



# Environment and Natural Resources Trust Fund

2021 Request for Proposal

## General Information

**Proposal ID:** 2021-161

**Proposal Title:** Threshold Resiliency with Increased Precipitation Uncertainty

## Project Manager Information

**Name:** Joe Magner

**Organization:** U of MN - College of Science and Engineering

**Office Telephone:** (612) 626-0875

**Email:** jmagner@umn.edu

## Project Basic Information

**Project Summary:** Minnesota decadal increases in precipitation have increased runoff, groundwater recharge, contamination, and infrastructure damage. ENRTF funded maps highlight landscapes at risk. We will assess and define critical ecological sustainability thresholds.

**Funds Requested:** \$1,899,000

**Proposed Project Completion:** 2024-06-30

**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): NE

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

Region(s): Metro

**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.**

We will address physical, chemical, and biological changes in NE Minnesota and the Hastings/Vermillion River watershed. Both rural and urban locations have experienced significant land-use change over multiple decades, while other areas are at risk pending future land-use. Minnesota has invested ENRTF dollars to create resource maps for citizens and scientists. Maps tell us which landscapes are most susceptible to adverse land-use change resulting in the loss of ecosystem services and water quality; yet fail to tell us threshold vulnerability of ecosystem sustainability, such as pollution because of increased precipitation. Currently, state agencies are focused on specific programs to protect and/or restore natural resources; however, a new threat exists that is not fully addressed by current programs. With a trend of increased precipitation, stream channels will erode and enlarge with increased runoff; higher water tables will result from more groundwater recharge and reduce wetland storage. Water quality will need to adjust to new hydrologic pathways and ecosystem shifts may reduce the current buffering capacity of the native plant and microbial communities. Proposed land-use development will superimpose a change in vulnerability that will increase the uncertainty for future sustainable terrestrial and aquatic life protection.

### **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 do not have a solution to the environmental threat based on current knowledge because we do not understand the limits of ecological resiliency given a loss of climatic stationarity. We seek funding to better understand current climate trends and how more precipitation will drive the physical, chemical, and biological attributes of selected watersheds in places like the Vermillion River Valley (outwash aquifer), and watersheds adjacent to the BWCA. We will conduct a comprehensive assessment of hydrologic processes, including precipitation, runoff, recharge, surface-groundwater connectivity, biogeochemical transformations, and the concordant terrestrial and aquatic biology. Our intent is to use innovative sensors, tools, and techniques to capture detailed information in sentinel sites embedded within 3D watersheds that contain streams, wetlands, lakes, and groundwater to establish current conditions and then compare data to past observations and model future trajectories of threshold resilience or system disequilibrium depending on the trend direction. State and local units of government are not mandated to perform this analysis; our work will provide guidance for future policy development. Long-term data acquisition sensors will be strategically placed to monitor physical, chemical and biological changes like the effort funded by ENRTF know as SLICE.

### **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?**

Outcomes will include understanding how current precipitation intensity and magnitude are changing water movement, storage, and quality of ecosystems in selected sentinel watersheds. This information will be translated for the public to better understand ecosystem resiliency and guide government officials on how to take action with constrained uncertainty. We will model possible and proposed land-use change activity superimposed upon a defined vulnerable landscape to determine if any critical thresholds have been or could be crossed beyond the natural resilience of the system. We will prepare a report that will guide state and local planners about climate and land-use change outcomes.

## Activities and Milestones

### Activity 1: Design, purchase and install data acquisition equipment to meet modeling outcomes

**Activity Budget:** \$800,419

**Activity Description:**

The objective of this activity will be to strategically design and implement a targeted data acquisition plan to support our ecosystem modeling efforts. This will be accomplished through three tasks:

Task 1: Define and locate systems and geographic logic to meet outcomes. We will aggregate previously collected data from government agencies, NGO's, and private initiatives to leverage as a historic record of past climatic and land-use activity; and use machine learning to find rich data sets to build upon for future sentinel system observation. Based on this analysis we will develop a targeted data acquisition plan.

Task 2: Acquire and deploy instrumentation. This instrumentation will include water level recorders and transducers, soil moisture sensors, and data loggers. Where possible we will upgrade data acquisition equipment to build robust data sets for trend analysis.

Task 3: Install the acquired instrumentation in selected nested locations. Sites will be selected in consultation with state and local officials to upgrade past efforts. Locations include watersheds in the Vermillion River Valley (outwash aquifer), and watersheds adjacent to the BWCA.

**Activity Milestones:**

Description	Completion Date
Design a statistically representative data collection network	2021-12-31
Purchase sensors, wells, data loggers and other equipment.	2022-01-31
Drill monitoring wells a selected locations	2022-06-30
Define and locate systems and geographic logic to meet outcomes	2022-06-30
Install the acquired equipment in selected nested locations.	2022-08-31

### Activity 2: Collect, analyze and interpret data

**Activity Budget:** \$498,581

**Activity Description:**

The objective of this activity will be to quantify the relationship between water storage, biogeochemical parameters, and fluxes on ecosystem vulnerability.

Task 1: Evaluate precipitation historical field data, meta-analysis results, and satellite data, with a particular focus on vegetative productivity and environmental sustainability.

Task 2: Hydrologic analyses. We will collect time-series measurements for soil moisture and evapotranspiration, as well as monthly grab samples of precipitation, streamflow, seasonal plants, and soil for dual-isotope fingerprinting. We will analyze time-series data alongside grab samples to better understand how, where, and when water is moving through the ecosystem.

Task 3: Biogeochemical analyses. We will collect water and shallow sediment core samples for biological and biogeochemical analyses. Water quality chemical analyses will include major cations and anions, N and P nutrients, iron, sulfur speciation, and total organic carbon; as well as stable isotopes for major elements. Total microbial (fungal and bacterial) communities will be analyzed using high throughput DNA sequencing and qPCR of key functional genes for biogeochemical N and S cycles. Aquatic emergent vegetation (e.g., wild rice density) and habitat space (e.g., embeddedness of riffle rocks) will be assessed concurrently.

**Activity Milestones:**

Description	Completion Date
Initial data sets from sensors transmitted to researchers	2022-12-31
Collect a comprehensive data set over four seasons	2023-09-30
Field collect selected biological data	2023-10-31
Perform statistical analysis on all data collected	2023-12-31
Analyze data sets to understand how parameters affect ecosystem vulnerability.	2023-12-31

### Activity 3: Model biogeochemical, aquatic, terrestrial, and the hydrologic response to increased precipitation

**Activity Budget:** \$600,000

#### Activity Description:

The objective of this activity will be to use the data gathered in Activity 2 to calibrate hydrogeologic models for groundwater flow and storage and to use the calibrated models to predict ecosystem responses associated with increased precipitation. This will be accomplished by developing and applying an integrated modeling framework that accounts for aspects of ecosystem function as well as groundwater dynamics. We will carry out the following tasks:

Task 1: Develop a conceptual sand/gravel hydrogeologic site model that includes well-pumping dynamics.

Task 2: Develop a 3D fracture flow model that simulates water movement and storage in the fractured zone.

Task 3: Evaluate how changes in precipitation and land-use affect groundwater dynamics, vadose storage, plant, and biotic health.

Task 4. Develop a soil-water/plant model to integrate with hydrogeologic models developed in Tasks 1 and 2.

Task 5. Apply an integrated modeling framework to simulate increased precipitation scenarios and predict potential ecosystem responses, including changes to microbial communities, aquatic emergent vegetation, and habitat space for aquatic organisms.

#### Activity Milestones:

Description	Completion Date
Quantify the effects of Darcian and fracture flows on ecosystem vulnerability	2022-03-31
Quantify potential effects to aquatic habitat space and emergent vegetation	2023-12-31
Quantify biogeochemical changes in the vadose zone, surface and groundwater	2023-12-31
Quantify plant evapotranspiration, recharge and runoff at selected locations	2023-12-31

## Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Euan Reavie	NRRI	Dr. Euan Reavie, Senior Research Associate & Assistant Initiative Director at NRRI, will serve as a collaborator responsible for providing guidance and oversight regarding biological and ecological analyses and assistance advising the postdoctoral researcher.	Yes
Salli Dymond	UMD	Co-PI	Yes
Peter Kang	UMN	Co-PI	Yes
Bridget Ulrich	NRRI	Dr. Ulrich, Aqueous Geochemist at NRRI, will serve as Co-PI. She will be responsible for overseeing geochemical analyses and data analysis and co-supervising project staff at NRRI.	Yes
John Nieber	UMN	Co-PI	No
Jason Ulrich	Minnesota Science Museum	Co-PI	Yes
Chan Lan Chun	UMD	Dr. Chan Lan Chun, Assistant Professor of Civil Engineering at UMD with a joint appointment at NRRI, will serve as a collaborator responsible for overseeing microbial and biological analyses and data analysis and co-supervising project staff at NRRI.	Yes
Valerie Brady	UMD	Dr. Valerie Brady, Research Associate at NRRI, will serve as a project collaborator. She will be responsible for providing technical guidance regarding biological analyses.	Yes

## 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?**

This work will be transferred to state agencies where Legacy funds can be used to continue the Sentinel effort. If our findings suggest immediate action is required we will work with the Legislature to craft language to expand the effort beyond the selected study areas.

## Project Manager and Organization Qualifications

**Project Manager Name:** Joe Magner

**Job Title:** Research Professor

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

Joe Magner is a licensed professional hydrologist (WI), a licensed professional soil scientist (MN), and an American Institute of Hydrology registered professional hydrogeologist. He received degrees from the University of Wisconsin-River Falls and the University of Minnesota and has served as an environmental scientist and educator in varying roles for over 40 years; primarily with the MN Pollution Control Agency but also advising US federal and local governments, and officials in China, India, Azerbaijan, and South Africa. Dr. Magner is a research professor in the Department of Bioproducts & and Biosystems Engineering at the University of Minnesota. He teaches classes and advises students in water quality, hydrology/soils, ecological engineering, and watershed management. Joe has successfully advised over 41 graduate students along with 95+ publications. Joe is a co-author of the 4th edition of Hydrology and the Management of Watersheds published by Wiley-Blackwell (2013). Dr. Magner has a proven track record of managing large grants and directing studies with professional staff, postdocs, graduate students, and undergrad students. He has advised clients such as David Letterman, the California Water Board, the Red River Basin Commission, private sector consultants, the Environmental Defense Fund, and The Nature Conservancy.

5/15/2020

**Organization:** U of MN - College of Science and Engineering

**Organization Description:**

The University of Minnesota is a public research university in Minneapolis and Saint Paul, Minnesota. It is the oldest and largest campus within the University of Minnesota system and has the sixth-largest main campus student body in the United States, with 51,580 students enrolled in Fall, 2016. The UMN is one of America's Public Ivy universities, which refers to top public universities in the United States capable of providing a collegiate experience comparable with the Ivy League. Founded in 1851, The University of Minnesota is categorized as an R1 Doctoral University with the highest research activity in the Carnegie Classification of Institutions of Higher Education. The University of Minnesota ranks eighth among U.S. public universities in research spending and generates an estimated \$8.6 billion annual economic impact for the state of Minnesota.

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
Joe Magner		Principal Investigator			36.5%	0.45		\$80,422
Peter Kang		Co-Principal Investigator			36.5%	0.12		\$29,061
Salli Dymond		Co-Principal Investigator			36.5%	0.12		\$49,908
Chan Lan Chun		Collaborator			36.5%	0.18		\$29,451
Bridget Ulrich		Co-Principal Investigator			36.5%	0.3		\$36,812
Euan Reavie		Collaborator			36.5%	0.12		\$23,598
Valerie Brady		Research Associate, Collaborator, provide guidance regarding aquatic ecological analyses.			36.5%	0.03		\$3,798
NRRI Post Doc		Researcher			25.4%	1.5		\$96,900
Graduate Research Assistant		Research Assistant, Bioproducts & Biosystems			45%	1.5		\$149,334
Graduate Research Assistant		Research Assistant, Bioproducts & Biosystems			45%	1.5		\$149,334
Graduate Research Assistant		Research Assistant, CSE Earth Sciences			39%	1.5		\$127,102
Graduate Research Assistant		Research Assistant, NRRI			51%	0.5		\$67,608
Undergraduate Research Assistant		Undergraduate Research Assistant, Bioproducts and Biosystems			0%	1.14		\$29,005
Undergraduate Research Assistant		Undergraduate Research Assistant, NRRI			0%	0.5		\$12,667
Tony Runkel		Chief Geologist at MGS, fracture and borehole characterization			31.8%	0.75		\$63,144
Julia Agnich		Technician			31.8%	0.15		\$9,885
Scott Alexander		Technician, overseeing drilling process and conducting tracer experiments			31.8%	0.3		\$26,215
Researcher		Researcher, NRRI			31.8%	1.5		\$96,509

Derrick Ferguson		Technician			31.8%	0.15		\$9,885
Aaron Pietsch		Technician			31.8%	0.15		\$9,885
							<b>Sub Total</b>	<b>\$1,100,523</b>
<b>Contracts and Services</b>								
Science Museum of Minnesota	Sub award	The grantee will work with PI Dr. Magner to provide data analysis and modeling assistance for understanding the physical, chemical and biological changes associated with increased precipitation in Minnesota. The grantee will focus on collecting and analyzing climate and topographical data.				1.05		\$86,000
Professional Services	Professional or Technical Service Contract	core drilling and well construction				-		\$50,000
Professional Services	Professional or Technical Service Contract	rotary-sonic drilling (4660 per 60 foot hole; boxes (\$10 per 2 foot box) transducers, perisaltic pump, water sampling supplies Major cation /anion and isotope analysis				-		\$89,070
							<b>Sub Total</b>	<b>\$225,070</b>
<b>Equipment, Tools, and Supplies</b>								
	Equipment	Equipment	YSI multi-parameter probe - 6 @ \$12,000; CSI Weather Station - 2 @ \$16,460 for North and South locations					\$104,920
	Tools and Supplies	Lab and Medical Supplies	OTT Bubble Level Sensors and data logger - 6; Cellular Modem for wireless communication - 6					\$32,860
	Tools and Supplies	Lab and Medical Supplies	NRRI					\$16,000
	Tools and Supplies	Lab and Medical Supplies	general operating supply costs for field works					\$3,000
	Tools and Supplies	Lab and Medical Supplies	Atmospheric/ET/soil moisture at 6 locations in 5 watersheds; \$1300 per station x 30. Extra equipment in years 2					\$47,600



			and 3, Vials, parafilm, General tools for building monitoring stations; field supplies					
	Tools and Supplies	Non-Capitalized Computer Hardware/Software	Laptop computer and software - 2					\$4,200
	Tools and Supplies	Non-Capitalized Lab Scientific or Field Equip	NRRI					\$16,000
	Tools and Supplies	Non-Capitalized Lab Scientific or Field Equip	Batteries, enclosures, solar panels and wiring materials					\$78,355
	Tools and Supplies	Non-Capitalized Lab Scientific or Field Equip	pressure/conductivity/temp/tracer probes, Flute liner purchases					\$47,000
							<b>Sub Total</b>	<b>\$349,935</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	Domestic travel cost for visiting a field site.	Peter Kang, domestic travel cost for visiting a field site and conducting field experiments.					\$6,000
	Miles/ Meals/ Lodging	Travel to sample and assist with field installation	Salli Dymond, Travel to sample and assist with field installation					\$9,000
	Miles/ Meals/ Lodging	Travel to the BWCA	Magner, Travel to the BWCA					\$15,000
	Miles/ Meals/ Lodging	NRRI Travel	NRRI Travel					\$11,000
							<b>Sub Total</b>	<b>\$41,000</b>
<b>Travel Outside Minnesota</b>								
	Conference Registration Miles/ Meals/ Lodging	Travel for AGU conference in final year of project	Salli Dymond, Travel for AGU conference in final year of project					\$2,472

							<b>Sub Total</b>	<b>\$2,472</b>
<b>Printing and Publication</b>								
	Publication	Magner, Report prep and graphic designer and Journal publication	Report prep and graphic designer and Journal publication					\$60,000
							<b>Sub Total</b>	<b>\$60,000</b>
<b>Other Expenses</b>								
		General Operating Services	NRRI, shipping costs					\$1,000
		Lab Services	NRRI, Geochemical sample analyses, DNA sequencing and molecular biological analyses, Vegetation analysis.					\$89,000
		Lab Services	Dymond, Bulk water isotopes \$5/sample x 30 samples sites x 12 months/year; Soil water isotopes \$15/sample x 60 samples sites x 4 months/year; Plant water isotopes \$15/sample x 60 samples sites x 4 months/year					\$27,000
		Short Term Rents & Leases	Kang, Borehole geophysics tool rental					\$3,000
							<b>Sub Total</b>	<b>\$120,000</b>
							<b>Grand Total</b>	<b>\$1,899,000</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
<b>State</b>				
			<b>State Sub Total</b>	-
<b>Non-State</b>				
			<b>Non State Sub Total</b>	-
			<b>Funds Total</b>	-

## Attachments

### Required Attachments

#### *Visual Component*

File: [ab3fce53-302.pdf](#)

#### *Alternate Text for Visual Component*

MGS map layers were used to create this map prepared by Eric Porcher to identify geographic locations in Minnesota where system resilience may be at risk because of climate and/or land-use change.

## Administrative Use

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

No

**Does your project have patent, royalties, or revenue potential?**

No

**Does your project include research?**

Yes

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

Yes, Sponsored Projects Administration

# Water Table Aquifer Vulnerability

