



# Environment and Natural Resources Trust Fund

## 2021 Request for Proposal

### General Information

**Proposal ID:** 2021-195

**Proposal Title:** Changing Snowmelt Impacts Minnesota Forests, Streams, and Groundwater

### Project Manager Information

**Name:** Kate Brauman

**Organization:** U of MN, Institute on the Environment

**Office Telephone:** (612) 625-7591

**Email:** kbrauman@umn.edu

### Project Basic Information

**Project Summary:** Changing snow and forests will affect water in soil and stream in unknown ways. By collecting field data and developing prediction tools, we can improve management of Minnesota's water resources.

**Funds Requested:** \$607,000

**Proposed Project Completion:** 2023-06-30

**LCCMR Funding Category:** Water Resources (B)

### Project Location

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

Statewide

**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.**

Snow and forests are essential to life in Minnesota. However, both Minnesota's winter precipitation and the composition and extent of our forests are changing, with potentially dramatic impacts on our water resources. Interaction between snowmelt and forests controls groundwater and surface water quantity and quality, and future tradeoffs are uncertain. For example, earlier snowmelt could increase forest water use, with more transpiration over a longer growing season reducing groundwater recharge and runoff to streams. Alternately, earlier snowmelt could reduce forest water use by concentrating forest water supply in soils during colder periods when forests use less water. Understanding which processes will dominate and how rivers and aquifers will respond is critical to managing Minnesota's water resources. Snow dynamics in the Midwest are critically understudied, however. Most snow studies have been done in the mountains of the western US, where the climate and landscape are substantially different. We expect snowmelt response and interactions with forests in the lower-relief topography, generally wetter climate, and unique ecosystems of Minnesota to have distinct patterns. Understanding snowmelt and its interaction with forests is critical to managing Minnesota's iconic landscapes and the availability and quality of water recharging groundwater and running to streams.

### **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 investigate how snowmelt affects the delivery of water, and the dissolved organic carbon and sediment it carries, from forested uplands to streams, addressing:

- 1) Impacts on ecosystems: What proportion of forest water use comes from snowmelt-sourced soil water?
- 2) Impacts on flood risk: How does the timing of snowmelt and soil frost and melt affect the magnitude of spring runoff?
- 3) Impacts on groundwater resources: How does snowmelt affect the partitioning between runoff, soil water, and aquifer recharge?
- 4) Impacts on surface water quality: How does snowmelt mediate the delivery of dissolved organic carbon and sediments from forests into streams?

We will work at (1) the USDA Marcell Experimental Forest near Grand Rapids, MN (Itasca County), with peatland and northern forests; (2) Cedar Creek Ecosystem Science Reserve in central Minnesota (Anoka County), with mixed prairies and oak savannas; and (3) a research station near Duluth, MN (St Louis County), a forested area that was agricultural. We will collect data on snow, plant water use, and water chemistry from snowpack to stream outlets, which we will use to develop predictive tools. We will work with natural resource managers to ensure the successful transfer of our findings to stakeholders.

### **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?**

- 1) We will develop a dataset of water, solute, and sediment fluxes that will provide critical baseline data for this and future studies of Minnesota water resources in a changing climate.
- 2) We will use this dataset to understand and predict the fate of snow through soils, plants, and streams, thereby addressing impacts on ecosystems, floods, groundwater resources, and water quality.
- 3) We will inform water management throughout Minnesota and the Midwest by working closely with natural resource managers to communicate our data and analyses in formats useful to our partners.

## Activities and Milestones

### Activity 1: Data collection on sites, plants, snow, and water chemistry

**Activity Budget:** \$409,603

**Activity Description:**

Data collection at all three field sites will be jointly led by Co-Investigators Dymond, Karwan, and Wickert. We will trace water movement from its origin on the landscape (snowpack) through its intermediate pathways (as overland flow above ground or through soils below ground) to its eventual destination (taken up by plants, into streams, or into groundwater). At each site, we will collect soil and plant data to characterize our sites. This will allow us to generalize our findings to all of Minnesota. In addition, we will monitor water storages (snowpack, soil moisture, and groundwater), fluxes (precipitation, streamflow, infiltration), and chemistry (dissolved organic carbon and sediment) by installing monitoring equipment along three transects at each site. This will allow us to capture spatial variability. Our monitoring plan is based on using inexpensive and open-source sensors and data loggers for monitoring and sampling different components of the water budget. This will provide cost savings in instrument acquisition and also cost savings in maintenance beyond the funded project duration. We will analyze melt-season stream-water samples from each of our field sites for total suspended solids, the key measurement of sediments, and dissolved organic carbon.

**Activity Milestones:**

Description	Completion Date
Characterization of soil and plants across three transects at each study site	2022-07-31
Water chemistry lab analyses	2023-06-30
Field data collected on water storage, flow, and water chemistry	2023-06-30

### Activity 2: Development of Assessment Tool to Predict Snow and Forest Effects on Water Balance

**Activity Budget:** \$124,082

**Activity Description:**

Co-investigators Feng and Ng will jointly lead work to incorporate data collected in Activity 1 into a computational assessment tool that predicts how changes in snow amounts can affect our rivers, aquifers, and forests. This work builds off Ng’s ongoing LCCMR project through which an “ecohydrological” computer model is being implemented over Minnesota to predict how changes in vegetation affect groundwater recharge. Here, we will add new field data and detailed snowmelt calculations developed by Feng to develop an updated computer model that can also accurately assess changes in snowmelt and determine its effect on plant water-use, streamflow, and groundwater recharge. Results from the computer model will be used to predict how forest ecosystems, flooding, stream quality, and groundwater reservoirs respond to variations in snow amounts and timing in settings represented by the study sites. Because the study sites span major types of physical and ecological conditions found across the state, our resulting assessment tool can be extended to state-wide applications in the future. This will help all Minnesotans better understand and prepare for changes in flood risks and water and forest resource availability as snow patterns shift.

**Activity Milestones:**

Description	Completion Date
Develop computational assessment tool for predicting snow impacts on flooding and water and forest resources	2022-06-30
Incorporate data from the three field sites into the computational assessment tool	2023-01-31
Use tool to assess flood risks and resource impacts at the representative sites	2023-06-30

### Activity 3: Coordination and outreach with forest and water managers across Minnesota

**Activity Budget:** \$73,315

**Activity Description:**

It is integral to our work that the data we generate are summarized and analyzed in ways useful outside of academia. Ensuring that our findings are clearly communicated to interested parties is an ongoing part of this project. Investigator Brauman will facilitate discussions with natural resource managers across the state to ensure relevant research directions at the project start and the successful transfer of final results to appropriate stakeholders. This builds on Brauman’s ongoing LCCMR-funded work to summarize and communicate downscaled climate data for Minnesota. We will leverage already-planned meetings and working groups related to that work to gain preliminary insight into the types of analysis of most interest to stakeholders and how they are likely to use this information once we generate it. We will also hold a public forum at the end of the project to help communicate our findings to the public and to garner their feedback on future projects and proposals. We anticipate some of our stakeholders to include, but not be limited to, the MN EQB, MN Department of Natural Resources, MN Pollution Control Agency, MN Department of Health, MN Department of Transportation, the Metropolitan Council, USDA Forest Service, NOAA, and USGS.

**Activity Milestones:**

Description	Completion Date
Stakeholder input on relevant data and useful analysis	2022-06-30
Public forum to communicate our findings	2023-06-30

## Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Andrew Wickert	University of Minnesota - Twin City	McKnight Land-Grant Assistant Professor, Department of Earth and Environmental Sciences	Yes
Gene-Hu Crystal Ng	University of Minnesota - Twin City	Assistant Professor, Department of Earth and Environmental Sciences	Yes
Xue Feng	University of Minnesota - Twin City	Assistant Professor, Department of Civil, Environmental, and Geo-Engineering	Yes
Diana Karwan	University of Minnesota - Twin City	Assistant Professor, Department of Forest Resources	Yes
Salli Dymond	University of Minnesota - Duluth	Assistant Professor, Swenson College of Science and Engineering	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?**

We anticipate that this project will jump-start larger collaborations and we commit to seeking funding from federal institutions, including the National Science Foundation, the Department of Energy, and the USGS Climate Adaptation Research Science Center. We will also apply for University of Minnesota funds to expand and extend this work.

## Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Understanding Water Scarcity, Threats, and Values to Improve Management	M.L. 2015, Chp. 76, Sec. 2, Subd. 04a	\$234,000
Assessment Tool for Understanding Vegetation Growth Impacts on Groundwater Recharge	M.L. 2016, Chp. 186, Sec. 2, Subd. 03f	\$212,000
Hydrologic Effects of Contemporary Forest Practices in Minnesota	M.L. 2015, Chp. 76, Sec. 2, Subd. 03r	\$150,000
Landslide Susceptibility, Mapping, and Management Tools	M.L. 2017, Chp. 96, Sec. 2, Subd. 03i	\$500,000

## Project Manager and Organization Qualifications

**Project Manager Name:** Kate Brauman

**Job Title:** Lead Scientist

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

Dr. Kate Brauman's research quantifies and communicates how changes in nature affect human wellbeing, with a particular focus on water resources. Building on approaches from hydrology, land use change science, economics, and policy, Brauman's work quantifies how water use by people affects the environment and our ability to live well in it. Brauman's project management experience includes serving as a Coordinating Lead Author for the Global Assessment of

the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). She also leads an international, interdisciplinary project to work closely with Investment in Watershed Services projects throughout South America, evaluating their current and future effectiveness. Closer to home, Brauman was tapped by the Minnesota State Government's Environmental Quality Board to identify relevant science for the 2020 State Water Plan focused on water and climate. In addition to research, Brauman is committed to and skilled at communication with the general public. In recognition of her commitment to public engagement, in 2017 Brauman was named an American Academy for the Advancement of Science (AAAS) Leshner Leadership Fellow in Science Engagement.

**Organization:** U of MN - Twin Cities

**Organization Description:**

The mission of the University of Minnesota's Institute on the Environment is to lead the way toward a future in which people and the environment prosper together. The Institute on the Environment (IonE) exists to accelerate the transition toward a more hopeful and sustainable future, while also preparing leaders and scholars for uncertainties that arise along the way. IonE supports breakthrough research across disciplines, develops the next generation of global leaders, and builds transformative partnerships across the state, region and globe. Current IonE topical foci are:

- illuminating the value of nature, often for people but also in its own right
- accelerating the transition to an economy based on renewable energy
- informing land use decisions so we can feed a growing global population without degrading planetary systems
- collaborating with the private sector to develop sustainable solutions to production and consumption challenges
- working with communities to build resilience and adapt to a changing climate
- reducing risk of water shortage in an increasingly resource-constrained world

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
Principal Investigator - Kate Brauman		Project management, lead stakeholder engagement in Activity 3			36.5%	0.5		\$67,315
Co-Investigator - Salli Dymond		Lead field sampling in Activity 1			36.5%	0.3		\$11,226
Co-Investigator - Diana Karwan		Lead water chemistry in Activity 1			36.5%	0.3		\$15,057
Co-Investigator - Xue Feng		Co-lead modeling in Activity 2			36.5%	0.3		\$14,135
Co-Investigator - Gene-Hu Crystal Ng		Co-lead modeling in Activity 2			36.5%	0.3		\$14,653
Co-Investigator - Andrew Wickert		Lead instrumentation design in Activity 1			36.5%	0.3		\$13,624
Instrumentation Technician		Design, construct, and co-deploy instrumentation networks. Manage networks and maintain telemetry.			31.8%	0.96		\$82,868
1 Graduate Research Assistants - Duluth		field monitoring and data collection. Cost for one year academic salary and two years of summer salary for an MS student. Student will be advised in Duluth by PI Dymond and will work on the field and chemistry component of the project.			72%	1.26		\$55,816
1 Graduate Research Assistant - CFANS		field monitoring and data collection. Cost for one year academic salary and two years of summer salary for an MS student. Student will be advised in Duluth by PI Karwan and will work on the field and chemistry component of the project.			72%	1.26		\$55,816
1 Graduate Research Assistant - CSE		Snow dynamics model development - co-advised by Xue and Crystal - we plan on coordinating recruiting efforts too, so at this point don't know if student will be in ES or CEGE.			78%	2		\$103,526
1 Undergraduate		Field technical and laboratory analysis. Cost for two years of summer support for a field technician to assist with field work (\$11.50/hr). Includes 150			0%	1		\$17,250

Research Assistant		hours for laboratory analyses during the academic year.						
							<b>Sub Total</b>	<b>\$451,286</b>
<b>Contracts and Services</b>								
Water Chemistry Analysis of Isotopes	Professional or Technical Service Contract	Lab Analyses – water chemistry analysis of isotopes, TSS, DOC. Based on cost for 2H/18O in water and plants to be analyzed at UMD Stable Isotopes Facility; flourecense analysis at UMN; TSS analysis to be analyzed at UMD; DOC analysis to be analyzed RAL				0		\$60,295
							<b>Sub Total</b>	<b>\$60,295</b>
<b>Equipment, Tools, and Supplies</b>								
	Tools and Supplies	Field supplies	Field supplies for water sampling. Supplies to build soil lysimeters (includes PVC, rubber tubing, epoxy, stoppers). Includes \$100/lysimeter x 2 depths x 27 sites					\$11,900
	Tools and Supplies	Lab supplies	Lab supplies for water quality analysis. Costs for pumps and bottles to collect water samples from groundwater and soil pore water. Costs include Nalgene bottles (\$500) and peristaltic pump (\$1000 x 2).					\$2,000
	Equipment	Sensors	Sensors – non-capital – soil moisture, groundwater pressure transducers, data loggers, stream gauges, snow-depth gauges, T/P/RH gauges, telemetry. Additional solar radiation sensors to monitor energy budget at each field site. \$3000/sensor x 3					\$50,374
	Tools and Supplies	Forum supplies	Materials, facility rental, and travel reimbursement for attendants at our public forum to share findings with key stakeholders					\$1,000
							<b>Sub Total</b>	<b>\$65,274</b>



<b>Capital Expenditures</b>								
		Weighing rain gauge	Weighing rain gage for snow and rain					\$5,145
							<b>Sub Total</b>	<b>\$5,145</b>
<b>Acquisitions and Stewardship</b>								
							<b>Sub Total</b>	-
<b>Travel In Minnesota</b>								
	Miles/ Meals/ Lodging	Field travel	Travel to field sites and accommodation while there for Pls and students, travel to stakeholder meetings					\$19,000
	Miles/ Meals/ Lodging	Team meetings travel	Travel to team meetings					\$3,000
							<b>Sub Total</b>	<b>\$22,000</b>
<b>Travel Outside Minnesota</b>								
							<b>Sub Total</b>	-
<b>Printing and Publication</b>								
	Publication	Publication Fees	Open acces publication fees, printed materials for stakeholders					\$3,000
							<b>Sub Total</b>	<b>\$3,000</b>
<b>Other Expenses</b>								
							<b>Sub Total</b>	-
							<b>Grand Total</b>	<b>\$607,000</b>

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
<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: [f6eda6a5-816.pdf](#)

#### *Alternate Text for Visual Component*

Snow, water, and forest monitoring will be undertaken at three sites across the state. At each site, we will take measurements down a hillslope and in stream channels. We will develop a tool to organize and synthesize the information we collect to predict changes in water availability, water quality, floods, and forests. Our findings will be regularly communicated with stakeholders, and the feedback they provide will be integrated into the project tools.

### Optional Attachments

#### *Support Letter or Other*

Title	File
Snow and Forests data to predict impact on people	<a href="#">86f4f915-417.pdf</a>
Letter of Support - Marcell Experimental Forest	<a href="#">0295742a-07d.pdf</a>
Letter of Support - Cedar Creek Ecosystem Science Reserve	<a href="#">9bf6c9ed-dd1.pdf</a>

## 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?**

No

# Changing Snowmelt Impacts Minnesota Forests, Streams, and Groundwater



