



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-189

Proposal Title: Multi-Scale Stream Habitat Complexity Confers Resilience

Project Manager Information

Name: Katya Kovalenko

Organization: U of MN - Duluth - NRRI

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Project Basic Information

Project Summary: Minnesota beloved streams are fish and wildlife biodiversity hotspots at risk of extreme climate events. Information on habitat structure conferring resilience is urgently needed to protect stream-dependent fauna.

ENRTF Funds Requested: \$298,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Small Projects (G)

Secondary Category: Fish and Wildlife (D)

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?

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.

Stream ecosystems depend on the physical complexity of their channels and shorelines, including features such as varied substrate, woody debris, undercut banks, and structurally diverse riparian zones. These features increase thermal buffering and organic matter retention, slow water, provide shelter during floods and droughts, and support diverse insect communities that fuel higher levels of the food web. Stream-riparian systems with high cross ecosystem complexity are more likely to recover from floods, droughts, and thermal extremes because structural refugia stabilize food webs and buffer disturbance.

However, most of this complexity has been lost since pre-industrial times due to channelization, agricultural drainage, bank armoring, and simplified riparian corridors. While Minnesota and ENTRF have invested heavily in stream restoration, many projects still rely on qualitative assessments, with limited ability to predict which restoration elements actually improve ecosystem resilience. As climate driven floods, droughts, and temperature extremes intensify, restoration investments risk prioritizing visible form over measurable function. There is an urgent need for quantitative, science-based evidence linking habitat structure to ecological resilience at the spatial scales that matter most for stream organisms—and for translating that evidence into practical restoration guidance.

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 an integrated multi-scale assessment of stream habitat complexity directly linked to ecosystem resilience, using biological indicators that integrate conditions over time rather than relying on short-term snapshots. Specifically, we will quantify in-stream and shoreline structural complexity across a gradient of streams using high-resolution LiDAR and field-based habitat assessments. We will then measure how this complexity supports food webs, beginning with aquatic insects and extending to birds and small mammals that rely on stream-emerging insects.

We will use stable isotope and metagenomic analysis to quantify stream insect and bird trophic position and niche width revealing which habitat features support longer, more stable food chains. This approach will allow us to identify specific habitat elements—such as woody debris, substrate diversity, and high-resolution attributes of riparian structure—that most strongly support biological diversity, biomass, and stability. By linking measurable structural attributes to food web resilience, we will generate predictive guidance rather than descriptive case studies. This project will answer what attributes are key for stream biodiversity hotspots, providing managers with concrete targets for future investments.

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 supports the protection, conservation, preservation, and enhancement of Minnesota natural resources by identifying habitat features that are critical for resilience of stream-dependent birds and small mammals. We will provide quantitative benchmarks that can be incorporated into stream management plans and restoration design standards to ensure that public investments in restoration yield long-lasting ecological benefits, even under changing climate conditions. The results will help ensure that stream vegetation buffers are ecologically meaningful and that restored streams are not only visually appealing but ecologically resilient, reducing long term maintenance costs and increasing return on public conservation investment.

Activities and Milestones

Activity 1: Select study streams to cover a range of instream and shoreline complexity

Activity Budget: \$77,538

Activity Description:

We will select candidate North Shore streams and stream reaches that cover a defined gradient of habitat complexity based on preliminary LiDAR analyses. We will seek input from MN DNR and MN Land Trust to identify recently restored streams for potential inclusion to ensure management relevance. We will then visit the sites to ground truth LiDAR derived metrics and verify differences in physical habitat structure among stream reaches. Once we have selected our study streams and reaches, we will conduct a detailed, reach-scale assessment of shoreline and in-stream structural complexity using high-resolution LiDAR coupled with field based habitat surveys. The metrics of shoreline complexity will include vertical and horizontal vegetation heterogeneity including spatial variation in structural layering and patchiness, which are known to be important for perching birds and small mammals by influencing microclimate buffering, predator avoidance, and foraging access. Our sampling design will include 10 streams with multiple stream reach replicates distributed along the structural complexity gradient to allow cross stream comparison and within stream replication.

Activity Milestones:

Description	Approximate Completion Date
Select candidate streams and stream reaches to cover a gradient of in-stream and shoreline complexity	August 31, 2027
Conduct a detailed assessment of in-stream habitat complexity and shoreline vegetation complexity	September 30, 2029

Activity 2: Characterize stream food webs and conduct community assessments of birds and small mammals

Activity Budget: \$174,391

Activity Description:

In the second year, we will conduct a detailed assessment of in-stream habitat complexity, including substrate embeddedness, particle size distribution, large woody debris abundance, and channel structural heterogeneity. We will also characterize stream food webs and conduct community composition and dietary assessment of birds and small mammals that directly or indirectly rely on aquatic insect emergence as a primary food source connecting stream and riparian communities. For stream food webs, we will assess food chain length and dietary niche using stable isotope analysis of approximately 3,000 macroinvertebrates, representing five replicates of ten focal taxa across 60 stream reaches. Bird community composition will be quantified using standardized point count surveys, allowing us to estimate species richness, abundance, and community structure along the habitat complexity gradient. To directly assess dietary reliance on stream insects, we will conduct targeted mist netting at a subset of reaches to collect fecal samples for metabarcoding analysis. These samples will allow us to link consumer resource use to measure habitat complexity and insect biomass. Together, bird surveys, dietary metabarcoding, and macroinvertebrate isotope analyses will provide an integrated assessment of how in-stream and riparian structural complexity supports cross-ecosystem food web stability and community resilience.

Activity Milestones:

Description	Approximate Completion Date
Collect stream macroinvertebrates for stable isotope and community composition analyses	September 30, 2029
Deploy small mammal traps for community assessment	September 30, 2029
Survey avian communities and collect fecal samples for metabarcoding analyses	September 30, 2029

Activity 3: Identify key habitat features for community resilience and develop recommendations for stream restoration

Activity Budget: \$46,071

Activity Description:

We will analyze community composition, stable isotope and metabarcoding data to derive quantitative metrics of food web resilience. These metrics will be connected to in-stream and shoreline habitat complexity to identify key habitat features that are associated with increased aquatic insect biomass, trophic diversity, dietary niche, food chain length as well as bird and mammal diversity. We will employ ensemble network modeling and high-performance computing to assess food web resilience indicators such as robustness, modularity, and redundancy. We will also compare our complexity findings with the snapshot assessments done by the MN DNR stream group and include MN DNR fish monitoring data to make a connection to fish communities. We will then develop science-based recommendations for stream restoration in collaboration with project partners and translate findings into practical guidance documents, data products, and decision support tools for managers. In addition, results will be synthesized into a transferable framework and predictive model that can be applied to other streams across the region.

Activity Milestones:

Description	Approximate Completion Date
Analyze results to rank habitat complexity features by importance for specific aspects of resilience	January 31, 2030
Reach out to project partners to discuss recommendation for stream restoration and protection guidelines	March 31, 2030
Complete an outreach publication with recommendations for stream restoration and prioritization	April 30, 2030
Complete a technical report, release data and submit two manuscripts to a peer-reviewed journal	May 31, 2030
Present results at a manager-focused conference and as a webinar for MN Land Trust	May 31, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Alexis Grinde	Natural Resources Research Institute, University of Minnesota	co-PI, Wildlife ecology expert, avian ecologist, will be leading avian community assessment and metagenomics sampling, contributing to site selection, report and manuscript preparation and outreach	Yes
Dr. Michael Joyce	Natural Resources Research Institute, University of Minnesota	co-PI, Wildlife ecology expert, will be leading LiDAR analysis and small mammal community assessment, and contributing to site selection, report and manuscript preparation and outreach	Yes
Dr. Amber Ulseth	Natural Resources Research Institute, University of Minnesota	co-PI, Aquatic ecology expert, will be contributing to study design, site selection, stable isotope analysis, report and manuscript preparation and outreach	Yes
Dr. Heidi Rantala	Minnesota DNR	collaborator, Aquatic ecology expert, will be contributing to stream identification, providing feedback on framework development and contributing to report and manuscript preparation and outreach	No
Dr. Annie Bracey	Natural Resources Research Institute, University of Minnesota	co-PI, Wildlife ecology expert, will be contributing to avian community assessment and metagenomics sampling, site selection, report and manuscript preparation and outreach	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 ENTRF Acknowledgement Requirements and Guidelines.

We will produce a public-facing outreach publication with practical recommendations for stream restoration and prioritization, a technical report detailing strategies for implementing results in stream management and restoration planning and a framework for stream habitat complexity assessment which can be applied to other Minnesota streams. We will work with the NRRI Marketing and Communications Team to develop the outreach materials.

To ensure results are shared with entities that can use these findings to improve management of resources in Minnesota, we will work with MN DNR and MN Land Trust to disseminate the outreach and technical report. We will maximize data accessibility to the public, managers and future ENTRF grantees by releasing open-source data via Zenodo. To ensure longevity of products, we will publish two Open Access peer-reviewed papers to reach a broader audience. Natural resource management must rely on peer-reviewed science, and this is where we deliver: the PI has a record of delivering 100% of promised peer-reviewed publications. We will select journals with an existing Open Access agreement with the University to save the ENTRF funds. We will also provide training for at least two summer students in stream ecology, machine learning, and high-performance computing.

We will use ENTRF Acknowledgment Guidelines to acknowledge the Environment and Natural Resources Trust Fund through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications and outreach.

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?

The framework will serve as a blueprint for assessing habitat complexity in other streams and to develop targeted conservation strategies which address aspects of stream complexity most critical for these unique stream ecosystems. We will leverage the results of this project to apply for longer-term federal grants to address the connection between complexity and capacity of ecosystems to bounce back after extreme floods. To ensure longevity of products, we will publish two Open Access peer-reviewed papers to reach a broader audience. We will maximize data accessibility to the public, managers and future ENTRF grantees by releasing open-source data.

Project Manager and Organization Qualifications

Project Manager Name: Katya Kovalenko

Job Title: Quantitative Ecologist and Data Scientist

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

I have more than 25 years of experience in ecology and statistics. My work spans freshwater, coastal, and wetland ecosystems and includes multi-institutional collaborations involving federal agencies, universities, NGOs, and international research teams. I have nationally and internationally recognized expertise in habitat complexity, including a highly cited synthesis paper on aquatic habitat complexity and editorial leadership of two Special Issues dedicated to advancing theory, metrics, and management applications of habitat complexity. I am a co-PI with the Minnesota Supercomputing Institute, and I integrate large ecological datasets with advanced computational workflows, further strengthening my capacity to manage data-intensive, interdisciplinary initiatives.

I have managed projects addressing high-priority environmental challenges, including invasive species impacts, habitat complexity and resilience, sea-level rise, watershed stressors, and food-web change in large lake and coastal systems. I have extensive experience with stream ecosystems, macroinvertebrates and stable isotopes. My publication record in high-impact journals such as Science, Nature, Ecological Applications, and Journal of Applied Ecology reflects consistent delivery of rigorous outcomes under complex project constraints.

I have led projects from conceptual design through implementation, analysis, and reporting, ensuring alignment with sponsor objectives and adaptive responses to emerging challenges. My work frequently involves harmonizing datasets across regions and time scales, developing indicators and assessment frameworks, and translating technical results for non-technical audiences. I emphasize clear communication, accountability, and inclusive collaboration, enabling teams to deliver high-quality products on schedule while maintaining scientific integrity. I am committed to delivering projects that inform management decisions, improve environmental outcomes, and maximize return on public and partner investment.

Organization: U of MN - Duluth - NRRRI

Organization Description:

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

Our mission: Deliver integrated research solutions that value our resources, environment and economy for a sustainable and resilient future.

NRRI collaborates broadly across the University system, the state and the region to address the challenges of a natural resource-based economy. Research is developed via extensive partnerships with industry, state and federal agencies and governmental units.

As an impartial, science-based resource, NRRI develops and translates knowledge through large-scale, interdisciplinary research. Our expertise focuses on defining resource opportunities, minimizing waste and environmental impact, maximizing natural resource value, and maintaining or restoring ecosystem function.

Major outcomes from NRRI projects include informing environmental management and policy and assisting industry and communities in defining and maintaining the social license to operate in natural systems. NRRI has established mechanisms for sharing outcomes through press releases, peer-reviewed journals, technical reports, annual reports, periodicals, and social media.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Dr. Katya Kovalenko, Principal Investigator		Quantitative ecologist and data scientist, aquatic ecologist, will lead the project, including stream selection, field verification, macroinvertebrate sampling, stable isotope processing and data analyses, framework development, report and manuscript preparation, and outreach efforts			26.8%	0.3		\$40,019
Dr. Amber Ulseth, Co-Investigator		Aquatic ecologist, will contribute to experimental design, stream assessment, stable isotope data interpretation, outreach, and report and manuscript preparation			26.8%	0.12		\$17,010
Dr. Alexis Grinde, Co-Investigator		Wildlife ecologist, Forest and Land Research Group Leader, will lead avian community assessment, contribute to data interpretation, outreach, report and manuscript preparation			26.8%	0.09		\$14,437
Dr. Michael Joyce, Co-Investigator		Wildlife ecologist, LiDAR specialist, will lead small mammal sampling and contribute to experimental design, stream assessment, outreach, and report and manuscript preparation			26.8%	0.06		\$7,207
Anna Mangan		Wildlife ecologist, will contribute to mammal sampling and isotope sample processing			24.4%	0.21		\$20,285
Holly Wellard Kelly		Aquatic scientist, will contribute to stream assessment and isotope sample processing			24.4%	0.09		\$9,773
Robert Hell		Principal laboratory technician, will contribute to stream assessment			24.4%	0.03		\$2,089
Stephen Kolbe		Avian ecologist, will contribute to avian community assessment and sample collection			26.8%	0.09		\$11,095
Stephen Nelson		Avian ecologist, will contribute to avian community assessment and metagenomic sample collection			24.4%	0.09		\$6,588
Annie Bracey, Co-Investigator		Avian ecologist, will contribute to experimental design, avian community assessment, report and manuscript preparation			26.8%	0.06		\$6,146
Kara Snow		Avian ecologist and metagenomics specialist, will lead metagenomic sample preparation and data interpretation			24.4%	0.6		\$41,679

Two TBD Graduate Students		Will assist with sample collection and processing, including fieldwork, sorting, drying and weighing samples for stable isotope analysis, will be trained in data analytics			19.5%	0.12		\$9,751
Four TBD Temp/Casual Field Technicians		Will assist with stream assessments, sample collection and processing			7.4%	0.21		\$12,530
Three TBD Undergraduate Students		Will assist with sample collection and processing, including fieldwork, sorting, drying and weighing samples for stable isotope analysis, will be trained in data analytics			0%	0.3		\$9,902
							Sub Total	\$208,511
Contracts and Services								
University of Minnesota Genomics Center	Internal services or fees (uncommon)	Metabarcoding analysis of collected non-invasive samples to understand dietary niche and reliance on stream insects				0		\$16,000
Cornell Stable Isotope Laboratory	Internal services or fees (uncommon)	Analysis of collected samples for N15/C13 including encapsulation (3500 samples) plus grinding (500 samples)		X		0		\$33,600
							Sub Total	\$49,600
Equipment, Tools, and Supplies								
	Tools and Supplies	Stable isotope supplies: \$10 x 3 forceps; \$200 dry ice; microcentrifuge vials \$20/500 X 6 bags + microcentrifuge boxes \$6 x 30; aluminum weighing boats with tabs \$11/100 x 5 (reused); Miscellaneous field supplies: kicknet, D net, waders, banding or handling supplies; Metabarcoding supplies: extraction kits, PCR reagents, consumables;	Supplies and reagents for sample collection and processing					\$8,800
							Sub Total	\$8,800
Capital Equipment								

							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Includes mileage and truck rate for 10 local trips by 3 teams, per diem and mileage for 4-6 people for 4 days/3 nights for 5-6 trips, truck daily rate (internal NRRI rate)	Fieldwork to select streams, fieldwork to conduct detailed stream complexity assessments, sample macroinvertebrates and survey bird and small mammal communities and collect samples for stable isotope and metabarcoding analyses					\$29,979
	Conference Registration Miles/ Meals/ Lodging	registration for 2 PIs, student registration free, day trips no per diem	Present results at a local conference					\$510
							Sub Total	\$30,489
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Printing	Outreach materials printing costs	Print outreach brochures for distribution to partners and at local conference; Open Access publication fees covered by the Big Ten Alliance agreement					\$300
							Sub Total	\$300
Other Expenses								
		Shipping costs	Sample shipping costs to the laboratory					\$300
							Sub Total	\$300

							Grand Total	\$298,000
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Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - Cornell Stable Isotope Laboratory	Internal services or fees (uncommon)	Analysis of collected samples for N15/C13 including encapsulation (3500 samples) plus grinding (500 samples)	Cornell Stable Isotope Laboratory is the gold standard laboratory for N15/C13 processing, with significantly lower costs, higher reliability and faster turn-around time. A viable alternative is not available within the state of Minnesota.

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	\$160,920
			Non State Sub Total	\$160,920
			Funds Total	\$160,920

Total Project Cost: \$458,920

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [3d00c709-70f.pdf](#)

Alternate Text for Visual Component

Complex stream habitat in a painting from the 19th century contrasted with a stream than lost its shoreline and in-stream complexity plus details of experimental design to show ecosystem effects (North Shore streams, macroinvertebrates, birds)...

Supplemental Attachments

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

Title	File
Authorization_Letter	6a63670b-7e4.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:

Megan Gorder, NRRI

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