# Environment and Natural Resources Trust Fund

2027 Request for Proposal

## General Information

**Proposal ID:** 2027-069

**Proposal Title:** Stream Complexity and Habitat Use in the Northwoods

## Project Manager Information

**Name:** Emily Fairfax

**Organization:** U of MN - St. Anthony Falls Laboratory

**Office Telephone:** (612) 625-8949

**Email:** efairfax@umn.edu

## Project Basic Information

**Project Summary:** We will use eDNA, remote sensing, and geospatial modeling to identify the biophysical characteristics of streams that provide climate-resilient habitat for key species with the goal of informing river restoration.

**ENRTF Funds Requested:** $675,000

**Proposed Project Completion:** June 30, 2030

**LCCMR Funding Category:** Fish and Wildlife (D)

## Project Location

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

Region(s): NE, NW,

**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.**

From 1950 to 2017, the Great Lakes region experienced 2.3C of warming, 14% more precipitation, 35% more heavy precipitation events, and the frost-free season grew 16 days longer. Winters are wetter and shorter, while summers are hotter and drier. Climate-related disturbances, such as drought, flood, and wildfire, are increasing in frequency and intensity. Meanwhile, many of our culturally important species (trout, moose, lynx, northern long-eared bat) have specific habitat requirements that include healthy streams and floodplain forests. Those habitats are shifting or disappearing altogether in response to climate change – especially in the Northwoods. Flowing waters and their floodplains are particularly vulnerable, in part due to their small size causing sensitivity to temperature and precipitation extremes, and in part due to a legacy of physical degradation from development, timber, and agriculture. While the former is innate, the latter can be addressed through restoration. However, our understanding of what biophysical conditions support increased biodiversity and climate resiliency in riverine and floodplain environments is limited - the majority of research has been done in the western US and the UK. A Minnesota-specific study of physical stream characteristics and habitat provisioning is needed to inform our restoration efforts and protect these unique Northwoods

**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 combine local-scale data with large-scale remote sensing and geospatial modeling to identify the biophysical conditions that support aquatic climate resiliency and high levels of biodiversity. We focus on flowing waters, as these are innately more vulnerable to disturbance and also more immediately responsive to restoration. At the local scale to watershed scale, we will use environmental DNA (eDNA) to characterize the ecological communities present in aquatic habitats of varying biophysical complexity in northern Minnesota throughout the year. Our eDNA samples will be collected seasonally at each site, with opportunistic sampling off schedule during any large-scale climate disturbances (e.g., a flood event, a drought). We will use remote sensing imagery to describe the geomorphic structure, physical in-stream features, and vegetation vigor of each site over time. These data, along with our field-scale eDNA data and existing precipitation records, temperature records, and generally static variables (e.g., slope, elevation, drainage area), will be integrated into a geospatial model from which we can quantitatively determine the biophysical characteristics of flowing waters that support higher biodiversity and maintain it during periods of environmental stress. This list of characteristics can be used to inform river restoration design and placements within a watershed.

**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 are identifying flowing waters that provide key habitat and describing the species they support. We are also beginning to characterize what makes some waters more resilient to environmental disturbances than others. We will 1) support conservation of the existing high value riverine habitat and 2) identify waters that could become key habitat and more resilient through strategic restoration and guide the restoration design. Our study design explicitly defines links between large-scale environmental processes with small-scale, on-ground landscape features and ecological impacts. We will produce an interactive map to facilitate restoration and conservation coordination between land and water management entities.

## Activities and Milestones

### Activity 1: Assess the Biophysical Complexity of Streams in Focal Species Ranges Over Time and to Inform Empirical Model for Species' Distribution

**Activity Budget:** $297,000

**Activity Description:**
Use remote sensing to evaluate stream complexity in the ranges of our focal species (moose, trout, lynx, and northern long-eared bat) over time and compare to shifting ranges. To do that we will:

- combine aerial imagery from the Minnesota Historical Aerial Photograph Database and satellite imagery from the Landsat, Sentinel, Planet and MAXAR satellites

- use that imagery to quantitatively describe stream complexity across the historic and modern range of focal species from 1950 - present, depending on data availability.

- establish a time series of change in complexity on all streams and rivers where 2 or more focal species range overlaps

- cross-compare the stream complexity time series to known time series data on shifts or shrinkage in species distribution and/or abundance from prior ecological research (e.g., the MN DNR aerial moose surveys, iNaturalist observations).

- collect and aggregate static and known environmental data including slope, streamflow, meteorology, land cover change, and disturbance records throughout the study area

- create a coarse preliminary model that determines the relative importance of total complex riparian habitat area and connectivity for our focal species at the watershed level

- identify a subset of watersheds for field eDNA and surveying

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Create a combined dataset of historical imagery and satellite imagery in focal species ranges | October 31, 2027 |
| Aggregate existing ecological data, surveys, and observations of focal species distribution over time | December 31, 2027 |
| Quantitatively describe stream complexity from imagery on all streams in the study area over time | March 31, 2028 |
| Integrate remotely sensed stream complexity data into empirical model with environmental factors and ecological data | April 30, 2028 |
| Select all field sites for eDNA and survey data collection | May 31, 2028 |

### Activity 2: eDNA and Field Observations of Species Habitat Use: Establishing Baselines and Trends

**Activity Budget:** $314,100

**Activity Description:**
In years 2 and 3, we'll use eDNA and traditional field methods to establish presence / absence of our focal species - moose, trout, lynx, and northern long-eared bat - at stream segments of varying biophysical complexity throughout their current and historic native ranges. We will collect eDNA samples primarily from water, and opportunistically from scat, browsed twigs, and paw prints. This will establish broader ecological baselines and also capture the spatiotemporal

dynamics of our focal species' use of stream and floodplain environments over the course of the year. This involves:

- In year 1, collecting eDNA samples and performing field surveys at a large but sparse subset of stream segments across several watersheds. Samples will be taken monthly to establish baselines of focal species' presence/absense during the different seasons and describe broader ecological communities present

- Analyzing eNDA to identify a smaller subset of watersheds that have focal species present during one or more seasons at multiple stream segments

- In year 2, densifying the spatial sampling protocol to characterize species distribution and movement in greater detail within the smaller subset

- Depending on the size of watersheds in year 2, sampling frequency may shift to once per season

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Collect broad and spatially spare eDNA monthly with complementary field surveys within focal species' range | May 31, 2029 |
| Analyze broad eDNA data and field survey to select watersheds for high spatial resolution sampling | May 31, 2029 |
| Densely sample 1-3+ watersheds (depending on size) at least once per season | May 31, 2030 |
| Analyze dense eDNA data and field surveys to input in models alongside stream complexity data | May 31, 2030 |

## Activity 3: Data Integration, Model Building, and Restoration Recommendations

**Activity Budget:** $63,900

**Activity Description:**
In years 2 and 3 we will finish building a geospatial model that takes in the existing ecological data and observations of our focal species, the time series of stream complexity in watersheds where two or more of our focal species ranges overlap from Activity 1, our eDNA and field observations from Activity 2, and publicly available environmental datasets such as landcover, stream flow, weather, climate, ice in and ice out dates, slope, and distance to large waterbodies and human infrastructure. From this model we will be able to determine the relative importance of stream complexity in providing habitat for our focal species 1) year round, and 2) during specific seasons to inform restoration design. We will also use the results to produce a map of current hotspots of activity from our focal species as well as potential future hotspots if habitat complexity and resilience is improved via restoration. This map and these recommendations will be shared with the relevant state land, water, and wildlife management agencies via publications, interactive web apps, and presentations from the research team. We will compare our results to similar studies out west and in the UK as well to begin understanding the generalizability.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Complete building model and test on dummy eDNA data until real data collection is complete | July 31, 2028 |
| Integrate all real eDNA and field data into model | June 30, 2030 |
| Evaluate the relative importance of stream complexity compared to other variables over space and time | June 30, 2030 |
| Complete all publications and presentations and share with partners and interested organizations and agencies | June 30, 2030 |

## 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.**
Throughout the project we will provide quarterly updates on our preliminary data and findings via a UMN research website and newsletter that interested parties can sign up for.

We anticipate having at least three publications arise from this work: one from the stream complexity time series mapping, one from the sparse eDNA sampling and baseline establishment, and one from the spatially dense eDNA sampling and evaluation of the role of stream complexity in providing habitat for the focal species. These will be published open-access and shared broadly via our own research web page and our departmental outreach coordinators.

As we approach the end of the proposed research, we will produce an interactive map that shows our data layers and results at the watershed scale (to avoid disclosing the exact locations of rare species like lynx). This map will be hosted on our website and PDF versions of it will be permanently archived.

We will write recommendations for river restoration sites to improve habitat connectivity for our focal species based on our eDNA results. These will be shared in presentations and meetings with relevant land, water, and wildlife management agencies and organizations. They will also be publicly archived as a map product.

## 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?**
Our methodology for both the remote sensing and the eDNA work will be documented in detail and published so that other users can continue to monitor species distribution and habitat use in the future. This may be funded through state or federal wildlife funds, or at a smaller scale through philanthropic and non-profit organizations. The knowledge of trends and importance of stream complexity is intended to inform restoration efforts for many years to come. We suspect there is a lot of opportunity to improve habitat quality and stream complexity and our map should point people to good sites for years.

## Other ENRTF Appropriations Awarded in the Last Six Years

| Name | Appropriation | Amount Awarded |
|---|---|---|
| Expanding the Application of Minnesota's Wetland Monitoring Data | M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 03v | $312,000 |

## Project Manager and Organization Qualifications

**Project Manager Name:** Emily Fairfax

**Job Title:** Assistant Professor

**Provide description of the project manager's qualifications to manage the proposed project.**
Dr. Emily Fairfax is an assistant professor in the Department of Geography, Environment, and Society as well as an Affiliate Faculty Member at the Saint Anthony Falls Laboratory, both at the University of Minnesota. Dr. Fairfax is an interdisciplinary ecohydrologist with expertise in ecosystem engineers, environmental disturbance, remote sensing,

geospatial modeling, machine learning, and science communication. She has 11 years of experience studying beavers, river restoration, and their influence on biophysical processes, in addition to extensive formal education in chemistry, physics, geology, and hydrology. Fairfax is globally recognized as a leading expert on ecosystem engineering and river restoration, and her research has been featured in The New York Times, The LA Times, NPR, PBS, Science Friday, BBC, and National Geographic, amongst others. Dr. Fairfax frequently partners and collaborates with state land and wildlife management agencies across the US, including MNDNR, to better understand how beavers are modifying waters, ecosystems, and landscapes in the context of a changing climate. Fairfax currently manages a productive stream ecology and river restoration research lab with 2 postdoctoral associates, 3 PhD students, 3 masters students, and 2 professional research assistants. Fairfax is a McKnight Land-Grant Professor at the University of Minnesota.

**Organization:** U of MN - St. Anthony Falls Laboratory

**Organization Description:**
St. Anthony Falls Laboratory at the University of Minnesota Twin Cities is an interdisciplinary fluid dynamics research lab that specializes in computer and physical modeling as well as education about rivers, streams, and lakes. The Department of Geography, Environment, and Society at the University of Minnesota Twin Cities is dedicated to creating and disseminating geographical and environmental knowledge through world-class research and teaching. Fairfax is a part of both of these departments / units at the University of Minnesota. This research will be carried out primarily through the St. Anthony Falls Laboratory.

## Budget Summary

| Category / Name | Subcategory or Type | Description | Purpose | Gen. Ineligible | % Benefits | # FTE | Classified Staff? | $ Amount |
|---|---|---|---|---|---|---|---|---|
| **Personnel** | | | | | | | | |
| Emily Fairfax: PI and Lead Investigator | | Assistant Professor at UMN Twin Cities in Department of Geography, Environment, and Society and Saint Anthony Falls Laboratory. Lead geospatial and remote sensing research and direct supervisor of postdoc, graduate student, and geospatial staff. Stream complexity, disturbance ecology, and river restoration specialist. | | | 38.5% | 0.03 | | $5,452 |
| James Macarthur: Postdoctoral Researcher | | Lead eDNA scientist and postdoctoral researcher. Support field surveys and geospatial modeling. PhD April 2026 (expected) from University of the Highlands and Islands: “Integrating molecular and traditional techniques to study the effects of beavers on migratory fish.” 5.5 years of molecular lab experience using both single-species (qPCR/dPCR) and community-level (metabarcoding) techniques. Covariate extraction from QGIS and statistical analysis of large spatial datasets in R. Prior mentoring and training experience teaching students from undergraduate to PhD how to collect, filter, extract and sequence eDNA water samples. Previous electrofishing experience. | | | 28.1% | 3 | | $293,632 |
| Graduate Student TBD | | PhD student to be recruited to take lead on geospatial modeling and mammal focus under the supervision and guidance of Fairfax. Support field surveys for fish abundance and distribution. Support eDNA analyses. | | | 28.9% | 1.14 | | $118,332 |
| Andy Riesgraf: Field Staff | | Master's degree level field staff to assist with data collection and analysis at field sites and in the lab. Extensive experience with field instrumentation and fish survey methods. | | | 38.5% | 0.51 | | $59,223 |
| Cris Hansen | | Administrative staff to support purchasing, paperwork, safety training, and other administrative duties associated with the project. | | | 34.9% | 0.18 | | $15,972 |
| Andrew Arlt: | | Geospatial research staff to support final model refinements and creation and distribution of interactive map product. | | | 38.5% | 0.08 | | $11,350 |

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|---|---|---|---|---|---|---|---|---|
| Geospatial Staff | | | | | | | | |
| | | | | | | | **Sub Total** | **$503,961** |
| **Contracts and Services** | | | | | | | | |
| University of Minnesota Genomics Center | Internal services or fees (uncommon) | Lab access to the UMN Genomics Center CoLab instruments and table space at $2000/yr for postdoc and $1000/yr for graduate student. Additional $7000/yr estimated in costs to run specialized advanced metabarcoding and eDNA analyses at the UMN Genomics Center. Total $10,000/yr for duration of project. | | | | - | | $30,000 |
| | | | | | | | **Sub Total** | **$30,000** |
| **Equipment, Tools, and Supplies** | | | | | | | | |
| | Equipment | Field eDNA Sampler plus accessories from Smith Root or similar | Two field samplers at $2300 each plus spare hoses (3 x $100/each) and in-line strainers (4 x $25/each) to efficiently collect eDNA samples and filter them in the field to reduce need to haul around 10's of kilograms of water samples while in remote wilderness areas. Samplers can be placed and set to run without additional interaction during sample collection, allowing multiple units to be deployed by one researcher if needed. | | | | | | $5,000 |
| | Equipment | Game Cameras x 20 | 20 game cameras with memory cards and batteries to install at select field sites and gather visual data of habitat use to complement the eDNA data. | | | | | $5,000 |
| | Tools and Supplies | Field Supplies | Spare batteries, memory cards, and other small parts to repair or replace field equipment as needed. Estimated $1000/yr in years 2 and 3 for replacement parts. | | | | | $2,000 |
| | Tools and Supplies | eDNA Laboratory Supplies | Primers, filters, chemicals, sequencing runs, gloves, sterile containers, and other laboratory supplies to perform | | | | | $90,039 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | complete eDNA analyses from extraction through species identification. Estimated at $31,013 per year which breaks down to approximately $100/sample for 300 samples per year in chemicals, filters, sequencing, and primers plus $13 per year in distilled water. We plan to sample roughly 100 field sites per year in triplicate. | | | | | |
| | Tools and Supplies | Postage and Shipping | Estimated $1000 per year in shipping costs to mail samples, hard drives, and equipment as needed. | | | | | $3,000 |
| | | | | | | | **Sub Total** | **$105,039** |
| **Capital Equipment** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Acquisitions and Stewardship** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Travel In Minnesota** | | | | | | | | |
| | Miles/ Meals/ Lodging | Field travel for postdoc, grad student, field staff, and/or PI. Estimated 500 miles round trip per field visit at $0.725 per mile (one car) = $363 per trip. Plus estimated $250 in campground and/or cabin fees depending on season and number of people working that field visit. Plus estimated $100 per trip vehicle rental fees, plus $68/day per diem for one person for 4 days to cover groceries for consumption in the backcountry = $985 per field visit. Estimate 10 field visits per year for duration of project, plus small buffer for mileage uncertainties = $10,000 per year in Minnesota travel | Go to the field in Northern Minnesota and collect eDNA samples and perform field surveys. | | | | | $30,000 |
| | | | | | | | **Sub Total** | **$30,000** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Travel Outside Minnesota** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Printing and Publication** | | | | | | | | |
| | Publication | Estimate 1 peer-reviewed publication per year for 3 years with APC and/or open access fee at $2000 per paper. | Disseminate results to greater scientific and management community | | | | | $6,000 |
| | | | | | | | **Sub Total** | **$6,000** |
| **Other Expenses** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| | | | | | | | **Grand Total** | **$675,000** |

## 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** | | | | |
| In-Kind | Unrecovered F&A | $649,200 (direct total minus tuition) x 0.54 = $350,000 unrecovered IDC | Secured | $350,000 |
| | | | **Non State Sub Total** | **$350,000** |
| | | | **Funds Total** | **$350,000** |

**Total Project Cost: $1,025,000**

**This amount accurately reflects total project cost?**

Yes

## Attachments

### Required Attachments

*Visual Component*

File: 85955be1-3d2.pdf

*Alternate Text for Visual Component*

A flowchart showing our challenge: stream habitat loss for key species, and our solution: eDNA and remote sensing studies to inform stream restoration efforts and guide the creation and protection of high quality habitat for lynx, moose, trout, and northern long eared bat....

### Supplemental Attachments

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

| Title | File |
|---|---|
| Fairfax UMN Institutional Letter | 1a724167-d20.pdf |
| Friends of BWCA Letter of Support | 945906cd-e11.pdf |
| MN Lakes and Rivers Letter of Support | f72aac92-284.pdf |
| Pollinator Friendly Letter of Support | 8d94d562-b19.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:**

none

**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**

N/A