Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2015 Work Plan

Date of Report: October 30, 2014

Date of Next Status Update Report: January 31, 2016

End Appropriation: 2018

Date of Work Plan Approval:

Project Completion Date: June 30, 2018

Does this submission include an amendment request? No

PROJECT TITLE: Prioritizing Future Management of North Shore Trout Streams

Project Manager: Lucinda B. Johnson

Organization: University of Minnesota Duluth, Natural Resources Research Institute

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Location: Cook, Lake, St. Louis

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$416,000**
	Amount Spent:	**$0**
	Balance:	**$416,000**

Legal Citation: M.L. 2015, Chp. 76, Sec. 2, Subd. 08a

Appropriation Language:
$357,000 the first year is from the trust fund and $59,000 the first year is from the great lakes protection account to the Board of Regents of the University of Minnesota – Duluth for the Natural Resources Research Institute to identify key areas in North Shore streams that supply the cold groundwater essential to sustaining trout fisheries in order to focus habitat restoration, protection, and management efforts on the areas that are most essential for long-term stream health and sustainability. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Prioritizing Future Management of North Shore Trout Streams

II. PROJECT STATEMENT:

Water temperature is generally considered one of the primary physical habitat parameters determining the suitability of stream habitat for fish species. Stream temperature affects individuals throughout their life cycle, with impacts on mortality, metabolism, growth, behavior, and reproduction. In Minnesota's North Shore trout streams cold groundwater is needed to keep stream temperatures below the thermal limit for trout and steelhead growth and survival, and for providing base flow during summer. Yet groundwater is not abundant in this region and thus is particularly important for sustaining these prized cold-water fisheries as the climate warms. MNDNR and NGOs such as Minnesota Trout Unlimited are focusing habitat restoration and protection efforts on a subset of North Shore watersheds most likely to sustain cold-water fisheries and quality angling into the next century. These groups need detailed information on the locations of groundwater discharge areas in priority watersheds to most effectively target habitat restoration and watershed protection efforts.

Trout streams are a scarce resource statewide, comprising just 7% of all stream and river miles. The North Shore of Lake Superior has one of the largest concentrations of trout streams in Minnesota, and is a major recreational draw. However, most streams lack substantial groundwater and are therefore particularly susceptible to climate change. While climate change can impact these streams in many ways, previous research has shown that increased water temperature is the greatest threat to the persistence of trout and steelhead fisheries in North Shore streams. Certain tributaries and stream reaches with localized groundwater inflows provide thermal refuges (stretches of colder water which trout actively select), allowing trout to survive during periods when much of the stream approaches or exceeds the stressful or lethal temperature thresholds. These streams also have higher base flows, providing habitat during drought periods. Streams with more cold-water refuges are most likely to maintain trout and steelhead populations as air temperatures increase with global climate change. Anecdotal evidence has identified some of the thermal refuges in North Shore streams, but no systematic identification of these important areas has been undertaken, nor has site-specific data collection (stream temperature and channel morphology) been done. **This project will provide the scientific data essential to ensure that restoration, protection and management are targeted at those reaches essential to ensuring long-term sustainability of cold-water fisheries.**

Our goals are to: (1) collect site-specific temperature data and map the locations of thermal refuges in "top tier" North Shore trout streams (~15 to 20 watersheds); (2) determine the regional and local channel characteristics, flow, geology, and land use / land cover associated with cold-water refuges, and predict which areas are most resilient to climate change; and (3) recommend targeted actions to increase the likelihood that these cold-water refuges will continue to exist in the future.

We will: (1) conduct extensive field surveys of "top tier" North Shore streams to locate reaches with locally cooler water temperatures and document soils, streamside vegetation types, and channel conditions at those sites; (2) document presence/absence of fish, particularly salmonids; (3) map locations of cold-water refuges and their association with fish presence/absence; (4) use local geomorphic data, new LiDAR tools, land cover and soils data to determine the regional and local conditions that support cold-water refuges; (5) use hydrologic and temperature models to predict future stream flow and temperature based on climate projections; and (6) collaborate with MNDNR, Minnesota Trout Unlimited and other fishing groups to identify appropriate protection and restoration actions. This information will assist MNDNR, Minnesota Trout Unlimited, and other citizen angling groups and management entities in identifying priority locations for habitat restoration, protection and

management. Citizen volunteers from Minnesota Trout Unlimited, other fishing groups, and tribal entities (organized by the 1854 Treat Authority) will play an important role in collecting stream temperature data. Field protocols and location data encompassing cold-water refuges will be shared with the Minnesota Spring Inventory project, led by the MNDNR and MN Geological Survey.

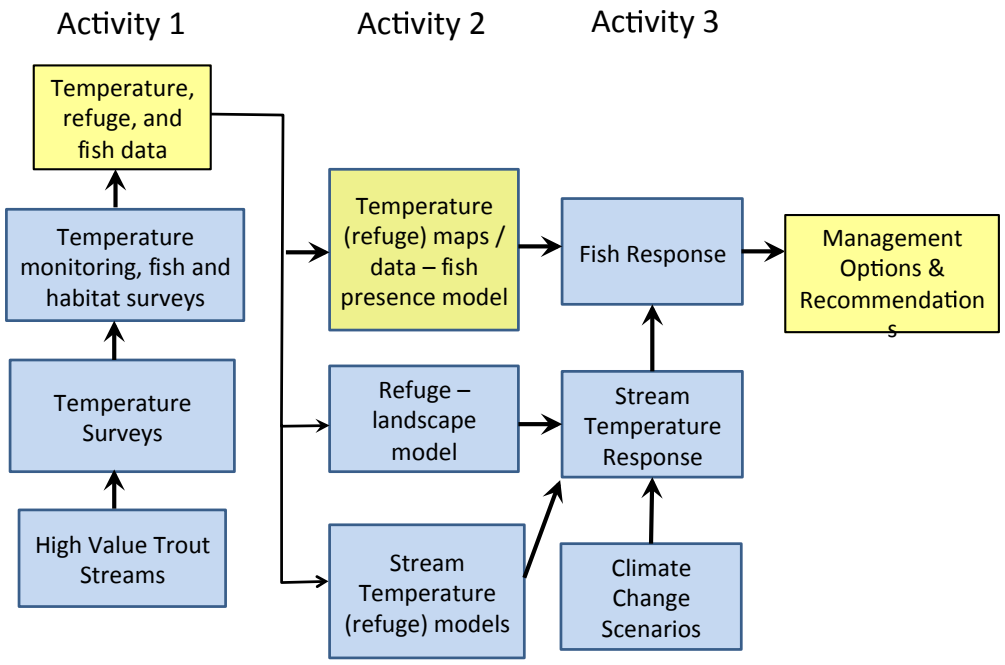

Figure 1. Flow diagram of tasks and activities. Yellow boxes represent outcomes and deliverables.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of: January 31, 2016

Project Status as of: June 30, 2016

Project Status as of: January 31, 2017

Project Status as of*:* June 30, 2017

Project Status as of*:* January 31, 2018

Overall Project Outcomes and Results:

1. Qualitative inventory of cold-water refuges in a set of high value North Shore trout streams.
2. Empirical models to predict the major determinants of cold-water refuges from local and landscape features.

3. Deterministic and empirical models predicting the potential impacts of climate change on cold-water fish habitat.
4. Additional stream temperature data (instantaneous and warm months) for critical North Shore streams to add to the knowledge base and database at NRRI.
5. Management recommendations for prioritizing activities for restoring critical cold-water fish habitat.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Survey Temperature and Fish in North Shore Streams
Description: A committee including fisheries managers (e.g., MNDNR), members of the angling community (e.g., MN Trout Unlimited, Steelhead Association, and others) and academics will be convened to initially identify the set of high value streams to be included in this study. This group will identify a set of about 15-20 high-value North Shore watersheds for this study. Accessible stream segments will be walked in mid-to-late summer by teams of volunteers from MN Trout Unlimited and other angler groups using fast-reacting digital thermocouples to continuously read water temperature. Stream temperature and a GPS waypoint will be recorded at any location where temperature is at least 2°C cooler than ambient stream temperature, habitat types associated with each cold-water refuge type will be noted, and habitat features relevant to stream temperature control and fish habitat will be recorded. This information will be used in Activity 2 to develop a map of stream temperature with types and location of cold-water refuges noted.

In-stream water temperature, cold-water refuge presence and quantity, and basic habitat data from temperature survey volunteers will be used to rank stream segments on a 1-5 scale for trout cold-water refuge potential (1 being highest potential and 5 being lowest potential). This ranking will be used to triage stream segments for further habitat and fish surveys by NRRI staff at about 100 stream reaches. At about 75% of these stream reaches, a qualitative habitat assessment will be performed, along with an electrofishing survey. The remaining 25% of sites will be selected from across the quality ranking scale for intensive fish sampling and habitat assessment. In addition, we will conduct intensive temperature monitoring in about 45 locations per year (Years 1 and 2). This monitoring will target specific refuge features within the stream; 3 loggers per site will be deployed to measure air temperature, water temperature within the cold-water refuge, and within the thalweg (area of greatest flow) of the stream. Continuous temperature data will be used to develop stream temperature models in Activity 2.

All field data will be downloaded and backed up daily to ensure data safety. Field data will be assembled into an existing database at NRRI, used for previous stream temperature studies of North Shore Streams. All manual-entry data will be double-checked by another person. Continuous temperature data will be quality-checked and then summarized to reflect the range, variability, max and min for 1, 7, 21 day periods. In addition, a GIS database will be augmented to include all available vegetation, land use, soils, and topography data for each catchment, along with links to the local habitat data in Activity 2.

Summary Budget Information for Activity 1:

ENRTF Budget:	**$ 185,238**
Amount Spent:	**$ 0**
Balance:	**$ 185,238**

Outcome	Completion Date
1. Identification of high-value trout streams	08/01/2015

2. Survey of temperature, fish and local geomorphology (field season 1 and 2)	10/01/2016

Activity Status as of: January 31, 2016

Activity Status as of: June 30, 2016

Activity Status as of: January 31, 2017

Activity Status as of*:* June 30, 2017

Activity Status as of*:* January 31, 2018

Final Report Summary:

ACTIVITY 2: Map local stream temperature and trout populations; relate local geology and land cover to temperature conditions

Description: The compiled cold-water refuge data (i.e., temperature data) from Activity 1 will be examined, and a discrete number of subclasses of refuges will be identified, based on characteristics such as refuge type (see Activity 1), size, temperature range, or natural vs. artificial pools. Temperature data from field surveys will be used to create maps of water temperature within the high-value streams sampled. This set of maps will form one of the deliverables for this project. Map products will be designed to depict instantaneous or summarized thermal metrics (e.g., means, max, min over the assessment period). Data will be posted on the NRRI's Lake Superior Streams website.

All temperature, fish, and habitat data collected in Activity 1 will be compiled into a spatially-referenced GIS database, which will build upon previous work in the region by L. Johnson and collaborators. Study reaches containing cold-water refuges will be identified and local catchments (e.g., watersheds of about 100 ha) will be delineated using LiDAR data. The LiDAR data also will be used to calculate slopes, depressional storage, and other topographical parameters within each catchment. Land cover, vegetation, surficial geology, and soil type data will be attributed to the catchments for each study stream. These data, along with 3-m and 10-m digital elevation model data, are currently available at the Natural Resources Research Institute.

A series of models, listed below, will be developed in this activity. Both empirical (statistical) and deterministic (physics-based) models will be used; the empirical models are useful for studying the spatial distribution of temperature and fish over the region, and the deterministic models give more detailed information on hydrology and temperature at specific locations. These models will allow us to predict where thermal refuges are likely to be, what benefit the refuges are to the fish populations, and how (or if) the presence of these refuges will make the North Shore trout stream more viable in the future under climate change.

1) Trout presence/absence model: this model will be used to determine how the distribution of brook trout is controlled by temperature and other habitat factors, using spatial data, field-collected habitat data, and results of the electrofishing survey.

2) Thermal refuge models: empirical models will be used to predict where cold-water refuges tend to occur, based on local landscape factors such as soil types, vegetation and topography. Deterministic models will zoom

in on specific stream locations to better understand how water temperatures in and near the refuges are controlled by local hydrology and landscape, and how they will respond to climate change.

3) Steam temperature models: empirical and deterministic models will be used to predict stream temperature as a function of climate and local landscape variables such as riparian shading and wetland density. The empirical models will be used to estimate stream temperature in unsampled streams and to determine how temperatures in streams with and without refuges will respond to climate change.

The outcome of these tasks will be a map of the cold-water refuges identified during the field surveys, a set of data and models relating trout presence / absence to temperature (including presence of cold-water refuges); models predicting presence / density of cold-water refuges based on landscape and local habitat characteristics; and models that determine specific relationships between water temperature and climate-related variables.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 125,599
Amount Spent: $ 0
Balance: $ 125,599

Outcome	Completion Date
1. Map of the thermal refuges in surveyed streams	**12/31/2016**
2. Correlate fish presence/absence with thermal refuges	**04/01/2017**
3. Quantify relationships of thermal refuges to geomorphology, hydrology, and land cover	**06/30/2017**
4. Predict local conditions producing thermal refuges	**06/30/2017**

Activity Status as of: January 31, 2016

Activity Status as of: June 30, 2016

Activity Status as of: January 31, 2017

Activity Status as of*:* June 30, 2017

Activity Status as of*:* January 31, 2018

Final Report Summary:

ACTIVITY 3: Regional projections of trout stream resilience to climate change
Description: The overall goal of Activity 3 is to use stream temperature - fish models previously developed by L. Johnson and colleagues, and the data set and models developed in Activity 2 to predict how trout stream habitat will respond to climate change, taking into account cold-water refuges.

Predicting future viability of cold-water fish habitat will require us to obtain and compile future climate projections in a suitable form to serve as input to the flow, temperature, and habitat models. The availability of downscaled GCM (global climate model) projections will be evaluated when the project starts. Future climate

scenarios will likely be assembled for a mid-century period (2046-2065) and a late century period (2081-2100); the final decisions will be made based on availability of climate projections and fisheries managers' needs. Each climate scenario will be based on an ensemble of GCMs to give, for example, predicted median, low, and high increases in air temperature for each time period.

The seasonal response of stream temperature to the climate change projections will be calculated, and temperature statistics will be compiled for subcatchments of varying sizes, levels of riparian shading and land use type, and for at least two future climate periods. The exact form of the compiled temperature statistics (daily average, weekly average, etc.) will be based on results of Activities 1 and 2. Initial stream temperature results will represent a baseline response for stream reaches without cold-water refuges. Depending on the results of Activities 1 and 2, future temperature changes for particular stream classes may be made to give additional information in refuge areas.

The future climate projections will be applied to the stream catchment models developed in Activity 2 to estimate changes in the seasonal temperature of surface runoff and shallow groundwater. Depending on the exact form of the models, it may also be possible to make projections about seasonal changes in groundwater input rates, which might be caused by changes such as shorter winters and longer open water periods.

Based on the projected temperature response of stream reaches, pools and groundwater inputs, the future viability of North Shore streams for trout will be evaluated. The projected changes in stream reach temperature and refuge temperature will be compared, and the overall change in viable refuge size or density will be estimated for different types of streams and sub-regions of the Superior North Shore. Using the empirical models of predicted stream temperatures and temperature – fish presence/absence relationships, the projected changes in overall stream temperature and cold-water refuges will be translated to projected changes in future viability of cold-water fish habitat.

The refuge and fish habitat predictions will be tested in a subset of unsampled streams using field data collected during the final year. Future fish presence/absence projections and risk of exceedances of trout thermal tolerances will then be made using the same procedures used for the sampled streams.

Management recommendations will be assembled based on the field data and the model results from all three Activities. A committee including fisheries managers (e.g., MNDNR), members of the angling community (e.g., MN Trout Unlimited, Steelhead Association, and others) and academics will be convened to initially identify the set of high value streams to be included in this study. This committee will also evaluate the results (i.e., projected changes in stream reach and refuge temperatures) and identify a set of recommendations to help protect and/or restore stream thermal refuges.

Summary Budget Information for Activity 3:

ENRTF Budget: $ 105,163
Amount Spent: $ 0
Balance: $ 105,163

Outcome	Completion Date
1. Project future viability of sampled North Shore trout streams	10/31/2017
2. Validate predictions in unsampled streams with field observations	10/31/2017
3. Project future viability of North Shore trout streams	12/31/2018

4. Develop management recommendations to protect North Shore cold-water refuges	06/30/2018

Activity Status as of: January 31, 2016

Activity Status as of: June 30, 2016

Activity Status as of: January 31, 2017

Activity Status as of*:* June 30, 2017

Activity Status as of*:* January 31, 2018

Final Report Summary:

V. DISSEMINATION:
Description:

1. Temperature data from field surveys will be used to create thermal maps of water temperature within the high-value stream segments sampled. This set of maps will form one of the deliverables for this project. Map products will be designed to depict instantaneous or summarized thermal metrics (e.g., means, max, min over the assessment period). Data will be posted on NRRI's *LakeSuperiorStreams.org* website. Temperature data will be incorporated into a master data set of stream temperature data that has been assembled by NRRI and is distributed upon request.
2. Management recommendations will be assembled based on the empirical data and model results from all three Activities. A committee including fisheries managers (e.g., MNDNR), members of the angling community (e.g., MN Trout Unlimited, Steelhead Association, and others) and academics will be convened to initially identify the set of high value streams to be included in this study. This committee will also evaluate the results (i.e., projected changes in stream reach and refuge temperatures) and identify a set of recommendations for future management. Management recommendations will be distributed in the form of personal contacts and presentations for local angling and management groups, documentation in the form of reports and peer reviewed papers to management agencies and non-governmental organizations (e.g., MNDNR; US Fish and Wildlife Service; The Nature Conservancy; tribes; local units of government.)
3. Results will initially be presented at the MN Water Resources Conference or other suitable venues. We expect one or more peer-reviewed papers to result from this work.

Status as of: January 31, 2016

Status as of: June 30, 2016

Status as of: January 31, 2017

Status as of*:* June 30, 2017

Status as of*:* January 31, 2018

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:
A. ENRTF Budget Overview:

Budget Category	$ Amount	Overview Explanation
Personnel:	$ 341,509	1 Project Manager 4% FTE each year for 3 years; 3 Co-managers – W. Herb 50% FTE years 1&3, 45% year 2; M. Cai 20% FTE years 1 & 2, 25% year 3; V. Brady 5% FTE each year for 3 years; 1 Research Fellow 20% FTE years 1 & 2, 10% year 3; 1 GIS Tech 10% FTE each year for 3 years; 1 Principal Lab Tech 20% FTE each year for 3 years; 2 Senior Lab Techs 10% FTE each person, each year for 3 years
Professional/Technical/Service Contracts:	$ 10,000	1 contract: John Lenczewski, Minnesota Trout Unlimited: organization of volunteer activities
Equipment/Tools/Supplies:	$ 23,905	Fast-reacting thermo-couple with wand ($500 ea x 11); temperature sensors ($130 ea x 105); download device ($250); software ($300); base station for temperature sensors ($125); GPS Units ($500 ea x 5); waterproof paper ($140); waders ($110 ea x 4); software license ($600), backup drive + memory and disk storage ($400)
Travel Expenses in MN:	$ 32,714	Project personnel Duluth to Twin Cities to confer w/collaborators & agencies $2,472 (mileage only -4 trips/yr x 3 yrs @ 350 mi RT ea @ $0.56/mi=$2,352 + car rental fee of $10/day*12 days=$120); In-state conference, yrs 2 & 3, $2,368 (mileage: 2 trips @350 RT ea @ $0.56/mi=$392: dept. car rental @ $10/day *3 days*2yrs=$60: lodging @ $133/day*2 days* 2 ppl*2yrs=$1064; meals @ $71/day *3 days * 2 ppl*2yrs=$852); Field travel $22,610 (9375 mi @ $0.56/mi=$5250: dept. car rental @ $15/day*86 days=$1,290: lodging @ $200/day*47 days=$9,400: meals @ $46/day*5 days*2ppl=$460, meals @ $46/day*45 days*3ppl=$6,210). Note-lodging rates allow for group lodging/cabins
Other:	$ 7,872	Conference calls $822 with collaborators to reduce travel costs ($330/yr.*2yrs + $162/yr*1yr; cost is $0.10/minute); GIS lab

		service ($4.10/hr, projected 500 hrs per year); Conference registration $900 ($225/ea*2 yrs * 2 ppl)
TOTAL ENRTF BUDGET:	**$ 416,000**	

Explanation of Use of Classified Staff: N/A

Explanation of Capital Expenditures Greater Than $5,000: N/A

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 4.4 FTEs

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 0.12 FTEs

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
NOAA	$ 10,000	$	Derive a stream classification system for North Shore streams to refine stream temperature and flow models.
State			
	$	$	
TOTAL OTHER FUNDS:	**$ 10,000**	**$**	

VII. PROJECT STRATEGY:

A. Project Partners:

Project Partners Not Receiving Funds:

- MNDNR partners will provide advice, existing data and, where feasible, field support. They will participate in developing management recommendations to protect cold-water stream habitat.

- MNDNR and MN Geological Survey personnel involved in the spring inventory will communicate survey methods to identify region-specific considerations (primarily related to access issues related to the remote nature of the north shore streams). The spring survey protocols and inventory will be considered for data dissemination.
- Local fishing groups have been contacted and have agreed to provide volunteer labor for the temperature surveys in Activity 1 (organized and coordinated by Minnesota Trout Unlimited, which is receiving funding for coordination, see below).
- The 1854 Treaty Authority may be able to assist with volunteer temperature surveys, depending on their workload and the timing of the surveys.

Project Partners Receiving Funds:

- Minnesota Trout Unlimited: $10,000 for a stipend for the MNTU coordinator to organize volunteers to collect temperature data and for travel expenses. This amount will also cover volunteer expenses of MNTU members assisting with temperature surveys and other data collection in years 1 and 2.

B. Project Impact and Long-term Strategy: This project is self-contained in its scope, and will contribute towards the long-term strategy of state agencies to maintain trout populations in North Shore streams. The project builds on data and results from several projects, including a MNDNR-funded project studying the impacts of climate change on MN cold-water lakes and North Shore trout streams. The data and results produced by this project will inform a wide variety of stream management and restoration efforts, and could be extended to other regions of the state or to a regional or national scale project.

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	$ Amount
Not applicable		$
		$

IX. VISUAL COMPONENT or MAP(S):

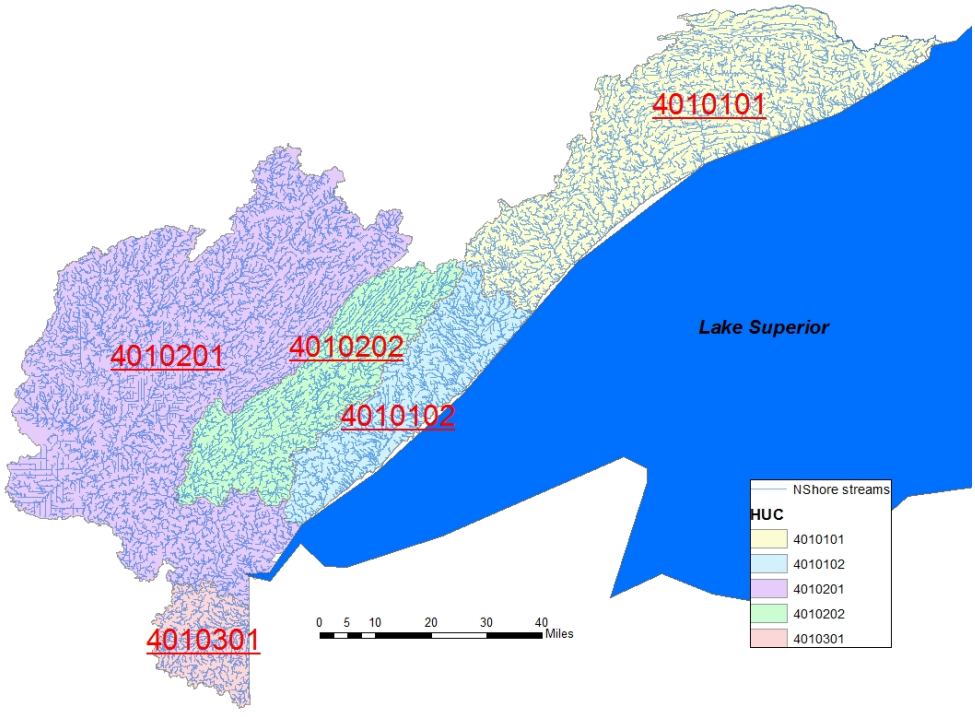

Figure 1. Location of Lake Superior South and North major Minnesota watersheds (4010102 and 4010101, and the stream networks located within them. This study will explore streams and stream segments just within these two major watersheds. All of these streams drain to Lake Superior and, thus, theoretically have the potential to support lake-run salmonids.

X. RESEARCH ADDENDUM: N/A

XI. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted no later than January 31, 2016; June 30, 2016; January 31, 2017; June 30, 2017; and January 31, 2018. A final report and associated products will be submitted between June 30 and August 15, 2018.

Environment and Natural Resources Trust Fund
M.L. 2015 Project Budget

Project Title: Prioritizing Future Management of North Shore Trout Streams
Legal Citation: M.L. 2015, Chp. xx, Sec. xx, Subd. xx
Project Manager: Lucinda Johnson
Organization: Natural Resources Research Institute, University of Minnesota Duluth
M.L. 2015 ENRTF Appropriation: $416,000
Project Length and Completion Date: 3 Years, June 30, 2018
Date of Report: October 30, 2014

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	Survey Temperature and Fish in North Shore Streams			Map local stream temperature and trout populations; relate local geology and land cover to temperature conditions			Regional projections of trout stream resilience to climate change				
Personnel (Wages and Benefits) $341,509	$125,147	$0	$125,147	$121,269	$0	$121,269	$95,093	$0	$95,093	$341,509	$341,509
Lucinda Johnson, Project Manager: $23,612 (66.2% salary, 33.8% benefits); 4% FTE each year for 3 years											
William Herb, Co-Investigator: $137,247 (66.2% salary, 33.8% benefits); 50% FTE yrs 1&3, 45% FTE yr 2											
Mei Cai, Co-Investigator: $57,251 (66.2% salary, 33.8% benefits); 20% FTE yrs 1&2, 25% FTE yr 3											
Valerie Brady, Co-Investigator: $14,345 (66.2% salary, 33.8% benefits); 5% FTE each year for 3 years											
Josh Dumke, Research Fellow; $29,931 (66.2% salary, 33.8% benefits); 20% FTE yrs 1&2, 10% FTE yr 3											
Jeremy Erickson, GIS Tech; $19,272 (66.2% salary, 33.8% benefits); 10% FTE each year for 3 yrs											
Robert Hell, Principal Lab Technician: $34,965 (73.7% salary, 26.3% benefits); 20% FTE each year for 3 years											
2 Senior Lab Technicians: $24,886 (73.7% salary, 26.3% benefits); 10% FTE each person, each year for 3 years											
Professional/Technical/Service Contracts $10,000											
John Lenczewski, MNTU project coordinator: organization of	$8,000	$0	$8,000				$2,000	$0	$2,000	$10,000	$10,000
Tools/Supplies $23,905											
Fast-reacting thermo-couple with wand ($500 ea x 11); temperature sensors ($130 ea x 105); download device ($250); software ($300); base station for temperature sensors ($125); GPS Units ($500 ea x 5); waterproof paper ($140); waders ($110 ea x 4); software license ($600), backup drive + memory and disk storage ($400)	$22,905	$0	$22,905	$1,000	$0	$1,000				$23,905	$23,905
Travel expenses in Minnesota $32,714											
Project personnel Duluth to Twin Cities to confer w/collaborators & agencies. Mileage only -4 trips/yr x 3 yrs @ 350 mi RT ea @ $0.56/mi=$2,352 + car rental fee of $10/day*12 days=$120							$2,472	$0	$2,472	$2,472	$2,472
In-state conference, yrs 2 & 3. Mileage: 2 trips @350 RT ea @ $0.56/mi=$392: Dept. car rental @ $10/day *3 days*2yrs=$60: Lodging @ $133/day*2 days* 2 ppl*2yrs=$1064; Meals @ $71/day *3 days * 2 ppl*2yrs=$852							$2,368	$0	$2,368	$2,368	$2,368
Field travel-9375 mi @ $0.56/mi=$5250: Dept. car rental @ $15/day*86 days=$1,290: Lodging @ $200/day*47 days=$9,400: Meals @ $46/day*5 days*2ppl=$460, Meals @ $46/day*45 days*3ppl=$6,210 Note-lodging rates allow for group lodging/cabins	$22,610	$0	$22,610							$22,610	$22,610
MNTU project coordinator and volunteer travel reimbursement, yrs 1 & 2. Mileage: 4,700 mi/yr@ $0.56/mi *2yrs	$5,264	$0	$5,264							$5,264	$5,264
Other $7,872											
Conference calls with collaborators to reduce travel costs, $330/yr @ $0.10/min	$162	$0	$162	$330	$0	$330	$330	$0	$330	$822	$822
GIS lab service: $4.10/hr, projected 500 hrs per year	$1,150		$1,150	$3,000	$0	$3,000	$2,000	$0	$2,000	$6,150	$6,150
Conference registration @ $225/ea*2 yrs * 2 ppl=$900							$900	$0	$900	$900	$900
COLUMN TOTAL	**$185,238**	**$0**	**$185,238**	**$125,599**	**$0**	**$125,599**	**$105,163**	**$0**	**$105,163**	**$416,000**	**$416,000**