



Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-129

Proposal Title: Causes and consequences of lake water quality change

Project Manager Information

Name: Gretchen Hansen

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

Office Telephone: (612) 624-4228

Email: ghansen@umn.edu

Project Basic Information

Project Summary: Understanding causes and consequences of changing water clarity in Minnesota's lakes can enable effective conservation and prioritize actions to locations where it will have the highest impact for fish habitat

Funds Requested: \$397,000

Proposed Project Completion: June 30 2025

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.

Lakes are critical for Minnesota's economy and culture. A lake's water quality is affected by land use, climate, and morphology. Changes in water quality impact recreational value and the fish community that a lake can support. Water clarity is a comprehensive indicator of water quality in lakes that is directly linked to ecosystem processes, economic value, and human use of water. Water clarity is changing in lakes across Minnesota - in some cases clarity is increasing, but in other lakes it is declining. Often, neighboring lakes are trending in opposite directions. Variable trends may be due to sensitivity to climate change and legacy nutrient effects, differences in characteristics such as size and depth, or land management practices. Water clarity impacts recreational use of lakes, suitability for important fish species, and lake responses to climate change. For example, clear water is associated with higher property values, but also with lower production of walleye and higher warming rates. Conversely, algal blooms negatively impact human and animal health and lead to anoxia and fish kills, especially as the climate warms. Effective management of water quality requires documenting the causes and consequences of changes and using this information to prioritize actions.

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 propose to integrate diverse datasets to document trends and identify drivers of water quality change across Minnesota lakes. Water clarity data are collected by many groups, but rarely are these data integrated at large scales. Working with established partnerships, we will leverage state, federal, and tribal agency data and expertise, citizen science, and remote sensing to quantify lake-specific trends. Cutting-edge statistical methods will be used to identify patterns in water clarity trends and their drivers across for approximately 1,000 lakes. We will document the roles of watershed land use, invasive zebra mussels, precipitation patterns, lake features, and lake temperatures. Because we know that different lakes respond differently, we will identify factors that make some lakes more sensitive to these changes. This broad scale, data intensive approach will provide powerful information on water clarity trends and characteristics of lakes that are most sensitive to change. We will use this information to guide our selection of case study lakes and watersheds with the high quality data necessary to examine causation more directly. Finally, we will link changes in clarity and associated consequences to temperature and oxygen to estimate individual lake suitability for economically important fish species across diverse lake types.

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?

Quantifying lake-specific trends in water clarity will identify locations where water quality has been degraded. This information will be publicly available. Identifying the drivers of changes will facilitate more effective management to enhance and preserve water quality in diverse lake types. Identifying sources of variation in lake responses will enable prioritization of management action to locations where it is most likely to be effective. Finally, we can identify locations where changing water clarity is likely to have negative consequences for fish communities. We will communicate this information with a public-facing web tool which will facilitate prioritization of conservation.

Activities and Milestones

Activity 1: Variability in water quality trends in lakes across Minnesota

Activity Budget: \$130,564

Activity Description:

Lake water clarity is an indicator of water quality, trophic status, and habitat condition. Changes in clarity impact lake ecosystems and may reflect changes in nutrient loading, land management, the presence of invasive species, precipitation regimes, and temperature. We will quantify changes in lake water clarity in lakes throughout Minnesota using data collected by state agencies, citizen monitoring, and via remote sensing. Based on previous work, we know that trends in water clarity vary among lakes. We will use statistical models to identify drivers of differential water clarity trends on a statewide scale, including changing land use, precipitation, temperature, and the presence of invasive species. We will explicitly account for interactions among local and regional drivers to identify lake or watershed characteristics that make some lakes more sensitive to changes than others. Annual and seasonal patterns will be integrated into LakeBrowser and within the Regional Lakes Monitoring network to communicate results to watershed managers and the general public.

Activity Milestones:

Description	Completion Date
Collate water clarity and land use change data for lakes in Minnesota	June 30 2023
Quantify lake specific trends in water clarity across Minnesota	December 31 2023
Identify drivers of water clarity trends in 1,000 Minnesota lakes	December 31 2023
Integrate information on clarity and land use change into public facing web application	June 30 2024

Activity 2: Case studies to understand mechanisms driving water quality change and its consequences for lakes

Activity Budget: \$137,070

Activity Description:

The causes of water quality changes are often complex, and linked to both watershed and in-lake factors. Leveraging large investments in monitoring and modeling, we will integrate diverse information to identify the underlying causes of change for a representative subset of lakes identified in Activity 1, that have detailed information to support analyses. Changes in water quality may be linked to landscape changes in land use and cover (e.g. suburbanization); invasive species (e.g. zebra mussels), in lake management (e.g. chemical treatment), legacy nutrients from historical loading and climate (e.g. warming leading to low oxygen and release of nutrients), or interactions among them. Since sensitivity to these factors changes with lake size, depth, and watershed hydrogeology, we will include a range of representative lake features in our analyses.

Data and models necessary to examine these factors exists but is widely dispersed. We will integrate information from public databases, local, state and federal monitoring programs, and remote sensing and GIS. This approach will allow identification of causes of changes, and translate them to their impacts on dissolved oxygen and lake productivity, providing quantitative understanding of changes that can be used to inform further management of lakes and watersheds.

Activity Milestones:

Description	Completion Date
Identify 15-25 focal lakes and their watersheds for detailed analyses of changes	June 30 2023

Assemble and analyze data focal lakes to identify key controls of lake responses	April 30 2024
Identify effects of clarity change on light, dissolved oxygen and productivity	March 31 2025

Activity 3: Impacts of water clarity changes on fish habitat

Activity Budget: \$129,366

Activity Description:

Changing water clarity has important implications for fish communities in Minnesota lakes. For example, walleye prefer dark or turbid water, while bluegill and bass prefer clearwater environments. Declining water clarity associated with algal blooms can reduce cool and coldwater fish habitat by reducing available oxygen in deeper, cooler waters. Furthermore, water clarity influences how lake temperatures respond to climate, with clearer lakes warming more quickly than turbid lakes.

We will leverage previously funded work to examine the sensitivity of fish habitat to changes in water clarity. We will estimate changes in the suitability of individual lakes for various fish species due to changes in water clarity and the associated temperature and dissolved oxygen response. We will use model predictions under realistic scenarios of water quality change to identify lakes and lake types where the consequences of water clarity change on fish species are likely to be largest. Results will be communicated to the public and to DNR fish managers using a web-based mapping tool demonstrating suitability of individual lakes for fish species of interest, including walleye, northern pike, cisco, yellow perch, largemouth bass, and bluegill.

Activity Milestones:

Description	Completion Date
Predicted fish habitat and community changes in 1000 lakes given water clarity trends	June 30 2024
Identification of lakes most sensitive to clarity change in terms of loss of fish habitat	December 31 2024
Develop web tool for communicating consequences of water clarity change on fish communities	June 30 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jacques Finlay	University of Minnesota	Co-PI	Yes
Naomi Blinick	University of Minnesota	Project partner	No

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?

Lake-specific water clarity trends and their drivers will be disseminated via webinars and scientific papers. Mechanisms driving diverse responses of water quality to environmental stressors will be identified in collaboration with watershed groups and communicated via webinars (e.g., the Midwest Glacial Lakes Partnership Lake Conservation Webinar Series, <https://midwestglaciallakes.org/resources/webinars/>). We will document our findings in a storymap-style website. This website will target Minnesotans interested in water quality and fish communities and explain our findings and what it means for effective management of watersheds to protect and conserve valued fish populations.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Assessing the Increasing Harmful Algal Blooms in Minnesota Lakes	M.L. 2016, Chp. 186, Sec. 2, Subd. 04b	\$270,000
Assessment of Surface Water Quality With Satellite Sensors	M.L. 2016, Chp. 186, Sec. 2, Subd. 04i	\$345,000
Determining Risk of a Toxic Alga in Minnesota Lakes	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 06f	\$200,000

Project Manager and Organization Qualifications

Project Manager Name: Gretchen Hansen

Job Title: Assistant Professor

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

Dr. Gretchen Hansen will serve as the project manager and lead PI of the proposed work. Dr. Hansen is an assistant professor in the University of Minnesota Department of Fisheries, Wildlife, and Conservation Biology and will serve as the primary advisor to the graduate student working on this project. Dr. Hansen has a Ph.D. in limnology and marine science and M.Sc. in Fisheries and Wildlife. She has spent the past decade working at the interface of science and policy in understanding ecosystem changes affecting Midwestern lakes. As a leading researcher working to understand drivers of trends in Midwestern fish habitat and populations, Dr. Hansen has worked on the effects of climate change, watershed land use, and water clarity on water quality and fish. She currently serves as project manager for a collaborative multi-agency team on a MAISRC project studying the impacts of zebra mussels and spiny water flea on the food webs of Minnesota's largest walleye lakes. Many of her research projects bring together experts in fisheries management, ecosystem dynamics, and computer science to address real-world management problems with cutting-edge science solutions. Dr. Hansen has a strong publication track record and a commitment to communicating effectively with stakeholders using multiple media, including online, interactive data visualization tools.

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

Organization Description:

The University of Minnesota Twin Cities is the state's land-grant university and one of the most prestigious public research universities in the nation. The research mission of the University is to seek new knowledge that can change how we all work and live. We apply our research and expertise to meet the needs of Minnesota, our nation, and the world through partnerships in addressing society's most pressing issues.

Within the University of Minnesota, faculty, staff, and students of Department of Fisheries, Wildlife, and Conservation Biology work on applied and fundamental problems related natural resource management and conservation. The mission of FWCB is to foster a high-quality natural environment by contributing to the management, protection, and sustainable use of fisheries and wildlife resources through teaching, research, and outreach. Our goals are to respond to societal needs for information and education pertaining to the conservation of our natural resources and to ensure excellent teaching, research, and outreach programs.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Assistant Professor Gretchen Hansen		Project manager, supervise student, post doc, and technician, assist with analysis, interpretation, and dissemination of results			27%	0.18		\$32,538
Jacques Finlay, Professor		Supervise student and post-doc, assist with data analysis and interpretation, writing and dissemination of results			27%	0.12		\$27,002
Graduate student - includes tuition		Lead data compilation and analysis of water quality drivers and in case study lakes			47%	1.5		\$144,336
Postdoctoral associate		Lead analysis of water quality trends, drivers, and consequences for fish habitat			20%	2		\$127,281
Web design and geospatial analyst		Assist with extraction of land use data, Develop web tools for outreach			24%	0.1		\$13,263
Lab manager/research specialist		lead data collation from multiple agencies and database management. Assist with reporting and web design.			24%	0.75		\$45,286
							Sub Total	\$389,706
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Equipment	Laptop computer (pending LCCMR approval) (1)	Laptop computer for post doc (pending LCCMR approval) for downloading and processing large state and national data in the field and conducting large scale data analysis that is not possible with existing equipment.	X				\$2,592
							Sub Total	\$2,592
Capital Expenditures								

							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Cost estimated as four trips with mileage (450 miles RT @ \$0.56/mile), 2 nights lodging (2 nights @\$150/night), and meals (3 days @ \$55/day). Actual costs will be reimbursed	Travel to local area offices of DNR, PCA, BWSR, and watershed organizations to collate data for activity 2.					\$2,868
	Conference Registration Miles/ Meals/ Lodging	Cost estimated as two trips for one person, registration (\$50), mileage (450 miles RT @ \$0.56/mile), 2 nights lodging (2 nights @\$150/night), and meals (3 days @ \$55/day). Actual costs will be reimbursed	Travel for one person to in-state professional conference or meeting (e.g., Minnesota AFS, Watershed Association Meeting) to present results in each of years 2, and 3 .					\$1,534
							Sub Total	\$4,402
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Printing	Poster and outreach material printing for meetings with agency partners and conferences	Poster and outreach material printing for meetings with agency partners and conferences					\$300
							Sub Total	\$300
Other Expenses								
							Sub Total	-
							Grand Total	\$397,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Equipment, Tools, and Supplies		Laptop computer (pending LCCMR approval) (1)	Laptop computer for post doc (pending LCCMR approval) for downloading and processing large state and national data on land use and water clarity and conducting large scale data analysis that is not possible with existing equipment.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
In-Kind	Unrecovered IDC 55% MTDC	Research support at UMN including budgets, libraries, administrative support.	Pending	\$218,350
			Non State Sub Total	\$218,350
			Funds Total	\$218,350

Attachments

Required Attachments

Visual Component

File: [2f426b1e-982.pdf](#)

Alternate Text for Visual Component

Conceptual model of project activities. First graphic shows hypothetical trends in water clarity for a lake - increasing, static, or decreasing. The next shows possible causes of water clarity change that we will identify, including land use, climate, land management, invasive species, legacy nutrients, and lake features. The final graphic shows a potential consequences to fish habitat of clarity change, including warming surface waters and bottom waters becoming unsuitable for fish due to la...

Optional Attachments

Support Letter or Other

Title	File
U of MN endorsement	27bedc49-ac3.pdf

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

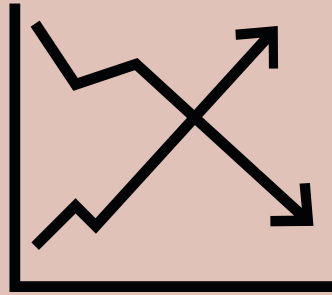
Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

What are the causes and consequences of Minnesota's changing lake water quality?

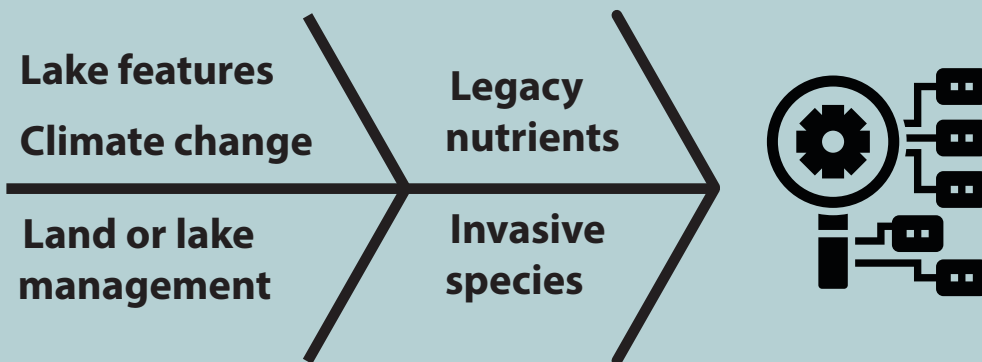
What are the trends?

Water clarity trends, a comprehensive indicator of water quality, differ among Minnesota lakes.



Activity 1
Lake trend analysis
Which lakes are changing, and how?

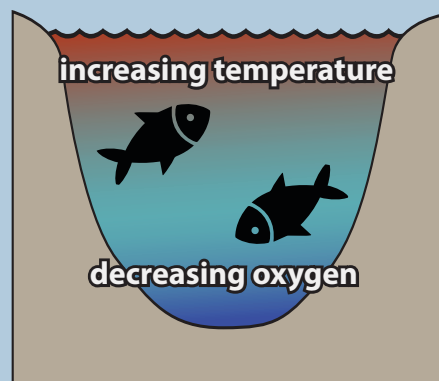
What are the causes for changing water quality?



Activity 2
Identify drivers
Why is water quality changing?

How will fish habitat be affected?

Fish have specific requirements for light, temperature, and dissolved oxygen, which are all affected by water clarity.



Activity 3
Consequences of change
How does clarity impact fish habitat through changes to lake temperature and oxygen?