November 30, 2029 |
| Assess water table dynamics across northeastern Minnesota with remote sensing to help prioritize restoration | June 30, 2030 |
| Evaluate remotely sensed water table variation by comparing with long-term Marcell Experimental Forest data | June 30, 2030 |

Activity 3: Synthesize greenhouse gas and water table monitoring data to predict emissions factors for peatlands of varying conditions**Activity Budget:** \$342,000**Activity Description:**

To translate our localized measurements into robust predictive tools, we will develop both empirical and mechanistic models to estimate greenhouse gas (GHG) emissions factors across a spectrum of peatland states. We will synthesize our high-frequency eddy covariance and chamber flux datasets with continuous water table records and agricultural treatment data. First, empirical models will be constructed to define the statistical relationships between primary environmental drivers, specifically hydrologic fluctuations and agricultural interventions, and resulting GHG fluxes. Next, we will parameterize process-based mechanistic models using these site-specific datasets to simulate the underlying dynamics governing carbon dioxide and methane production and transport. By validating these models against our multi-scale observations, we will generate highly accurate, state-specific emissions factors. This synthesis will ultimately allow us to forecast the GHG impacts of land-use conversion and evaluate the climate mitigation potential of future restoration strategies across northern Minnesota.

Activity Milestones:

| Description | Approximate Completion Date |
|--|-----------------------------|
| Estimate emission changes with land use changes on degraded peatlands | June 30, 2030 |
| Assess the most important landscape characteristics that influence GHG emissions | June 30, 2030 |
| Determine the environmental variables that control the temporal variability of GHG emissions | June 30, 2030 |
| Predict how drought will alter GHG emissions in different peatland landscapes | June 30, 2030 |

Activity 4: Monitor water quality in waters from restored peatlands**Activity Budget:** \$44,000**Activity Description:**

We will monitor water quality including nutrients, suspended solids, and mercury in waters draining the peatlands where we are monitoring greenhouse gases. Peatland restoration can have mixed effects on water quality conditions so collecting new data from peatlands ranging from pristine to having an agricultural land use history will help fully assess how restoration impacts water quality.

Activity Milestones:

| Description | Approximate Completion Date |
|---|-----------------------------|
| Collect and analyze water quality samples from restored peatlands | November 30, 2029 |

Project Partners and Collaborators

| Name | Organization | Role | Receiving Funds |
|-----------------------------------|---------------------------------------|---|-----------------|
| Chris Lenhart and Timothy Griffis | University of Minnesota - Twin Cities | Co-Investigators | Yes |
| Mark Felice | The Nature Conservancy | Chamber-based greenhouse gas measurement lead | Yes |
| Laura Bourgeau-Chavez | Michigan Technical University | Remote sensing lead | Yes |

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.

We will share our results with State agencies through meetings with staff scientists and through participation in scientific meetings within the State. We will also share all of our data in public data repositories to optimize the dissemination of our data for other uses. Finally, we will publish peer-reviewed papers so that natural resources managers can use our science in formal documented decisions about how to manage restored peatlands in Minnesota.

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 work is a second phase of monitoring that was funded by the LCCMR in 2023 (Dr. Chris Lenhart was the lead PI) to understand the restoration of drained peatlands. We have added three sites to this original effort using resources from NRRI. The infrastructure that we have implemented will allow us to seek additional resources from science and management agencies within the State and federally to continue this effort beyond the life of the proposed project. We have additional resources at NRRI to maintain monitoring of our restored peatlands to understand how their restoration responds over the long-term.

Project Manager and Organization Qualifications

Project Manager Name: Mark Green

Job Title: Research Associate

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

Dr. Green has managed over \$3 million in research projects that monitor and generate management-relevant understanding of water and land resources within the U.S.

Organization: U of MN - Duluth - NRRI

Organization Description:

The Natural Resources Research Institute is a state-chartered applied research institute of the University of Minnesota's Research and Innovation Office. NRRI maintains three sites in Northern Minnesota, focused on informing sound, long-term decisions on the use and stewardship of natural resources.

NRRI Fens is a 425-acre property near Zim, Minnesota, was acquired in 1986 to restore its function as a valuable

peatland and fens bog after being drained in the 1950s for farmland. Decades of effort have restored the peatland - nature's most effective carbon sequestration solution - and the restoration credits were sold to state agencies. Ongoing research on the site will continue to inform successful peatland restorations across the nation.

Budget Summary

| Category / Name | Subcategory or Type | Description | Purpose | Gen. Ineligible | % Benefits | # FTE | Classified Staff? | \$ Amount |
|---------------------------------|---------------------|-----------------------------|---------|-----------------|------------|-------|-------------------|------------------|
| Personnel | | | | | | | | |
| Dr. Mark Green | | Principal Investigator | | | 26.8% | 0.75 | | \$125,971 |
| Dr. Christopher Lenhart | | Co-Principal Investigator | | | 26.8% | 0.48 | | \$63,063 |
| Dr. Amber Ulseth | | Co-Principal Investigator | | | 26.8% | 0.51 | | \$72,674 |
| Dr. Timothy Grffis | | Co-Principal Investigator | | | 26.8% | 0.15 | | \$42,174 |
| Dr. Shubham Aggarwal | | Greenhouse gas flux modeler | | | 20.7% | 0.42 | | \$30,119 |
| Caleb Hammer | | Field technical support | | | 24.4% | 0.3 | | \$26,122 |
| Emily Deering | | Field technical support | | | 24.4% | 0.21 | | \$22,059 |
| Robert Hell | | Field technical support | | | 24.4% | 0.75 | | \$81,156 |
| Holly Wellard Kelly | | Field technical support | | | 24.4% | 0.24 | | \$24,819 |
| Kari Pierce | | Field technical support | | | 24.4% | 0.51 | | \$50,723 |
| Brennan Pederson | | Field technical support | | | 24.4% | 0.75 | | \$57,053 |
| Undergraduate Researcher, NRR1 | | Field technical support | | | 0% | 0.06 | | \$1,980 |
| Seasonal Field Technician, NRR1 | | Field technical support | | | 7.4% | 0.06 | | \$3,507 |
| Graduate Student | | Data analysis and synthesis | | | 19.5% | 0.22 | | \$26,059 |
| Undergraduate Researcher, BBE | | Data analysis | | | 0% | 0.27 | | \$10,127 |
| | | | | | | | Sub Total | \$637,606 |
| Contracts and Services | | | | | | | | |

| | | | | | | | | |
|---------------------------------------|--------------------|---|---|---|--|------|------------------|------------------|
| TBD | Service Contract | Microbial analysis of microbes for methane and CO2 emissions | | | | 0 | | \$14,000 |
| Michigan Technological University | Subaward | Peat hydrologic remote sensing. Michigan Tech will be requesting \$214,710 in salary and fringes for 7 personnel, and \$10,173 in supplies for PCI geomatics radar remote sensing software licenses, AWS storage, AWS compute costs, AWS data transfer costs, and miscellaneous supplies. | | X | | 2.25 | | \$224,883 |
| The Nature Conservancy | Subaward | Greenhouse gas monitoring. Their budget consists of \$63,413 in personnel time, \$22,230 in travel, and \$7,336 in supplies, including supplies needed for setup of experimental measurements at peatland sites, gas flux collars, wells, pressure transducers, soil moisture/temperature probe, and sphagnum donor material. | | | | 0.75 | | \$92,979 |
| | | | | | | | Sub Total | \$331,862 |
| Equipment, Tools, and Supplies | | | | | | | | |
| | Tools and Supplies | We are requesting field supplies, including water table recorders and general supplies for field measurements. | In order to accurately measure water table heights, we will need these instruments. These data will also provide basic data for comparison with remotely sensed water tables. | | | | | \$40,567 |
| | Equipment | Replacement equipment and repair gear | For sampling soil for microbe analysis and water sample collection | | | | | \$3,000 |
| | Tools and Supplies | Water Level Loggers | This is for purchase of 7 water level data loggers from Solinst | | | | | \$4,000 |
| | Equipment | Flux Tower Replacement parts | Replacement and repair of parts for flux towers, related cables and attachments | | | | | \$16,000 |
| | | | | | | | Sub Total | \$63,567 |
| Capital Equipment | | | | | | | | |
| | | We request \$92,000 for a nitrous oxide gas analyzer to allow us to measure the fluxes of nitrous oxide from peatland soils. | Nitrous oxide lost from peatlands to the atmosphere can be a significant greenhouse gas, so this instrument will allow us to measure these fluxes. | X | | | | \$92,000 |
| | | | | | | | Sub Total | \$92,000 |

| | | | | | | | | |
|-------------------------------------|-----------------------|---|--|--|--|--|--------------------|--------------------|
| Acquisitions and Stewardship | | | | | | | | |
| | | | | | | | Sub Total | - |
| Travel In Minnesota | | | | | | | | |
| | Miles/ Meals/ Lodging | We are budgeting 52 visits to the field sites per year for the field team, and three visits to the Twin Cities for the two scientists to work with collaborators on data synthesis. | The team will need to travel to field sites often to measure greenhouse gas fluxes. The project leadership team will also need to travel to the Twin Cities to meet with other researchers working with the State or at the University of Minnesota. | | | | | \$16,465 |
| | Miles/ Meals/ Lodging | 10 trips per year x 300 = 3,000 x 3 = 9,000 | We will need to attend meetings in the State to share our results and learn about other research that is relevant for our project success. | | | | | \$9,000 |
| | | | | | | | Sub Total | \$25,465 |
| Travel Outside Minnesota | | | | | | | | |
| | | | | | | | Sub Total | - |
| Printing and Publication | | | | | | | | |
| | Publication | We request \$6,000 to support two publication of our results. | Producing peer-reviewed publications will be important to support managers who will implement peatland restoration activities. | | | | | \$6,000 |
| | Publication | Publication Fees | The cost to publish articles | | | | | \$3,000 |
| | | | | | | | Sub Total | \$9,000 |
| Other Expenses | | | | | | | | |
| | | Shipping Costs | Shipping of Hg samples: shipping mercury samples from water | | | | | \$4,500 |
| | | | | | | | Sub Total | \$4,500 |
| | | | | | | | Grand Total | \$1,164,000 |

Classified Staff or Generally Ineligible Expenses

| Category/Name | Subcategory or Type | Description | Justification Ineligible Expense or Classified Staff Request |
|---|---------------------|---|---|
| Contracts and Services - Michigan Technological University | Subaward | Peat hydrologic remote sensing. Michigan Tech will be requesting \$214,710 in salary and fringes for 7 personnel, and \$10,173 in supplies for PCI geomatics radar remote sensing software licenses, AWS storage, AWS compute costs, AWS data transfer costs, and miscellaneous supplies. | The hydrologic remote sensing team at Michigan Tech is so highly advanced in this field that working them will cost much less than comparable teams in Minnesota, thus the project will be much more efficient by working with Michigan Tech. |
| Capital Equipment | | We request \$92,000 for a nitrous oxide gas analyzer to allow us to measure the fluxes of nitrous oxide from peatland soils. | Nitrous oxide is a potent greenhouse gas that is emitted from agricultural peatland soils. We need this instrument to be able to quantify those fluxes. Additional Explanation : This instrument will be used for monitoring peatland nitrous oxide fluxes throughout the useful life of the instrument at NRRRI. |

Non ENRTF Funds

| Category | Specific Source | Use | Status | Amount |
|------------------|---|---|----------------------------|------------------|
| State | | | | |
| | | | State Sub Total | - |
| Non-State | | | | |
| In-Kind | UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 54% modified total direct costs. | Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs) | Secured | \$429,650 |
| | | | Non State Sub Total | \$429,650 |
| | | | Funds Total | \$429,650 |

Total Project Cost: \$1,593,650

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [eb8af643-263.docx](#)

Alternate Text for Visual Component

This project will help predict how restoration of peatlands that have been in degraded from intensive land uses like agriculture can be restored to reduce greenhouse gas emissions and enhance flood water storage, while minimizing mercury losses to downstream ecosystems....

Supplemental Attachments

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

| Title | File |
|-------------------------------|----------------------------------|
| Green Transmittal Letter 2026 | 716daad0-751.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:

umdspa@d.umn.edu

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