



# Environment and Natural Resources Trust Fund

2022 Request for Proposal

## General Information

**Proposal ID:** 2022-209

**Proposal Title:** Winter Dynamics of Trout Streams: Southeast/Southcentral Minnesota

## Project Manager Information

**Name:** Leonard Ferrington

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

**Office Telephone:** (651) 226-8519

**Email:** ferri016@umn.edu

## Project Basic Information

**Project Summary:** Warming temperatures resulting from climate change will affect trout populations in Minnesota. Streams of Minnesota are particularly vulnerable. We will model winter dynamics to identify the most vulnerable headwater streams

**Funds Requested:** \$497,000

**Proposed Project Completion:** June 30 2025

**LCCMR Funding Category:** Methods to Protect, Restore, and Enhance Land, Water, and Habitat (F)

## Project Location

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

Region(s): SE

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

Region(s): SE

**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 Driftless Region (DR) of Minnesota was not glaciated during the recent glaciation of MN and the geology includes extensive karst landscape conducive to groundwater flows that re-surface at springs or seepages and buffer temperature regimes of streams. Resurfacing groundwater keeps streams cold in summer (but warm in winter!), creating quality habitat for trout. More than 185 streams are managed in Minnesota for trout sport fishing. Trout sport fishing provides economic impact to local communities, estimated (Trout Unlimited (2008), to be valued at 1.1 billion dollars. Additional non-designated streams contain trout populations but are marginal in terms of thermal regimes with little or no management programs. With past LCCMR grants, we have modeled thermal regimes and insect/trout dynamics in 48 designated trout streams in central/eastern DR. Here we propose to investigate and model winter dynamics of 36 more streams along the western periphery of the DR which, when combined with our past research findings, will provide a data base robust enough to extrapolate to all trout streams in DR, so that statistically-based management plans can be targeted to both managed and marginal trout streams to reduce the impact of increasing thermal regimes predicted by global warming models

### **What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.**

We will build on our past research findings that relate predictive thermal regression models of how groundwater inputs interact within geological, landscape and streambed conditions to buffer water temperatures of trout streams. This will allow us to predict ranges of thermal suitability of headwater stream segments for maximum growth of different trout species in winter, and how conditions vary within and among streams, which will enable managers to position and tune restoration efforts with greatest impact in extending the moderating influence of groundwater on stream temperature. We will use both historical and newly-measured air and water temperatures (we can sample & process data for 10 streams/yr.) to map groundwater influences at fine spatial scales. The predictive models we develop will relate local geological conditions in headwater streams to a statistical model for prioritizing management actions. We will use field designs and lab techniques that we developed and refined during our previous and current LCCMR-funded projects focused in SE Minnesota so that results of this project will be comparable and statistical contrasts and comparisons at large spatial scales within Minnesota will be valid. The predictive models will allow us to pinpoint areas of priority for stream restoration and habitat modification efforts.

### **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?**

Specific outcomes are to (1) develop thermal predictive models for 30 headwater stretches of streams located in an arc along the western-most periphery of the DR; (2) determine composition, abundances and phenologies of winter-active aquatic insects that form trout diets in winter; (3) determine molecular variability of selected winter-active "species" that, based on our current findings, are likely to have distinctive physiologies and other biological attributes which suggest cryptic species are present in stream sections of the central and eastern portions of the DR; (4) determine if there is additional molecular variability in the more isolated headwater sections of streams.

## Activities and Milestones

### Activity 1: Developing Predictive Thermal Model Relationships Between Ambient Air Temperatures and Daily Average Water Temperatures For Headwaters Sections of Trout Streams.

**Activity Budget:** \$210,275

**Activity Description:**

We will build on past research findings relating predictive modeling of how groundwater inputs interact with geology and streambed conditions to buffer water temperatures of trout streams. This will allow us to predict ranges of thermal suitability for maximum growth of different trout species in winter in headwater streams, and how conditions vary within and among stream segments, which will enable managers to position and tune restoration efforts with greatest impact in extending the moderating influence of groundwater on stream temperature. We will use both historical and newly-measured air and water temperatures (we can collect & process data for 10 streams/yr.) to map groundwater influences at fine spatial scales in headwater streams. The predictive models we develop will relate local geological conditions in headwater streams to statistical models for prioritizing management actions. We will use field designs and lab techniques identical to those we developed and refined during our previous and current LCCMR-funded project in the Driftless Region of SE Minnesota so that results of this project will be comparable, and statistical contrasts at large spatial scales within Minnesota will be valid. The predictive models will allow us to recommend areas of priority for stream restoration and habitat modification efforts.

**Activity Milestones:**

Description	Completion Date
Collect temperature data and develop Predictive Thermal Models (PTM) for initial 10 of 30 streams.	June 30 2023
Collect temperature data and develop Predictive Thermal Models (PTM) for additional 10 of 30 streams.	June 30 2024
Collect temperature data and develop Predictive Thermal Models (PTM) for remaining 10 of 30 streams.	June 30 2025

### Activity 2: Assess emergence patterns of winter-active aquatic insect species and determine their genetic structure at preselected mitochondrial and nuclear genes

**Activity Budget:** \$266,221

**Activity Description:**

Our research demonstrates that emergence of aquatic insects in winter serve as primary food for trout, and that trout eat large numbers of adults during emergence peaks. More than 30 species emerge during winter in streams of the DR. Emergences of the insects are highly variable among streams, over time throughout winter, and across different stream sites even within a stream. We are currently using our newly developed molecular techniques to target mitochondrial and nuclear gene markers to differentiate species that are poorly defined morphologically, or are newly discovered. Several lines of evidence suggests the differing genetic compositions could indicate species with differing thermal preferences in streams, especially among spatially isolated headwaters, which may result in different population densities, growth rates and/or nutritional value for trout. Better understanding the insect dynamics will allow improved estimates of stocking rates and carrying capacities of trout among streams, and even longitudinally within streams. We will use the same methods we developed for our previous research of winter insect patterns in the DR, including monthly collections of larvae from stream bottom substrates, and adults from on snow banks near streams, to estimate emergence peaks, and quantify insect mass, in addition to genetic structure.

**Activity Milestones:**

Description	Completion Date
Monthly collections of larvae and adults (Dec-Feb) first 10 streams, all sites; determine genetic structure	June 30 2023
Monthly collections of larvae and adults (Dec-Feb) second 10 streams, all sites; determine genetic structure	June 30 2024
Monthly collections of larvae and adults (Dec-Feb) third 10 streams, all sites; determine genetic structure	June 30 2025

### Activity 3: Expand, update and develop additional pages and links to existing technical website for dissemination interim and final research results.

**Activity Budget:** \$20,504

#### Activity Description:

This project focuses on research related to the functional roles and system-level dynamics that aquatic insects have during winter in trout streams managed for sport fishing. Our findings are of interest to researchers (locally, nationally and internationally), and summaries are disseminated via our lab web site (<https://midge.cfans.umn.edu/research/winter-active-chironomidae>). Technical and peer-reviewed publication are listed and links for downloading are provided. This web site requires regular maintenance and updating to keep it functional and current.

In addition, we intend to develop an interface to reciprocally connect our research web site to another web site, "Bug-Below-Zero" (<https://www.bugsbelowzero.com/>), which is designed to encourage and guide citizen volunteers wanting to assist in research during winter related to dynamics of winter-emerging aquatic insects found on snow banks near trout streams. This second site is constructed to educate non-technical stakeholder groups and schools about the presence, biology, and significance of winter-active insects. The undergraduate technician hired for this activity will be knowledgeable of state-of-the art website design and functionality, and will be tasked with updating and expanding the technical research website and creating reciprocal connectivity to the "Bugs-Below-Zero" web site as it, too, expands and encompasses new functionality.

#### Activity Milestones:

Description	Completion Date
Expand, update and develop additional pages and links to existing technical website, first year results	June 30 2023
Expand, update and develop additional pages and links to existing technical website, second year results	June 30 2024
Expand, update and develop additional pages and links to existing technical website, third year results	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 be funded?**

We will communicate with MN DNR fisheries biologists and coordinate with Trout Unlimited to keep them informed of our findings. We will identify areas in headwater streams where thermal regimes are at or near levels that are vulnerable to increasing to environmental warming predicted by climate change models for central Minnesota. We will seek funding from other sources during execution of this project to leverage LCCMR-funded efforts, and use University-based internships, work-study and Undergraduate Research Opportunities as resources to expand and extend the efforts of our student work force. Our results will be made available for management through public websites.

## Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Improve Trout-Stream Management by Understanding Variable Winter Thermal Conditions	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 03i	\$400,000

## Project Manager and Organization Qualifications

**Project Manager Name:** Leonard Ferrington

**Job Title:** Professor (University of Minnesota, Department of Entomology)

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

Leonard C. Ferrington Jr. has maintained an active research program dealing with responses of aquatic invertebrates to water quality conditions for 39 years, and is a specialist in the ecology, taxonomy and systematics of aquatic insects, with a focus on cold-adapted aquatic insects active in winter that serve as diets for trout. He is a professor in the Department of Entomology at the University of Minnesota (2000-present) and served for six years as co-director of the Environmental Sciences, Policy & Management undergraduate degree program in the College of Foods, Agricultural and Natural Resources Sciences. He presently is a track coordinator for this same degree program. In 2021 he was named as an honorary Fellow of The Society for Freshwater Sciences, based on career excellence and national/international reputation for research accomplishments into dynamics of freshwater organisms. He has been PI or Co-Pi on more than 5.1 million dollars of grant-funded research projects, with funding from the NSF, USGS, National Park Service, US EPA, US Department of Energy, Minnesota SeaGrants, MN LCCMR, and various private contract labs involved in environmental monitoring and assessment. He has published 107 peer-reviewed journal articles and 40 technical articles. He has contributed chapters to four editions of the Aquatic Insects of North America (the primary identification text for aquatic insects in North America) and wrote two sections in "Freshwater Animal Diversity Assessment" (Hydrobiology 198, 2008), which was a collective effort of 163 experts commissioned by the European Union International Convention on Biological Diversity and funded by DIVERSITAS. Len will serve as project PI and be responsible for overall project management, and will supervise day-to-day duties of personnel related to Activities 1 and 2. See web site at --- <http://midge.cfans.umn.edu/current-fellows/ferrington>

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

**Organization Description:**

The Department of Entomology in the College of Food, Agricultural and Natural Resource Sciences is a research, service and teaching unit at the University of Minnesota, Twin Cities. The department specializes on investigating and understanding ways in which insects interact within natural and human-built systems, and the roles that they play in

nutrient cycling and energy flow in natural and managed ecosystems, including agriculture, forestry, fisheries and aquatic components of the landscape of Minnesota. The teaching and service components include public outreach and education with stakeholder groups, including sport fisheries organizations and interest groups. This proposal was prepared by Leonard Ferrington, who is the director of the Chironomidae Research Group within the Department of Entomology (<https://midge.cfans.umn.edu/current-fellows/ferrington>). The research group consists of graduate and undergraduates that are involved in research project directed by Ferrington. Additional faculty that participate within the research group are: Dr. James Perry, Dr. Bruce Vondracek, Dr. Amy Schrank and Dr. Rebecca Swenson. All will actively contribute expertise to this project. The research activities proposed in this application will be conducted under the auspices of the Chironomidae Research Group, with Ferrington serving as Principal Investigator.

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
Project Principal Investigator (Ferrington)		Overall project supervision, assistance with field work related to Activities 1 & 2, supervision of Graduate Research Assistants (GRA) involved in Activities 1 & 2, development of web design concepts, photographic layout and composition of text for web updates, and supervision of activities of undergraduate technician responsible for web updates, expansion and functionality. Summed across all three activities, Ferrington will devote 18% of time each year of the project. (NOTE: All salaries and fringe benefits [including tuition] are based on best estimates of rates that will be in effect at the initiation of this project. Rates are increased by 3% annually to adjust for inflation. Estimates for travel and supplies are based on costs in effect at the time of preparation of this proposal, but are increased by 3% annually to adjust for inflation).			36.5%	0.54		\$92,984
Graduate Research Assistants (Two, one to work on each of Activities #1 & #2). Graduate Research Assistant (Position #1): GRA #1 will perform tasks associated with Activity 1, including assisting with field collection of		Perform field and laboratory tasks related to Activities #1 & #2. One GRA will complete development of thermal models and assist in developing phenologies, longevities and reproductive output of winter-active species amenable to laboratory observation and manipulation. The other GRA will do field collections of winter-active insects for molecular analyses, and will perform all follow-up lab procedures to isolate, amplify and characterize the gene sequences. This person will also analyze the implications of the gene sequences with respect to possible cryptic species or distinct physiological variants among winter-active species, and interpret their phenological patterns.			19.9%	3		\$176,716

<p>insect samples, sample processing, specimen identification, data analysis, thermal modeling. The GRA will devote 20 hrs/week (=50% appointment) per year to the project. This GRA will also supervise day-to-day activities of the undergraduate technicians #1 &amp; #3. Graduate Research Assistant (Position #2): GRA #2 will perform tasks associated with Activity #2, including field collection of insect samples, sample processing, DNA amplification &amp; interpretation, phylogenetic data analysis &amp; modeling, determinations of longevities, oviposition rates, rates of</p>								
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embryogenesis and larval hatching, and culturing for in-lab experimentation. The GRA will devote 20 hrs/week (=50% appointment) per year to the project. This GRA will also supervise day-to-day activities of the undergraduate technician #1.								
Field/Lab Undergraduate Technicians (2, one to work on each of Activities #1 & #2)		Field safety protocols for working in streams require teams of two or more persons to be present while collecting samples in streams. Each undergraduate assistant will work with the GRA and serve as the second person in the field team.			0%	1.56		\$37,554
Undergraduate Technician for online website development.		This undergraduate technician will work on website updates, expansion and all functionalities improvements.			0%	0.21		\$5,007
							<b>Sub Total</b>	<b>\$312,261</b>
<b>Contracts and Services</b>								
							<b>Sub Total</b>	-
<b>Equipment, Tools, and Supplies</b>								
	Tools and Supplies	Tools and Disposable Supplies: Activity 1--- Thirty electronic water temperature recording devices for field acquisition of temperature data @ \$ 135/device. To be used for "in situ" recording of	Facilitate sample collection, temperature data collection, studies of longevities and reproductive output, molecular genetics and other					\$31,424

		water temperatures at hourly intervals at all field sites/year. Sample jars, collecting nets and sieves, microscope slides, shelf vials, reagents for genetic analyses, specimen preservatives, forceps preservatives, slide storage boxes, supplies for specimen curation, measurement and long term storage. Activity 2: Sample jars, collecting nets and sieves, microscope slides, shelf vials, reagents for genetic analyses, specimen preservatives, forceps preservatives, slide storage boxes, and disposable clean-up and sanitizing supplies. Disposable laboratory chemicals and other kits for sample amplification, lab process, genetic analyses, specimen curation and measurement, long term storage and analyses.	research objectives. Some supplies are also needed for longterm maintainence and curation of specimens for archiving and future verifications using voucher specimens.					
							<b>Sub Total</b>	<b>\$31,424</b>
<b>Capital Expenditures</b>								
							<b>Sub Total</b>	-
<b>Acquisitions and Stewardship</b>								
							<b>Sub Total</b>	-
<b>Travel In Minnesota</b>								
	Miles/ Meals/ Lodging	Travel related to Activities 1 & 2 will be necessary to place electronic recording devices in streams, to collect biological samples at stream sample sites and retrieve recording devices after data are recorded. Includes costs of vehicle rentals from Fleet Services at the University of Minnesota, mileage charges, and anticipated lodging and per diem while on travel to complete field work. Travel will be to sample sites at streams, once a month for three months in winter each year to collect samples and download stream temperature recordings.	Monthly trips to sample ten streams per year, to set out and retrieve temperatures recording devices and collect winter-active insects for subsequent lab-based analyses.					\$44,002
							<b>Sub Total</b>	<b>\$44,002</b>

<b>Travel Outside Minnesota</b>								
							<b>Sub Total</b>	-
<b>Printing and Publication</b>								
	Publication	Publication of results in professional journals related to findings for Activities 1 & 2. We anticipate 2/3 publications per year for each year of the project	Transmit research findings to colleagues and other involved in basic and applied research related to freshwater research enterprise.					\$6,000
							<b>Sub Total</b>	<b>\$6,000</b>
<b>Other Expenses</b>								
		Purchase of permits: Permits are required to enter and sample in most state parks and must be obtained for special scientific and natural areas. Permits must be purchased annually for all persons performing field work. It is anticipated that several sample sites located in state parks, or protected waters that flow into or through state managed lands.	Needed so that field teams can sample headwater streams located in state parks along the western periphery of the Driftless Region.					\$695
		Tuition Fees for Graduate Research Assistants.	All GRA must be enrolled in graduate programs, and tuition reimbursement is required to be provided from research grants that the students are involved in for their thesis or dissertation research. Consequently, both GRA students employed in this research will integrate results from the project into their thesis or dissertation.					\$102,618
							<b>Sub Total</b>	<b>\$103,313</b>
							<b>Grand Total</b>	<b>\$497,000</b>

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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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: [a29428e2-e78.docx](#)

#### *Alternate Text for Visual Component*

This map (modified from MNDNR map of Designated Trout Steams) shows the location of designated trout streams in The Driftless Region of Minnesota. The streams that we have completed research on are located in the central portion and eastern edges of the Driftless Region and are located within the area outlined in blue. The streams that we propose to work in this proposed project are headwater streams that flow in an easterly or southeasterly direction to the central portion of the Driftless R...

### Optional Attachments

#### *Support Letter or Other*

Title	File
Letter of approval and support from the University of Minnesota SPA Unit.	<a href="#">bc02f6a3-a87.pdf</a>

## 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?**

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

This map (modified from MNDNR map of Designated Trout Steams) shows the location of designated trout streams in The Driftless Region of Minnesota. The streams that we have completed research on are located in the central portion and eastern edges of the Driftless Region and are located within the area outlined in blue. The streams that we propose to work in this proposed project are headwater streams that flow in an easterly or southeasterly direction to the central portion of the Driftless Region. All are located along western periphery of the Driftless Region and situated within the area outlined in red. Most are headwaters of designated trout streams managed as coldwater fisheries resources by MN DNR, but some are not officially designated as coldwater fisheries resources, but contain residual populations of trout, several of which are highly isolated populations of brook trout.



