**PROJECT TITLE: Invasive Rock Snot Threatens North Shore Streams**

**I. PROJECT STATEMENT: A North Shore stream was invaded by rock snot and the time to stop it is now!**

In 2018, the first nuisance growth of rock snot (aka *Didymospenia geminata* or, more simply “didymo”) developed in the North Shore’s Poplar River and we don’t know why. Didymo is a freshwater diatom (a type of algae) that can form nuisance mats of goo in coldwater streams worldwide, both in its native range and where it is invasive. Formation of didymo mats in streams has aesthetic, economic, and recreational impacts, including impacting angling and recreation. Economic impacts to tourism have exceeded $20 million per year following invasions elsewhere, **a serious threat to the North Shore’s $250 million summer economy**. Didymo mats disrupt community structure and ecosystem function in streams, alter habitat and food web dynamics, impact fish and invertebrate abundance and diversity, and result in major shifts in natural bacterial composition.

**Summary: With LCCMR support we will understand:**1) the distribution, dynamics, and effect of *Didymosphenia geminata* in North Shore streams
2) why did rock snot form in the Poplar River and what other streams are at risk?
3) the source of didymo in North Shore streams
4) share information and work with with resource managers, citizen groups, and resource users to stop rock snot invasion of North Shore streams.

**Two hypotheses may explain rock snot:** The **aggressive colonization hypothesis** maintains that an aggressive strain of *Didymosphenia geminata* is being introduced and invading coldwater streams. The **changing environmental conditions hypothesis** states that environmental conditions (e.g., nitrogen to phosphorus ratios or timing of nutrient delivery) have become favorable to the formation of didymo mats. *Understanding which of these models is supported by data is vital to management response*.

While didymo has been documented in the near shore algal community of Lake Superior with increasing frequency since the 1960s, the Poplar River, near Lutsen, MN, is the first stream that has been colonized. Didymo is unique because it only blooms in oligotrophic (low nutrient) waters and recently, mats have been observed more frequently in streams similar to those on the North Shore around the world, including New Zealand, South America, Canada, and the US. Research shows thicker didymo mats have formed along the Superior shoreline annually for over a decade; however, it was only in 2018 that didymo was first observed colonizing North Shore streams in either single cells or mat form. It is unclear why the mat formed in the Poplar River and whether didymo is already invading other North Shore streams.

**We can solve rock snot:** If the populations in North Shore streams and Lake Superior are not each-other’s closest relatives (i.e., the stream didymo came from elsewhere), efforts for prevention of didymo mat formation will be focused on preventing movement of the alga among streams, paralleling practices that prevent the spread of other microbes in freshwater systems. Alternatively, if the stream didymo originated from Lake Superior populations, management practices should focus on understanding the specifics that promote mat formation. In both cases, we will fully understand the source and cause of mat formation and broadly communicate the threat, implications, and management response to didymo mat formation in North Shore streams.

**II. PROJECT ACTIVITIES AND OUTCOMES**

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| **Activity 1: Understand didymo mat formation and distribution in North Shore streams and Lake Superior****Description:**We will monitor the Poplar River and Lake Superior shoreline near the mouth of the Poplar to determine if a didymo mat reforms in the next two years and monitor the timing and environmental conditions associated with mat formation in the stream and lake. We will similarly sample 3-4 other stream-lakeshore pairs along the North Shore to document changes in the algal community and associated environmental conditions. Sampling will be monthly from April-November and will include sampling of the algal community and chemical (e.g., nutrients, dissolved organic carbon) and physical characteristics of the stream. Temperature, water depth, and flow will be measured continuously throughout the project. During peak didymo growth (late Aug-Sept 2019) a single survey each year will target 20 major North Shore stream-lakeshore pairs to fully assess current didymo presence and susceptibility of North Shore resources. All sampling will adhere to MNDNR protocols for preventing spread of aquatic invasive species.**ENRTF BUDGET: $140,596** |  |

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| **Outcome** | **Completion Date** |
| *1. Describe the algal communities and environmental conditions in 4-5 paired Lake Superior shoreline and North Shore tributary sites*  | *January 2022*  |
| *2. Survey all major North Shore streams for presence of Didymo and invasion susceptibility during peak growth*  | *December 2021* |
| *3. Communicate findings with natural resource managers, citizens, and scientists through presentations, signage, fact sheets, social media, and peer-reviewed publications.* | *June 2022* |

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| **Activity 2: Genetic variability in MN didymo populations and the associated bacterial community.****Description:**We will collect genetic information on North Shore tributary and Lake Superior coastal didymo populations to determine if the populations in the Poplar River and other North Shore streams are most closely related to didymo populations in Lake Superior or to other didymo populations in North America. We will apply reduced representation genomic sequencing on each population from the Lake Superior region and analyze the new data in the context of preexisting genomic data for didymo populations across the continental US. We will characterize the bacterial communities using 16S rRNA gene sequencing from total DNA extracted from the periphyton mat samples to predict broader ecological consequences of didymo and learn how nuisance blooms are triggered in ultra-clean waters. **ENRTF BUDGET: $57,300** |  |

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| **Outcome** | **Completion Date** |
| *1. Sequence genetics of North Shore didymo populations to determine source of rock snot*  | *January 2022*  |
| *2. Determine genetic structure of the microbial mat community among lake and stream pairs and how changes in these communities alter ecological function and nutrient pathways in these systems.*  | *December 2021* |
| *3. Communicate results with natural resource managers (MNDNR, state parks, watershed* *groups, MPCA) to inform management through meetings, signage, and presentations.*  | *June 2022* |

**III. PROJECT PARTNERS AND COLLABORATORS:**

This project will be led by the St. Croix Watershed Research Station (Dr. Mark Edlund) and the MNDNR (Dr. Heidi Rantala). Other collaborators include Dr. Robert Pillsbury (UW-Oshkosh) and Dr. Teofil Nakov (University of Arkansas) who provide specialized sole source molecular analyses to the project.

**IV. LONG-TERM IMPLEMENTATION AND FUNDING:**

The MNDNR, as well as local watershed groups, will use data from this study to understand what causes nuisance didymo mats in North Shore streams. Understanding why mats form (aggressive colonizer or changing environment) is critical to managing didymo in streams, as management activities differ depending on the cause of mat formation. After understanding conditions that favor didymo mat formation in North Shore streams, documenting the impacts on stream invertebrate, fish, and algal communities will be our next steps.

**V. SEE ADDITIONAL PROPOSAL COMPONENTS:**

**A. Proposal Budget Spreadsheet, B. Visual Component or Map, G. Letter or Resolution**